

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

RIN 1018-AB69

42-94

Endangered and Threatened Wildlife and Plants; Determination of Endangered or Threatened Status for 24 Plants From the Island of Kauai, HI

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Final rule.

SUMMARY: The U.S. Fish and Wildlife Service (Service) determines endangered status pursuant to the Endangered Species Act of 1973, as amended (Act), for 21 plant taxa and threatened status for 3 plant taxa. All but seven of the taxa are endemic to the island of Kauai, Hawaiian Islands. The exceptions are found on the islands of Niihau, Oahu, Molokai, Maui, and/or Hawaii, as well as Kauai. The 24 plant taxa and their habitats have been variously affected or are currently threatened by 1 or more of the following: habitat degradation by animals (e.g., goats, pigs, axis and mule deer, cattle, and red jungle fowl); competition for space, light, water, and nutrients by naturalized, introduced vegetation; erosion of substrate produced by weathering, or human or animal caused disturbance; recreational and agricultural activities; habitat loss from fires; and predation by animals (goats and rats). Due to the small number of existing individuals and their very narrow distributions, these taxa and most of their populations are subject to an increased likelihood of extinction and/or reduced reproductive vigor from stochastic events. This rule implements the protection and recovery provisions provided by the Act for these plant taxa.

EFFECTIVE DATE: March 28, 1994.

ADDRESSES: The complete file for this rule is available for public inspection, by appointment, during normal business hours at the U.S. Fish and Wildlife Service, 300 Ala Moana Boulevard, room 6307, P.O. Box 50167, Honolulu, Hawaii 96850.

FOR FURTHER INFORMATION CONTACT: Robert P. Smith, at the above address (808/541-2749).

SUPPLEMENTARY INFORMATION:**Background**

Brighamia insignis, *Cyanea asarifolia*, *Cyrtandra limahuliensis*, *Delissea rhytidosperma*, *Diellia pallida*, *Exocarpos luteolus*, *Hedyotis cookiana*,

Hibiscus clayi, *Lipochaeta fauriei*, *Lipochaeta micrantha*, *Lipochaeta waimeaensis*, *Lysimachia filifolia*, *Melicope haupuensis*, *Melicope knudsenii*, *Melicope pallida*, *Melicope quadrangularis*, *Munroidendron racemosum*, *Nothoestrum peltatum*, *Peucedanum sandwicense*, *Phyllostegia waimeae*, *Pteralyxia kauaiensis*, *Schiedea spergulina* var. *leopoda*, *Schiedea spergulina* var. *spergulina*, and *Solanum sandwicense* are endemic to or have the majority of their populations on the island of Kauai, Hawaii. Seventeen of these taxa are endemic to the island of Kauai, Hawaii; two additional taxa are now found only on Kauai. One of these taxa is now or was previously also known from Niihau, four from Oahu, two from Molokai, two from Maui, and one from the island of Hawaii.

The island of Kauai is the northernmost and oldest of the eight major Hawaiian Islands (Foote *et al.* 1972). This highly eroded island, characterized by deeply dissected canyons and steep ridges, is 553 square miles (sq mi) (1,430 sq kilometers (km)) in area (Department of Geography 1983). Kauai was formed about six million years ago by a single shield volcano. Its caldera, once the largest in the Hawaiian Islands, now extends about 10 mi (16 km) in diameter and comprises the extremely wet, elevated tableland of Alakai Swamp (Department of Geography 1983). Because the highest point on Kauai, at Kawaikini Peak, is only 5,243 feet (ft) (1,598 meters (m)) in elevation (Department of Geography 1983), it lacks the contrasting leeward montane rainfall patterns found on other islands that have higher mountain systems. Rainfall is, therefore, distributed throughout the upper elevations, especially at Mount Waialeale, Kauai's second highest point at 5,148 ft elevation (1,569 m) (Department of Geography 1983). Mount Waialeale is one of the wettest spots on earth, where annual rainfall averages 450 inches (in) (1,140 centimeters (cm)). (Honda *et al.* 1967, Joesting 1984). To the west of the Alakai Swamp is the deeply dissected Waimea Canyon, extending 10 mi (16 km) in length and up to 1 mi (1.6 km) in width. Later volcanic activity on the southeastern flank of the volcano formed the smaller Haupu caldera. Subsequent erosion and collapse of its flank formed Haupu Ridge (Macdonald *et al.* 1983). One of the island's most famous features is the Na Pali Coast, where stream and wave action have cut deep valleys and eroded the northern coast to form precipitous

cliffs as high as 3,000 ft (910 m) (Joesting 1984).

Because of its age and relative isolation, levels of floristic diversity and endemism are higher on Kauai than on any other island in the Hawaiian archipelago. However, the vegetation of Kauai has undergone extreme alterations because of past and present land use. Land with rich soils was altered by the early Hawaiians and more recently converted to agricultural use or pasture (Gagne and Cuddihy 1990). Intentional or inadvertent introduction of alien plant and animal taxa has also contributed to the reduction of native vegetation on the island of Kauai. Native forests are now limited to the upper elevation mesic and wet regions within Kauai's conservation district. The 24 taxa in this rule occur in that district, between 400 and 4,000 ft (120 and 1,200 m) elevation in the western and northwestern portions of the island or within large State owned tracts of natural area reserves, forest reserves, and parks. Most of the taxa included in this rule persist on steep slopes, precipitous cliffs, valley headwalls, and other regions where unsuitable topography has prevented agricultural development or where inaccessibility has limited encroachment by alien animal and plant taxa.

The 24 taxa included in this rule are distributed throughout the island of Kauai and grow in a variety of vegetation communities (grassland, shrubland, and forests), elevational zones (coastal to montane), and moisture regimes (dry to wet). Six taxa are found in various lowland dry communities. These once abundant communities are now fragmented due to fire, development, and the ingress of alien plants and animals. *Munroidendron racemosum* extends from coastal mesic vegetation communities to higher elevations in lowland dry (Hawaii Heritage Program (HHP) 1990a) and mesic forests. *Peucedanum sandwicense* is found within a variety of vegetation communities, ranging from coastal to lowland dry to mesic shrublands and forests. Only 1 of the 24 taxa is found in grasslands. *Brighamia insignis* grows within Kauai's lowland dry grassland and shrubland communities in the Na Pali region, where the annual rainfall is usually less than 65 in (170 cm). Three taxa, *Hibiscus clayi*, *Delissea rhytidosperma*, and *Melicope knudsenii*, are located within lowland dry forests, the latter two extending into mesic forests. Lowland dry forests are characterized by an annual rainfall of 20 to 80 in (50 to 200 cm), which falls between November and March, and a

well-drained, highly weathered substrate rich in aluminum (Gagne and Cuddihy 1990).

Nineteen of the 24 taxa have all or a significant number of their populations in lowland mesic or wet forest communities. Lowland mesic forest communities lie between 100 and 3,000 ft (30 and 1,000 m) elevation and are characterized by a 6.5 to 65 ft (2 to 20 m) tall canopy and a diverse understory of shrubs, herbs, and ferns. The annual rainfall of 45 to 150 in (120 to 380 cm) falls predominantly between October and March (Gagne and Cuddihy 1990). This mesic community often grades into lowland wet forests which are typically found on the windward side of the island or in sheltered leeward situations between 330 and 3,940 ft (100 and 1,200 m) elevation. The rainfall in this lowland wet community may exceed 200 in (500 cm) per year. These forests were once the predominant vegetation on Kauai but now exist only on steep rocky terrain or cliff faces. The substrate is generally of well-drained soils that may support tree canopies up to 130 ft (40 m) in height (Cuddihy and Stone 1990, Gagne and Cuddihy 1990).

The habitat of *Solanum sandwicense* extends to the higher elevation and drier portions of montane mesic forests, whereas the habitat of *Exocarpos luteolus* extends into montane wet forests. *Nothocestrum peltatum* and *Phyllostegia waimeae* are the only taxa found strictly within these montane communities, which typically occur above 3,000 ft (1,000 m) elevation (HHP 1991). The annual rainfall in montane communities may exceed 280 in (700 cm) (Gagne and Cuddihy 1990).

The land that supports these 24 plant taxa is owned by various private parties, the City and County of Honolulu, and the State of Hawaii (including State parks, forest reserves, natural area reserves, the Seabird Sanctuary, and land managed under a cooperative agreement with the National Park Service).

Discussion of the 24 Plant Taxa Included in This Final Rule

Asa Gray (in Mann 1868) described *Brighamia insignis* based upon alcohol-preserved flowers and fruits collected by William Tufts Brigham on Molokai and a dried specimen collected on Kauai or Niihau by Ezechiel Jules Remy. The specific epithet means "outstanding," referring to the plant's unique appearance. Brigham's bottled material, since lost, would today be considered to be *Brighamia rockii*. Other published names that Thomas G. Lammers (1989), in the currently accepted treatment of the genus,

considers to be synonymous with *B. insignis* include *B. insignis* f. *citrina* (Forbes 1917a), *B. citrina* (St. John 1958), and *B. citrina* var. *napaliensis* (St. John 1969b).

Brighamia insignis, a member of the bellflower family (Campanulaceae), is an unbranched plant 3 to 16 ft (1 to 5 m) tall with a succulent stem that is bulbous at the bottom and tapers toward the top. The fleshy leaves, which measure 5 to 8 in (12 to 20 cm) long and 2.5 to 4.5 in (6.5 to 11 cm) wide, are arranged in a compact rosette at the apex of the stem. Fragrant yellow flowers are clustered in groups of 3 to 8 in the leaf axils (the point between the leaf and the stem), with each flower on a stalk 0.4 to 1.2 in (1 to 3 cm) long. The hypanthium (basal portion of the flower) has 10 ribs and is topped with 5 oval or loosely triangular calyx lobes (partially fused sepals) 0.02 to 0.04 in (0.5 to 1 millimeter (mm)) long. The yellow petals are fused into a tube 2.8 to 5.5 in (7 to 14 cm) long and 0.1 to 0.2 in (3 to 4 mm) wide, which flares into five elliptic lobes. The fruit is a capsule 0.5 to 0.7 in (13 to 19 mm) long containing numerous seeds. This species is a member of a unique endemic Hawaiian genus with only one other species, presently known only from Molokai, from which it differs by the color of its petals, its shorter calyx lobes, and its longer flower stalks (Hillebrand 1888; Johnson 1986; Lammers 1990; Rock 1919; St. John 1958, 1969b; Takeuchi 1982).

Historically, *Brighamia insignis* was known from the headland between Hoolulu and Waiahuakua Valleys along the Na Pali Coast on the island of Kauai, and from Kaali Spring on the island of Niihau (HHP 1991a1, 1991a2, 1991a4). The Na Pali Coast populations are still extant and additional populations are known from the same general area. The two Na Pali Coast populations within or on the boundary of the Hono O Na Pali Natural Area Reserve (NAR) are within 0.4 mi (0.6 km) of each other (HHP 1991a1, 1991a3). There are also two populations in the Haupu Range within 2.7 mi (4.3 km) of each other (HHP 1991a2, 1991a5). In 1992, Hurricane Iniki destroyed approximately half of the individuals in the Na Pali Coast populations and 7 of the 12 individuals in the Haupu area (Perlman 1992; Steve Perlman, Hawaii Plant Conservation Center (HPCC), pers. comm., 1992). The 5 populations grow on State and private land and total fewer than 40 plants. The status of the small population on privately owned Niihau is not known, although there are reports that it was destroyed when the supporting cliff fell away (HHP 1991a4; Wichman and St.

John 1990; Charles Christensen, Hawaii Department of Agriculture (DOA), and John Fay, U.S. Fish and Wildlife Service (FWS), pers. comms., 1991). This species grows predominantly on the rocky ledges with little soil or steep sea cliffs in lowland dry grassland and shrubland from sea level to 1,300 ft (400 m) elevation (Gagne and Cuddihy 1990, Lammers 1990). Associated plant taxa include *Canthium odoratum* (alaha'e), *Chamaesyce celastroides* ('akoko), *Eragrostis variabilis* (kawelu), and *Heteropogon contortus* (pili grass) (Gagne and Cuddihy 1990; HHP 1991a1 to 1991a3).

Feral goats (*Capra hircus*) pose the major threat to *Brighamia insignis* by causing defoliation and stem damage, restricting populations to inaccessible cliffs, and probably causing rock slides that degrade the plant's habitat. Alien plant taxa are another major threat to the survival of this species, especially introduced grasses such as *Melinis minutiflora* (molasses grass), *Setaria gracilis* (yellow foxtail), and *Sporobolus africanus* (smutgrass), which prevent establishment of seedlings. Other alien plants that potentially pose a threat are *Lantana camara* (lantana), *Psidium cattleianum* (strawberry guava), *Psidium guajava* (common guava), and *Syzygium cumini* (Java plum). Hikers transport weed seeds to areas where *Brighamia insignis* grows and dislodge rocks that can damage plants. Wildfire also poses a serious threat to this species. Some plants flower but fail to set seed, which may be due to a lack of pollinators or a reduction in genetic variability due to the few existing individuals. *Brighamia insignis* is also threatened by stochastic extinction due to low total numbers and the frequency of disturbance events, such as the rock slides in their cliff habitat. Carmine spider mite (*Tetranychus cinnabarinus*), an introduced insect, has been observed to cause leaf loss in both cultivated and wild individuals of *Brighamia insignis* (Christensen 1979; HHP 1991a1 to 1991a4; HPCC 1990a; Perlman 1979; St. John 1969b, 1981b; Takeuchi 1982; Wagner *et al.* 1990; Tim Flynn, National Tropical Botanical Garden (NTBG), pers. comm., 1991; S. Perlman, pers. comm., 1993).

Robert W. Hobdy collected a specimen of *Cyanea asarifolia* on Kauai in 1970. Harold St. John (1975) later described and named the taxon. The specific epithet refers to the leaves, which are similar in shape to those in the genus *Asarum*. Recently, St. John (1987d, St. John and Takeuchi 1987) placed the genus *Cyanea* in synonymy with *Delissea*, resulting in the new combination *Delissea asarifolia*, but

Lammers (1990) retains both genera in the currently accepted treatment of the family.

Cyanea asarifolia, a member of the bellflower family, is a sparingly branched shrub 1 to 3.3 ft (0.3 to 1 m) tall. The heart-shaped leaves are 3.3 to 4.1 in (8.5 to 10.5 cm) long and 2.8 to 3.1 in (7 to 8 cm) wide with leaf stalks 4.7 to 5.9 in (12 to 15 cm) long. Thirty to 40 flowers are clustered on a stalk 1 to 1.2 in (25 to 30 mm) long, each having an individual stalk 0.3 to 0.4 in (7 to 10 mm) in length. The slightly curved flowers are white with purple stripes, 0.8 to 0.9 in (20 to 22 mm) long, and about 0.1 in (3.5 mm) wide with spreading lobes. The five anthers have tufts of white hairs at the tips. The nearly spherical fruit is a dark purple berry about 0.4 in (1 cm) long. This species is distinguished from others of the genus that grow on Kauai by the shape of the leaf base, the leaf width in proportion to the length, and the presence of a leaf stalk (Lammers 1990, St. John 1975).

For over 20 years, *Cyanea asarifolia* was known only from a population of five or six plants above the bed of Anahola Stream on Kauai at its type locality (HHP 1991b1). Because recent attempts to locate this population were unsuccessful, this population is now thought to be extirpated (T. Flynn, pers. comm., 1991). In 1991, Steven Perlman and Ken Marr discovered a population of 14 mature plants and 5 seedlings at the headwaters of the Wailua River in central Kauai on State owned land (HHP 1991b2; S. Perlman, pers. comm., 1991). This species typically grows in pockets of soil on sheer rock cliffs in lowland wet forests (Ken Marr, University of British Columbia, pers. comm., 1991) at an elevation of approximately 1,080 ft (330 m). Associated plant taxa include ferns, *Hedyotis elatior* (manono), *Metrosideros polymorpha* ('ohi'a), *Touchardia latifolia* (olona), and *Urera glabra* (opuhe) (Lammers 1990; St. John 1975; Robert Hobdy, Hawaii Department of Land and Natural Resources (DLNR), and S. Perlman, pers. comms., 1991).

Cyanea asarifolia is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals. Plants in the area in which the only currently known population occurs are vulnerable to occasional hurricanes, natural rock slides, and over-collecting for scientific purposes. In 1992, Hurricane Iniki heavily damaged the *Cyanea asarifolia* population, either directly or indirectly destroying all but four or five juvenile plants. Plants observed after Hurricane Iniki were frequently damaged by introduced slugs or rodents (Loyal

Mehrhoft, FWS, pers. comm., 1993). Habitat degradation by feral pigs (*Sus scrofa*), at least one of which has invaded the plant's habitat, is a potential threat (T. Flynn, David Lorence, NTBG, and S. Perlman, pers. comms., 1991).

Lawrence H. MacDaniels first collected *Cyrtandra limahuliensis* on Kauai in 1926. St. John (1987a) described the species, naming it for Limahuli Valley, where Steven Perlman collected the type specimen in 1978.

Cyrtandra limahuliensis, a member of the African violet family (Gesneriaceae), is an unbranched or few-branched shrub up to 5 ft (1.5 m) tall. The opposite, elliptic leaves are usually 6 to 12 in (15 to 30 cm) long and 2 to 4.7 in (5 to 12 cm) wide. The upper surface of the toothed leaves is moderately hairy and the lower surface, with deep veins, is moderately or densely covered with yellowish brown hairs. Single downy flowers are borne in the leaf axils. The slightly curved corolla tube (fused petals) barely extends beyond the calyx. The calyx encloses the approximately 0.8 in (2 cm) long berries at maturity. The following combination of characteristics distinguish this species from others of the genus: the leaves are usually hairy, especially on lower surfaces; the usually symmetrical calyx is tubular or funnel-shaped and encloses the fruit at maturity; and the flowers are borne singly (St. John 1987a, Wagner et al. 1990).

Historically, *Cyrtandra limahuliensis* was known from three areas on Kauai: Wainiha Valley; Lumahai Valley; and near Kilauea River (HHP 1991c4, 1991c5, 1991c8; C. Christensen, pers. comm., 1992). One population remains in Wainiha Valley and 11 others exist on Kauai in Limahuli Valley, Waipa Valley, on Mount Kahili, along the north fork of Wahiawa Stream, along Anahola Stream, Waioli Valley, and near Powerline Trail on private and State land (HHP 1991c1 to 1991c3, 1991c5 to 1991c7; HPCC 1991a1 to 1991a2; T. Flynn, R. Hobdy, S. Perlman, and Warren L. Wagner, Smithsonian Institution, pers. comms., 1991; D. Lorence et al., in litt., 1991). The 12 known populations, distributed over a 13 by 18 mi (20 by 30 km) area, range in size from solitary shrubs to large populations of over 1,000 plants (HHP 1991c1 to 1991c3, 1991c5 to 1991c7; D. Lorence, in litt., 1993). The largest populations of this species occur in the upper Waioli Valley, where 3 populations total at least 2,100 individuals (D. Lorence, in litt., 1993). Another location with "hundreds or perhaps thousands" of plants (W.L. Wagner, pers. comm., 1991) is limited to

a 0.25 sq mi (0.4 sq km) area along the north fork of the Wailua River. Other botanists familiar with this population believe it to number no more than 500 individuals (T. Flynn and D. Lorence, pers. comms., 1991). A total of 2,800 to 3,000 plants are known from these 12 populations. This species typically grows along streams in lowland wet forests at elevations between 800 and 2,850 ft (240 and 870 m) (Wagner et al. 1990). Associated taxa include *Antidesma platyphyllum* var. *hillebrandii* (hame), *Athyrium sandwichianum* (ho'i'o), *Perrottetia sandwicensis* (olomea), 'ohi'a, *Dicranopteris linearis* (uluhe), *Gunnera kauaiensis* ('ape'ape), *Hedyotis* sp. (manono), and *Psychotria* sp. (kopiko) (HHP 1991c1, 1991c7; T. Flynn, pers. comm., 1991).

The major threat to *Cyrtandra limahuliensis* populations is competition with invasive alien taxa, especially strawberry guava. Each population has additional threats: Competition with the introduced grass *Paspalum conjugatum* (Hilo grass) and *Melastoma candidum* (NCN) at the Mount Kahili population; competition with common guava and habitat degradation by feral pigs at the Anahola Stream population; and competition with *Hedychium flavescens* (yellow ginger) at the Wainiha Valley population. Individuals of the Wailua Stream population are situated at the base of a steep cliff and are vulnerable to natural landslides. The Waioli Valley populations are threatened by several alien weeds: *Rubus rosifolius* (thimbleberry); *Youngia japonica* (Oriental hawksbeard); *Erechtites valerianifolia* (fireweed); and *Blechnum occidentale* (NCN). Hurricanes are also a potential threat, but most of the plants have grown back vigorously since Hurricane Iniki (HHP 1991c1; T. Flynn, R. Hobdy, D. Lorence, and W.L. Wagner, pers. comms., 1991; D. Lorence, in litt., 1993).

Cyrtandra limahuliensis is not immediately in danger of extinction, but if the threats outlined above are not curtailed, the species will become endangered in the future.

Remy first collected a specimen of *Delissea rhytidosperra* on Kauai between 1851 and 1855. Horace Mann, Jr. (1867) chose the specific epithet to describe its wrinkled seeds. Heinrich Wawra (1873) later described another species, *D. kealiae*, which he said was closely related to *D. rhytidosperra*. In the current treatment of the family, Lammers (1990) considers *D. kealiae* to be synonymous with *D. rhytidosperra*. *Delissea rhytidosperra*, a member of the bellflower family, is a branched

shrub 1.6 to 8.2 ft (0.5 to 2.5 m) tall. The lance-shaped or elliptic leaves are 3.1 to 7.5 in (8 to 19 cm) long and 0.8 to 2.2 in (2 to 5.5 cm) wide and have toothed margins. Clusters of 5 to 12 flowers are borne on stalks 0.4 to 0.8 in (1 to 2 cm) long; each flower has a stalk 0.3 to 0.5 in (8 to 13 mm) long. The greenish white (sometimes pale purple) corolla is 0.6 to 0.8 in (14 to 20 mm) long. The stamens are hairless, except for a small patch of hair at the base of the anthers. The nearly spherical dark purple fruits are 0.3 to 0.5 in (7 to 12 mm) long and contain numerous white seeds. This species differs from other taxa of the genus by the shape, length, and margins of the leaves and by having hairs at the base of the anthers (Hillebrand 1888; Lammers 1990; Rock 1913, 1919; Wimmer 1953).

Historically, *Delissea rhytidosperma* was known from scattered locations throughout the island of Kauai. Populations ranged as far north as Wainiha and Limahuli Valleys, as far east as Kapaa and Kealia, and as far south as Haupu Range between the elevations of 1,000 and 3,000 ft (300 and 1,000 m) (HHP 1991d3 to 1991d7). Today, only one population with six individuals, located in State owned Kuia NAR, is known to exist (HHP 1991d1; S. Perlman, pers. comm., 1993). The only other populations seen in recent years were a single plant in Limahuli Valley which is now dead and 20 plants in the Haupu Range (Bruegmann 1990; HHP 1991d2; Perlman 1992; S. Perlman, pers. comm., 1991). The latter population was destroyed by Hurricane Iniki in 1992 (Perlman 1992; S. Perlman, pers. comm., 1993). This species generally grows in diverse lowland mesic forests or *Acacia koa* (koa)-dominated lowland dry forests that have well-drained soils with medium- to fine-textured subsoil (Foote et al. 1972, Gagne and Cuddihy 1990, Lammers 1990). Associated plant taxa include *Dianella sandwicensis* ('uki'uki), *Diospyros sandwicensis* (lama), *Nestegis sandwicensis* (olopua), and *Styphelia tameiameia* (pukiawe) (HHP 1991d1, 1991d2).

Habitat degradation by mule deer or black-tailed deer (*Odocoileus hemionus*), feral goats, and feral pigs is the major threat affecting the survival of *Delissea rhytidosperma*. Other threats are predation by rats (*Rattus* spp.), fire, over-collecting for scientific or horticultural purposes, landslides, and competition with alien plants such as *lantana*, *Passiflora ligularis* (sweet granadilla), and *P. mollissima* (banana poka). This species, with a single extant population of six individuals, is threatened by stochastic extinction and/

or reduced reproductive vigor due to the small number of existing individuals. Hurricanes are an additional, and major, threat (Bruegmann 1990; HHP 1991d1; HPCC 1990b; John Obata, HPCC, and S. Perlman, pers. comms., 1991, 1993).

About 1875, Valdemar Knudsen, a rancher on Kauai, collected a fern at Halemanu, which Wilhelm Hillebrand (1888) named *Lindsaya laciniata*, the specific epithet referring to the divided fronds. Hillebrand also indicated two varieties: var. *subpinnata*, a bipinnate form, which may actually represent another species (Wagner 1952); and an unnamed form. Friedrich Ludwig Emil Diels (1899) transferred the species to *Diellia*, resulting in *Diellia laciniata*, the name in use at the time the species was proposed (Lamoureux 1988). Recent studies have recognized these populations as a new species, *Diellia pallida* (W.H. Wagner 1993).

Diellia pallida, a member of the spleenwort family (Aspleniaceae), is a plant that grows in tufts of three to four light green, lance-shaped fronds along with a few persistent dead ones. The midrib of the frond ranges from dark purple to brownish gray in color and has a dull sheen. Scales on the midrib are brown, gray, or black; 0.1 to 0.2 in (3 to 5 mm) long; and rather inconspicuous. The fronds measure 12 to 22 in (30 to 55 cm) in length and 2 to 5 in (5 to 12 cm) in width and have short black hairs on the underside. Each frond has approximately 20 to 40 pinnae (divisions or leaflets). The largest pinnae are in the middle section of the frond, while the lower section has triangular, somewhat reduced pinnae, with the lowermost pair of pinnae raised above the plane of the others. The sori (groups of spore-producing bodies), which are frequently fused along an extended line, are encircled by a prominent vein. This species differs from others of this endemic Hawaiian genus by the color and sheen of the midrib, the presence and color of scales on the midrib, and the frequent fusion of sori (Hillebrand 1888; Wagner 1952, 1987).

Diellia pallida was known historically from Halemanu on Kauai (Hillebrand 1888). The species had not been seen since 1949, when a collection was made in Kuia NAR (Warren H. Wagner, University of Michigan, pers. comm., 1991). It is currently known from two populations on State land on the island of Kauai within Kuia NAR and Koaie Canyon. The recently discovered population on the west side of Waimea Canyon within Puu Ka Pele Forest Reserve is now apparently extirpated (CPC 1989a, 1990; HHP 1991e1 to 1991e3; Wagner 1952; D. Lorence, pers.

comm., 1991; S. Perlman, pers. comm., 1993; D. Lorence et al., in litt., 1991). The two known populations extend over a 7 by 3 mi (11 by 5 km) area. In 1987, Joel Lau of The Nature Conservancy of Hawaii (TNCH) discovered the Koaie Canyon population of three or four individuals (Bruegmann 1990; HHP 1991e3; Joel Lau, Hawaii Heritage Program, and S. Perlman, pers. comms., 1991). Botanists of NTBG have since discovered two plants in Puu Ka Pele Forest Reserve, but the plants have since disappeared and were likely destroyed by goats (D. Lorence et al., in litt., 1991). Recent visits to the Kuia NAR and Koaie populations have found a total of less than 10 extant individuals for this species (HPCC 1991c; Perlman 1992; J. Lau and D. Lorence, pers. comms., 1991; S. Perlman, pers. comms., 1991, 1993). This species grows on bare soil on steep, rocky, dry slopes of lowland mesic forests, 1,700 to 2,300 ft (530 to 690 m) in elevation. Associated plant taxa include *koa*, *Alectryon macrococcus* (mahoe), *Aleurites moluccana* (kukui), *Antidesma platyphyllum* (hame), 'ohi'a, *Myrsine lanaiensis* (kolea), and *Rauvolfia sandwicensis* (hae) (HHP 1991e1 to 1991e3; S. Perlman, pers. comm., 1991; D. Lorence et al., in litt., 1991).

Competition with alien plants, especially *lantana* and *Melia azedarach* (Chinaberry), constitutes the major threat to *Diellia pallida*. Introduced grasses, such as *Stenotaphrum secundatum* (St. Augustine grass) and *Opismenus hirtellus* (basketgrass), and two naturalized taxa of Polynesian introduction, *kukui* and *Cordyline fruticosa* (ti), degrade this species' habitat. Feral goats cause erosion near the plants and trample and possibly browse these plants. Other threats to this species are habitat degradation by feral pigs and mule deer, fire, over-collecting for scientific purposes, as well as stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (HHP 1991e2, 1991e3; Bruegmann 1990, Wagner 1950; J. Lau, S. Perlman, and D. Lorence, pers. comms., 1991).

Reverend John Mortimer Lydgate first collected *Exocarpos luteolus* in 1908 and Charles N. Forbes (1910) described the species two years later. The specific epithet means "yellow" and refers to the color of the receptacle (base of flower) and fruit.

Exocarpos luteolus, a member of the sandalwood family (Santalaceae), is a moderately to densely branched shrub, 1.6 to 6.6 ft (0.5 to 2 m) tall with knobby branches. The leaves are of two kinds, minute scales and more typical leaves. The latter, which are usually present,

are elliptical, lance-shaped or oval, usually 2 to 3.2 in (5 to 8 cm) long and 1 to 1.4 in (25 to 36 mm) wide, and lack a leaf stalk. The green flowers have five to six petals about 0.04 in (1 mm) long. The pale yellow fruit is a drupe (single-seeded fleshy fruit), usually 0.4 to 0.7 in (11 to 19 mm) long, with four distinct indentations at the apex. About 0.2 to 0.4 in (6 to 9 mm) of the drupe is exposed above the fleshy, golden-yellow receptacle. This species is distinguished from others of the genus by its generally larger fruit with four indentations and by the color of the receptacle and fruit (Degener 1932a, 1932b; Forbes 1910; Wagner *et al.* 1990).

Historically, *Exocarpos luteolus* was known from three locations on Kauai: Wahiawa Swamp; Kaholuamanu; and Kumuwela Ridge (HHP 1991f1, 1991f5, 1991f7). This species is now known to grow on Kumuwela Ridge as well as in Kauaikiinana Valley, near Honopu Trail, Waialai, and on the rim of Kalalau Valley within or on the boundary of Kokee State Park (HHP 1991f3 to 1991f6; HPCC 1991c; D. Lorence *et al.*, *in litt.*, 1991) in a 3 sq mi (5 sq km) area and on Kamalii Ridge in Kealia Forest Reserve (HHP 1991f2), roughly 16 mi (26 km) away. All known populations are on State land and are estimated at 250 individuals (HHP 1991f2, 1991f4, 1991f6; Derral Herbst, FWS, pers. comm., 1991; S. Perlman, pers. comm., 1991, 1993; D. Lorence *et al.*, *in litt.*, 1991). There are reliable, but unconfirmed, reports that this species was collected on the slopes of Anahola Mountain about 1970 (D. Herbst, pers. comm., 1991). *Exocarpos luteolus* is found at elevations between 2,000 and 3,600 ft (600 and 1,100 m) in a variety of habitats: Wet places bordering swamps; on open, dry ridges; and lowland to montane, 'ohi'a-dominated wet forest communities (HHP 1991f1, 1991f3, 1991f4, 1991f6; Wagner *et al.* 1990). Associated taxa include koa, pukiawe, and uluhe (HHP 1991f2 to 1991f5).

Destruction of habitat by feral goats and pigs and competition with *Erigeron karvinskianus* (daisy fleabane) are major threats to *Exocarpos luteolus*. Aggressive alien taxa degrading this plant's habitat include *Acacia mearnsii* (black wattle), *Corynocarpus laevigatus* (karakanut), *Myrica faya* (firetree), and *Rubus argutus* (prickly Florida blackberry), all woody plants that displace native Hawaiian taxa. Other threats to this species include: rats, that eat the fruits; goats, that browse the plants; and fire, erosion, and over-collecting for scientific purposes (HHP 1991f6; T. Flynn and S. Perlman, pers.

comms., 1991; D. Lorence *et al.*, *in litt.*, 1991).

Louis Charles Adelbert von Chamisso collected a plant specimen in 1816 at Kealakekua, island of Hawaii, and named it *Kadua cookiana* (Chamisso and Schlechtendal 1829). The specific epithet commemorates Captain James Cook, the first European to anchor at Kealakekua Bay. Ernest G. Steudel (1840) transferred the species to the genus *Hedyotis*, resulting in the combination *H. cookiana*.

Hedyotis cookiana, a member of the coffee family (Rubiaceae), is a small shrub with many branches 4 to 8 in (10 to 20 cm) long. The papery-textured leaves are long and narrow, 1.5 to 3 in (4 to 8 cm) long and about 0.2 to 0.5 in (0.5 to 1.2 cm) wide, and fused at the base to form a sheath around the stem. The bisexual or female flowers are arranged in clusters of threes on flower stalks about 0.3 to 0.6 in (8 to 15 mm) long, with the central flower on the longest stalk. Beneath the flower clusters are sharp-pointed bracts (modified leaves). The fleshy white corolla is trumpet-shaped and about 0.3 to 0.4 in (8 to 9 mm) long, with lobes about 0.08 in (2 mm) long. Fruits are top-shaped or spherical capsules about 0.1 in (3.0 to 3.5 mm) long and 0.1 to 0.2 in (3.5 to 4 mm) wide that open at maturity to release wedge-shaped reddish brown seeds. This plant is distinguished from other species in the genus that grow on Kauai by being entirely hairless (Fosberg 1943, Hillebrand 1888, Chamisso and Schlechtendal 1829, Wagner *et al.* 1990).

Historically, *Hedyotis cookiana* was known from only three collections: Kealakekua on the island of Hawaii; Halawa and Kalawao on Molokai; and at the foot of the Koolau Mountains on Oahu (Fosberg 1943, HHP 1991g2, Hillebrand 1888). There is no evidence that it still exists on any of those islands. This species was discovered in 1976 by Charles Christensen on the island of Kauai in Waiahuakua Valley on State land (HHP 1991g1). Between 50 and 100 plants are scattered along a 0.25 mi (0.4 km) distance in the streambed and lower part of the waterfall. Although this population has not been observed since its discovery, it is still believed to be extant (C. Christensen, pers. comm., 1991). *Hedyotis cookiana* generally grows in streambeds or on steep cliffs close to water sources in lowland wet forest communities (C. Christensen, pers. comm., 1991) and is believed to have formerly been much more widespread on several of the main Hawaiian Islands at elevations between

560 and 1,200 ft (170 and 370 m) (Wagner *et al.* 1990).

The major threat to *Hedyotis cookiana*, with only one known population, is stochastic extinction and/or reduced reproductive vigor. Potential threats include competition with alien plants, which are invading the area, and habitat modification by feral pigs and goats, which have been observed in the area. Individuals of *Hedyotis cookiana* grow in a stream bed and on the side of a waterfall. These areas are vulnerable to flooding and other natural disturbances (HHP 1991u6; C. Christensen, pers. comm., 1991).

In 1928, Albert W. Duvel discovered several trees of *Hibiscus clayi* that had been damaged by cattle (*Bos taurus*) and brought the species into cultivation. Isa and Otto Degener named the species after the late Horace F. Clay, a horticulturist and college instructor who brought the species to their attention (Degener and Degener 1959a). Sister Margaret James Roe, in her study of the genus in Hawaii, named *H. newhousei* as another species from Kauai (Roe 1959, 1961). In the currently accepted treatment of the Hawaiian members of the family, David M. Bates (1990) considers *H. newhousei* to be a synonym of *H. clayi*.

Hibiscus clayi, a member of the mallow family (Malvaceae), is a shrub or tree 13 to 26 ft (4 to 8 m) tall with stems bearing sparse hairs at the branch tips. The oval or elliptical leaves are usually 1 to 3 in (3 to 7 cm) long and 0.6 to 1.4 in (15 to 35 mm) wide and have a hairless upper surface and slightly hairy lower surface. The leaf margins are entire or toothed toward the apex. The flowers are borne singly near the ends of the branches. The flaring petals are dark red, 1.8 to 2.4 in (45 to 60 mm) long, and 0.4 to 0.7 in (10 to 18 mm) wide. The green tubular or urn-shaped calyx is usually 0.6 to 1 in (15 to 25 mm) long with five or six shorter bracts beneath. The fruits are pale brown capsules, 0.5 to 0.6 in (12 to 14 mm) long, containing about 10 oval, brownish-black seeds about 0.16 in (4 mm) long. This species is distinguished from other native Hawaiian members of the genus by the lengths of the calyx, calyx lobes, and capsule, and by the margins of the leaves (Bates 1990, Degener and Degener 1959a).

Hibiscus clayi is known from scattered locations on private and State land on the island of Kauai: The Kokee region on the western side of the island; Moloaa Valley to the north; Nounou Mountain in Wailua to the east; and as far south as Haiku near Haliu Stream (HHP 1991h1 to 1991h5). At this time, only the Nounou Mountains population

with four trees, is known to still exist (HHP 1991h2, 1991h3; David Bates, Cornell University, T. Flynn, and S. Perlman, pers. comms., 1991; D. Lorence *et al.*, in litt., 1991). It is unclear whether the one individual from the Kokee region was a cultivated plant. This lowland dry forest species generally grows on slopes at an elevation of 750 to 1,150 ft (230 to 350 m). Associated taxa include Java plum, koa, kukui, and ti (Bates 1990; HHP 1991h1, 1991h2).

Before cattle were removed from the area, they greatly damaged the habitat of *Hibiscus clayi*. Competition with alien plant taxa currently threatens this species. Strawberry guava is the greatest threat, but common guava, Hilo grass, Java plum, kukui, lantana, ti, and *Schinus terebinthifolius* (Christmas berry) are also present. The area of the Nounou Mountain population has been planted with *Araucaria columnaris* (columnar araucaria), which is reseeding itself there and may prevent regeneration of native plants. The close proximity of most of the plants to a hiking trail makes them prone to disturbance. Pigs pose a potential threat to the species. The small total number of existing individuals poses a threat of stochastic extinction and/or reduced reproductive vigor (Degener and Degener 1959a; HHP 1991h1 to 1991h3; HPCC 1990c; T. Flynn, pers. comm., 1990; D. Bates, T. Flynn, D. Herbst, and R. Hobdy, pers. comms., 1991).

Abbe Urbain Jean Faurie first collected *Lipochaeta fauriei* on Kauai in 1910. During the following year, H. Leveille (1911) named the plant in honor of him. St. John (1972) described another species from Kauai, *L. deltoidea*, but the authors of the current treatment place this name in synonymy with *L. fauriei* (Wagner *et al.* 1990).

Lipochaeta fauriei, a member of the aster family (Asteraceae), is a perennial herb with somewhat woody, erect or climbing stems up to 16 ft (5 m) long. The toothed leaves are narrowly triangular, slightly hairy, 3 to 5 in (7 to 13 cm) long, and about 1.2 in (3 cm) wide. Flower heads occur in clusters of 2 to 3, each comprising 6 to 8 ray florets, 0.2 to 0.5 in (6 to 13 mm) long and about 0.1 in (2.3 mm) wide, and 30 to 35 disk florets 0.1 to 0.2 in (3.3 to 3.9 mm) long. The bracts beneath the flower heads are purple near the base. Fruits are knobby-textured achenes (dry, one-seeded fruits) about 0.1 in (2.5 to 3 mm) long and 0.07 in (1.5 to 2 mm) wide. The achenes of the disk florets are sometimes thinner and shorter than those of the ray florets. This species belongs to a genus endemic to the Hawaiian Islands and is one of three

species found only on the island of Kauai. This species differs from the others on Kauai by having a greater number of disk and ray flowers per flower head, typically longer leaves and leaf stalks, and longer ray flowers (Gardner 1976, 1979; St. John 1972; Sherff 1935b; Wagner *et al.* 1985, 1990).

Historically, *Lipochaeta fauriei* was known from Olokele Canyon on the island of Kauai (Gardner 1979, HHP 1991i5). This species is now also known from four other areas on Kauai: Koaie Canyon; Poopooiki; Haelele; and lower Hikimoe Valleys (HHP 1991i1 to 1991i4; HPCC 1990d2, 1990d3; St. John 1972). All 5 populations, totalling fewer than 70 individuals, are found on State land (HHP 1991i1 to 1991i3; HPCC 1990d2, 1990d3; R. Hobdy and J. Lau, pers. comms., 1991), encompassing a 6 by 7 mi (10 by 11 km) area. This species most often grows in moderate shade to full sun and is usually found on the sides of steep gulches in diverse lowland mesic forests at an elevation of about 1,570 to 2,950 ft (480 to 900 m) (Wagner *et al.* 1990). Associated plant taxa include basketgrass, kukui, lama, and *Hibiscus waimeae* (koki'o ke'oke'o); the major alien associate is lantana (HHP 1991i1 to 1991i3; HPCC 1990d2, 1990d3).

The major threats to *Lipochaeta fauriei* are degradation of its habitat by feral goats and competition with invasive alien plant taxa, especially lantana. Feral pigs pose a potential threat to the species and fire is a significant threat. The small total number of individuals comprises a threat of stochastic extinction and/or reduced reproductive vigor to this species (HHP 1991i1 to 1991i3; HPCC 1990d1 to 1990d3; R. Hobdy, J. Lau, and S. Perlman, pers. comms., 1991).

Thomas Nuttall (1841) described *Schizophyllum micranthum* based on a specimen collected on Kauai in 1840 during the United States Exploring Expedition. The specific epithet refers to the small size of the flowers. In 1843, Guilielmo Gerardo Walpers published the superfluous name *Aphanopappus nuttallii* based on the same specimen described by Nuttall (Gardner 1979). Gray (1861) transferred the species to the genus *Lipochaeta*, resulting in *L. micrantha*. Amos Arthur Heller (1897) transferred the species into the genus *Aphanopappus*, resulting in *A. micranthus*. Otto Degener and Earl Edward Sherff (Sherff 1941) described *L. exigua* as another Kauai taxon based on a specimen collected by Otto Degener and Emilio Ordonez. In his monograph of the genus, Robert C. Gardner (1979) recognized *L. micrantha* var. *exigua* along with the typical variety, and this

is accepted in the current treatment (Wagner *et al.* 1990).

Lipochaeta micrantha, a member of the aster family, is a somewhat woody perennial herb. The 1.6 to 6.6 ft (0.5 to 2 m) long stems grow along the ground and root at the nodes, with the tip of the stem growing upward. The roughly triangular leaves measure 0.8 to 3.8 in (2.1 to 9.7 cm) long and 0.5 to 3.1 in (1.2 to 7.8 cm) wide. They are sparsely hairy, with margins smooth or variously lobed. Flower heads are in clusters of two or three. Each head contains four to five ray florets, 0.1 to 0.2 in (2.3 to 5.8 mm) long and 0.06 to 0.14 in (1.4 to 3.5 mm) wide, and five to nine disk florets, about 0.1 in (2.7 to 3.1 mm) long. The two recognized varieties of this species, *exigua* and *micrantha*, are distinguished by differences in leaf length and width, degree of leaf dissection, and the length of the ray florets. The smaller number of disk florets separates this species from the other members of the genus on the island of Kauai (Gardner 1976, 1979; Degener and Degener 1959b, 1962; Sherff 1935b; Wagner *et al.* 1990).

Only two populations of *Lipochaeta micrantha* var. *exigua* are known from the vicinity of Haupu Range on the island of Kauai (HHP 1991j3). The populations of this variety are distributed over a 1.5 mi (2.4 km) distance on privately owned portions of Haupu Range and total between 100 and 500 individuals (HHP 1991j1, 1991j2; HPCC 1991d; T. Flynn, pers. comm., 1991). Historically, *Lipochaeta micrantha* var. *micrantha* appears to have been more widely distributed on Kauai in Olokele Canyon, Hanapepe Valley, and in the Koloa District (HHP 1991k1, 1991k5; HPCC 1991d; T. Flynn and S. Perlman, pers. comms., 1991). This variety is now known only from two to four populations located on State land in Koaie Canyon on Kauai, totalling 150 to 570 individuals (CPC 1992; HHP 1991k1, 1991k5; S. Perlman, pers. comms., 1991, 1993). The populations encompass an area of 1.4 square miles (2.3 sq km) approximately 1.4 mi (2.3 km) apart. Both varieties generally grow on exposed rocky slopes in diverse lowland mesic forests and sometimes on grassy ridges at an elevation of 1,000 to 1,300 ft (300 to 400 m) (HHP 1991j1 to 1991j3, 1991k1 to 1991k5; Wagner *et al.* 1990). Associated plant taxa include alahe'e, lama, 'ohi'a, *Chamaesyce celastroides* var. *hanapepensis* ('akoko), and *Neraudia kauaiensis* (Gardner 1979; HHP 1991j1, 1991k1, 1991k2).

The major threats to *Lipochaeta micrantha* are habitat degradation by feral ungulates and competition with alien plant taxa. Feral pigs threaten the

habitat of both varieties of *Lipochaeta micrantha* and signs of damage by feral goats have been seen near individuals of var. *micrantha*. Alien plant taxa, such as lantana, affect the habitats of both varieties. *Pluchea carolinensis* (sourbush) is found near var. *exigua*. Daisy fleabane and *Stachytarpheta* spp. are components of the habitat of var. *micrantha*. Both varieties are threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing populations (HHP 1991j1, 1991j2, 1991k1, 1991k5; HPCC 1990e, 1990f; T. Flynn, pers. comm., 1991; D. Lorence *et al.*, in litt., 1991).

Hobby collected the first specimen of *Lipochaeta waimeensis* in 1967. Five years later, St. John (1972) described it as a new species, naming it for the Waimea Canyon where it grows.

Lipochaeta waimeensis, a member of the aster family, is a low growing, somewhat woody perennial herb with stems 3 to 6.5 ft (1 to 2 m) long that root at the nodes. The linear or narrowly elliptical leaves are 1.9 to 2 in (4.7 to 5 cm) long, 0.2 to 0.3 in (5 to 8 mm) wide, hairy along major veins on the upper surface, and evenly hairy on the lower surface. Flower heads are borne singly or in clusters of two or three. The outer head bracts are lance-shaped and measure 0.1 to 0.2 in (3 to 4 mm) long and 0.06 to 0.08 in (1.5 to 2 mm) wide. The oval ray florets number four or five per head and are about 0.13 in (3.2 to 3.5 mm) long and about 0.1 in (3 mm) wide. The disk florets number 20 to 25 per head. The fruits are knobby, winged achenes 0.1 in (2.2 to 2.5 mm) long and about 0.08 in (1.7 to 2.3 mm) wide. The ray achenes are slightly wider and have longer wings than those of the disk. This species differs from the two other taxa of the genus included in this rule (*L. fauriei* and *L. micrantha*) in having a different leaf shape and shorter leaf stalks and ray florets (Gardner 1976, 1979; St. John 1972; Wagner *et al.* 1990).

Lipochaeta waimeensis is known only from the type locality, along the rim of Kauai's Waimea Canyon on State land (HHP 1991m1, HPCC 1991e). Fewer than 10 plants are scattered over a 2.5 acre (ac) (1-hectare (ha)) area (Gerald Carr, University of Hawaii at Manoa, and S. Perlman, pers. comms., 1991). This population grows on eroded soil on a precipitous, shrub-covered gulch in a diverse lowland mesic forest at an elevation between 1,150 and 1,300 ft (350 and 400 m) (HHP 1991m1, Wagner *et al.* 1990). The vegetation at the site is predominantly alien consisting of *Grevillea robusta* (silk oak), *Leucaena leucocephala* (koa haole), and *Rhynchelytrum repens* (Natal redtop); however, native taxa

include *Dodonaea viscosa* ('a'ali'i) and *Lipochaeta connata* (nehe) (CPC 1989b, 1990; S. Perlman, pers. comm., 1991) also occur here.

Alien plant taxa competing with and threatening *Lipochaeta waimeensis* include koa haole, Natal redtop, silk oak, and *Opuntia ficus-indica* (prickly pear, panini). The existing soil erosion problem is exacerbated by the presence of feral goats. The single population, and thus the entire species, is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals. Over-collecting for scientific purposes also poses a threat (G. Carr and S. Perlman, pers. comms., 1991).

In 1912, Lydgate collected a plant specimen on Kauai that he and Forbes named *Lysimachia filifolia* (Forbes 1916). They chose the specific epithet, which means "thread-leaved," in reference to the plant's very narrow leaves. Heller (1897) created a new genus, *Lysimachiopsis*, in which he placed all endemic Hawaiian taxa of *Lysimachia*, and Otto and Isa Degener (1983) later published *Lysimachiopsis filifolia*. The current treatment (Wagner *et al.* 1990) recognizes *Lysimachiopsis* as a section of *Lysimachia*. Most recently, St. John (1987b) published many species, varieties, and combinations of *Lysimachia*, one or more of which may fit into this species (Wagner *et al.* 1990).

Lysimachia filifolia, a member of the primrose family (Primulaceae), is a small shrub 0.5 to 1.6 ft (15 to 50 cm) tall. The linear leaves measure 0.6 to 2.1 in (15 to 54 mm) long and 0.01 to 0.07 in (0.3 to 1.8 mm) wide and are usually alternately arranged. They are single-veined and sparsely hairy or hairless. The bell-shaped flowers are reddish purple, 0.2 to 0.4 in (6 to 10 mm) long, and borne singly on flower stalks about 0.7 to 1.2 in (18 to 30 mm) long that elongate upon fruiting. Fruits are thick, hard capsules about 0.2 in (5 to 6 mm) long that contain numerous minute, nearly black, irregularly shaped seeds. This species is distinguished from other taxa of the genus by its leaf shape and width, calyx lobe shape, and corolla length (Forbes 1916, Wagner *et al.* 1990).

Historically, *Lysimachia filifolia* was known only from the upper portion of Olokele Valley on Kauai (HHP 1991n1). This species is now known from two other areas: The headwaters of the Wailua River on Kauai; and the slopes of Waiahole Valley in the Koolau Mountains of Oahu (HHP 1991n2, 1991n3; HPCC 1990g1, 1990g3). Three closely situated colonies on Kauai are located within a 0.5 sq mi (1.3 sq km)

area and total 76 individuals (K. Marr, pers. comm., 1991). The Oahu population contains about 150 to 200 individuals (CPC 1989a; HHP 1991n3; HPCC 1990g1, 1990g3). Both populations of this species are located on State land, totalling approximately 225 to 275 individuals. This species typically grows on mossy banks at the base of cliff faces within the spray zone of waterfalls or along streams in lowland wet forests at an elevation of 800 to 2,200 ft (240 to 680 m) (HHP 1991n1 to 1991n3; HPCC 1990g1, 1990g3; Wagner *et al.* 1990; K. Marr, pers. comm., 1991). Associated plant taxa include mosses, ferns, liverworts, pili grass, *Cuphea carthagenensis* (tarweed), and *Pilea peploides* (HHP 1991n3; J. Lau, pers. comm., 1991).

The major threat to *Lysimachia filifolia* is competition with alien plant taxa. Individuals of this species on Kauai are damaged and destroyed by natural rock slides in their habitat, which is near the bottom of steep cliffs. *Hydrocotyle sibthorpioides* (marsh pennywort), tarweed, and thimbleberry, although not invasive weeds, are present in this near-pristine area of Wailua Stream and may degrade the native ecosystem. At least one feral pig has made its way into this area, indicating that this disruptive animal is a potential threat. Individuals of *Lysimachia filifolia* on Oahu are vulnerable to rock slides and compete for space with alien plants such as marsh pennywort, tarweed, *Ageratina riparia* (Hamakua pamakani), and *Schefflera actinophylla* (octopus tree). Because only one population of *Lysimachia filifolia* occurs on each of only two islands, the species is threatened by stochastic extinction. Hurricane Iniki caused at least some damage to the Wailua River population (HHP 1991n3; HPCC 1990g2; D. Lorence and S. Perlman, pers. comms., 1991; L. Mehrhoff, pers. comm., 1993).

In 1927, MacDaniels collected a plant specimen on Kauai that St. John (1944) later named *Pelea haupuensis*. The specific epithet refers to the type locality, Haupu, the only known site for this plant until it was discovered in Waimea Canyon in 1989. Thomas G. Hartley and Benjamin C. Stone (1989, Stone *et al.* 1990, Wagner *et al.* 1990) synonymized the genus *Pelea* with *Melicope*, resulting in the current name for this taxon, *Melicope haupuensis*.

Melicope haupuensis, a member of the citrus family (Rutaceae), is a tree about 26 ft (8 m) tall. The oval leaves, 2 to 5.1 in (5 to 13 cm) long and 1.1 to 2.2 in (28 to 56 mm) wide, are oppositely arranged. Flowers grow in clusters of five to seven on stalks

usually 0.1 to 2.8 in (2 to 7 mm) long, each flower on a stalk 0.04 to 0.12 in (1 to 3 mm) long. Only female flowers are known. The flowers are about 0.14 in (3.5 mm) long, dotted with oil glands, and covered with a dense mat of hairs. Fruits are distinct follicles (a dry fruit that splits open lengthwise), 0.35 to 0.43 in (9 to 11 mm) long, with a hairless exocarp and endocarp (outermost and innermost layers of the fruit wall, respectively). Unlike other taxa of this genus on Kauai, the exocarp and endocarp are hairless and the sepals are covered with dense hairs (St. John 1944, Stone 1969, Stone *et al.* 1990).

For 62 years, *Melicope haupuensis* was known only from the type locality on the north side of Haupu Ridge on Kauai (HHP 1991o3). In 1989, two plants were discovered within 1 mi (1.6 km) of each other along the banks of Koaie Stream on State owned land in Waimea Canyon (HHP 1991o1, 1991o2; HPC 1991f). These plants grow on moist talus slopes in 'ohi'a-dominated lowland mesic forests (Stone *et al.* 1990) with such associated taxa as 'a'ali'i and hame, at elevations between 1,230 and 2,690 ft (375 and 820 m) (HHP 1991o1 to 1991o3).

Habitat degradation by feral goats and competition with invasive alien plant taxa such as lantana and yellow foxtail threaten *Melicope haupuensis*. A potential threat to members of this genus is their known susceptibility to black twig borer (*Xylosandrus compactus*), a burrowing beetle ubiquitous in Hawaii at elevations below 2,500 ft (670 m). The existence of only two known trees of this species constitutes a threat of stochastic extinction, over-collecting, and/or reduced reproductive vigor (Hara and Beardsley 1979; HHP 1991o1, 1991o2; Medeiros *et al.* 1986).

Knudsen sent a plant specimen he found at Waimea to Hillebrand, who named it *Pelea knudsenii* in honor of its collector (Hillebrand 1888). In an action that was not supported by other taxonomists, Emmanuel Drake del Castillo (1890) transferred several species from the genus *Pelea* to the genus *Evodia*. Hartley and Stone (1989) synonymized the genus *Pelea* with *Melicope*, resulting in the combination *M. knudsenii*. Other names now included in *M. knudsenii* are *Pelea multiflora* (Rock 1911), *P. knudsenii* var. *multiflora* (Rock 1918), and *P. tomentosa* (St. John 1944).

Melicope knudsenii, a member of the citrus family, is a tree usually 10 to 33 ft (3 to 10 m) tall with smooth gray bark and yellowish brown to olive-brown hairs on the tips of the branches. Leaves are variable, ranging from oblong to

elliptic, 3.5 to 9.8 in (9 to 25 cm) long and 1.8 to 3.9 in (4.5 to 10 cm) wide. The lower surface of the leaves is uniformly covered with olive-brown hairs, but the upper surface is only sparsely hairy along the midrib. The densely hairy flowers are bisexual or may be unisexual. There are usually 20 to 200 flowers per cluster in the leaf axils. The sepals and petals are covered with silky gray hairs and the sepals persist in fruit. The fruits are 0.7 to 1.2 in (18 to 30 mm) wide and are comprised of distinct follicles, 0.3 to 0.6 in (8 to 14 mm) long. The hairless exocarp is dotted with minute glands. The endocarp also lacks hairs. Seeds number one or two per carpel (ovule-bearing structure) and are about 0.2 in (5 to 6 mm) long. The distinct carpels of the fruit, the hairless endocarp, the larger number of flowers per cluster, and the distribution of hairs on the underside of the leaves distinguish this species from *M. haupuensis* and other species of the genus (Degener *et al.* 1962a, 1962b; Hillebrand 1888; Rock 1913; Stone 1969; Stone *et al.* 1990).

Historically, *Melicope knudsenii* was known only from the southeast slope of Haleakala on Maui and from Olokele Canyon on Kauai (HHP 1991p1, 1991p5). This species remains in the Auwahi and Kanaio areas of Maui (R. Hobdy and Arthur Medeiros, Haleakala National Park, pers. comms., 1991) on privately owned land, but its numbers have decreased considerably from being "very common" in 1920 to between 20 and 30 plants when it was last observed in 1983 (CPC 1990; HHP 1991p1). On Kauai, three populations, each consisting of one individual, remain on State land in the Koaie drainage area of Waimea Canyon (HHP 1991p2 to 1991p4; S. Perlman, pers. com., 1991) and are distributed across a distance of 1.6 mi (2.6 km). This species, therefore, totals between 23 and 33 individuals at present. *Melicope knudsenii* grows on forested flats or talus slopes in lowland dry to mesic forests at an elevation of about 1,500 to 3,300 ft (450 to 1,000 m) (Stone *et al.* 1990). The Auwahi population on Maui, however, grows on a substrate of 'a'a lava in a remnant native forest, dominated by a continuous mat of *Pennisetum clandestinum* (Kikuyu grass) (HHP 1991p1; Medeiros *et al.* 1986). Plants associated with the Kauai populations include 'a'ali'i, hame, 'ohi'a, and *Xylosma* (HHP 1991p3, 1991p4).

Competition with alien plant taxa and habitat degradation by feral and domestic animals are the major threats affecting *Melicope knudsenii*. On Kauai, this species competes with lantana and is affected by feral goats and pigs. On

Maui, *Melicope knudsenii* grows in an area currently grazed by domestic cattle, where a continuous mat of Kikuyu grass prevents seedlings from establishing. Feral goats and feral pigs are also present in the area of the Maui population. Axis deer (*Axis*), found on the south slope of Haleakala Mountain and increasing in numbers, are a potential threat. This species is potentially threatened by black twig borer, a ubiquitous insect that lives at elevations up to 2,500 ft (670 m) in Hawaii and is known to infest members of *Melicope*. This species is also threatened by fire, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals (HHP 1991p2 to 1991p4; Hara and Beardsley 1979; Medeiros *et al.* 1986; van Riper and van Riper 1982; Patrick Beil, Puu Mahoe Arboretum. R. Hobdy, A. Medeiros, and Steve Montgomery, Bishop Museum, pers. comms., 1991).

Hillebrand (1888) described *Pelea pallida* based on a specimen he collected on Oahu. The specific epithet refers to the plant's pale leaf veins and lower leaf surfaces. Drake del Castillo (1890) transferred the species to the genus *Evodia*, a combination not accepted by other taxonomists. Faurie described *P. leveillei* in 1912 based on a specimen collected on Kauai (Stone 1969). Following the transfer of the genus *Pelea* to *Melicope* (Hartley and Stone 1989, Wagner *et al.* 1990), authors of the current treatment of the Hawaiian members of the genus (Stone *et al.* 1990) now consider *Evodia pallida*, *P. pallida*, and *P. leveillei* to be synonyms of *Melicope pallida*.

Melicope pallida, a member of the citrus family, is a 20 to 33 ft (6 to 10 m) tree with grayish white hairs and black, resinous new growth. The leaves, 2.4 to 8.3 in (6 to 21 cm) long and 1 to 3.1 in (2.5 to 8 cm) wide, are grouped in threes, with each leaf loosely folded. Fifteen to 35 pale yellowish-green flowers are also clustered in groups of 3 along a fuzzy white stalk up to 2.4 in (6 cm) long. The petals are usually lance-shaped and measure 0.1 to 0.2 in (3.5 to 5 mm) long. Fruits contain two shiny black seeds about 0.1 in (3.5 mm) long in each of the usually four distinct carpels. This species differs from *M. haupuensis*, *M. knudsenii*, and other members of the genus by the following combination of characteristics: Resinous new growth; leaves folded and in clusters of three; and fruits with separate carpels (Degener *et al.* 1960, Hillebrand 1888, St. John 1944, Stone *et al.* 1990, Wagner *et al.* 1990).

Historically, *Melicope pallida* was known from various locations in the

Waianae Mountains on Oahu and from Hanapepe on Kauai (HHP 1991q2 to 1991q4, 1991q7). This species is now known from two locations at the base of Mount Kaala and near Palikea, within TNCH's privately owned Honouliuli Preserve in the Waianae Mountains on Oahu, and from four State owned locations on Kauai in Kalalau Valley, Koaie Stream in Waimea Canyon, and Hanakapiai Valley (HHP 1991q1, 1991q6, 1991q8; HPCC 1991g1, 1991g2; T. Flynn, J. Lau, and S. Montgomery, pers. comms., 1991). The population near Palikea was last visited in 1960 (HHP 1991q1); it is thought to contain only a few plants. Fewer than five plants are known from the island of Oahu (S. Montgomery, pers. comm., 1991). Populations were discovered in 1991 near the rim of Kalalau Valley (about 65 plants) and Honopu Rim (12 plants) (Kenneth Wood, HPCC, pers. comm., 1991), giving a total of less than 100 known plants for this species. *Melicope pallida* usually grows on steep rock faces in drier regions of lowland mesic forests at an elevation of 1,600 to over 3,000 ft (490 to 910 m) (Stone et al. 1990; J. Lau, pers. comm., 1991; D. Lorence et al., in litt., 1991). Associated plant taxa include *Abutilon sandwicense*, *Alyxia oliviformis* (maile), *Dryopteris* sp., 'ohi'a, *Pipturus albidus* (mamaki), *Sapindus oahuensis* (lonomea), *Tetraplasandra* sp. ('ohe), and *Xylosma hawaiiense* (mana) (HHP 1991q1, 1991q5, 1991q8; J. Lau, pers. comm., 1991).

The major threats to *Melicope pallida* are habitat destruction by feral animals and competition with alien plant taxa. On Kauai, feral goats and feral pigs destroy habitat of *Melicope pallida* and weeds, such as daisy fleabane and prickly Florida blackberry, compete with the species. The Oahu populations of *Melicope pallida* face strong competition from introduced plants, especially *Clidemia hirta* (Koster's curse) and *Toona ciliata* (Australian red cedar). A potential threat to *Melicope pallida* is the black twig borer, which is known to occur in areas where this species grows and to feed on members of the genus *Melicope*. Additional threats to *Melicope pallida* are fire and stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (Hara and Beardsley 1979; HHP 1991q6, 1991q8; Medeiros et al. 1986; T. Flynn, J. Lau, S. Montgomery, and K. Wood, pers. comms., 1991; D. Lorence et al., in litt., 1991).

St. John and Edward P. Hume described *Melicope quadrangularis*, based on a specimen collected by Forbes on Kauai in 1909 (St. John 1944). The

specific epithet, meaning "four-angled," describes the cube-shaped capsule. Hartley and Stone (1989) synonymized the genus *Pelea* with *Melicope*, resulting in the combination *M. quadrangularis*.

Melicope quadrangularis, a member of the citrus family, is a shrub or small tree. Young branches are generally covered with fine yellow fuzz but become hairless with age. The thin, leathery, elliptical leaves, 3.5 to 6 in (9.5 to 16 cm) long and 2 to 3 in (4.5 to 7.5 cm) wide, are oppositely arranged. The upper leaf surface is hairless and the lower surface is sparsely hairy, especially along the veins. Flowers are solitary or in clusters of two. The specific floral details are not known. The fruits are somewhat cube-shaped, flattened capsules, about 0.5 in (13 mm) long and about 0.8 in (19 to 22 mm) wide with a conspicuous central depression at the top of the fruit. The capsules are four-lobed and completely fused. The exocarp is sparsely hairy and the endocarp is hairless. This species differs from others in the genus in having the following combination of characters: Oppositely arranged leaves; only one or two flowers per cluster; cube-shaped capsules with fused lobes; and a deep central depression at the top of the fruit (St. John 1944, Stone 1969, Stone et al. 1990).

Melicope quadrangularis is known from the type locality in the Wahiawa Bog region of Kauai (HHP 1991r1; Stone et al. 1990). One adult plant and two seedlings were discovered in 1991 in that area by Ken Wood of HPCC on an east-facing slope of Wahiawa Ridge at 2,800 ft (850 m) elevation on privately owned land. Subsequent exploration has resulted in the location of 13 individuals of this species. The plants are growing in a diverse lowland forest that ranges from mesic to wet conditions with other plants, such as 'ohi'a, opuhe, uluhe, *Broussaisia arguta* (kanawao), *Cyrtandra pickeringii* (ha'iwale), other *Melicope* species (alani), *Metrosideros waialealae*, and abundant ferns and mosses (K. Wood, pers. comm., 1991; D. Lorence et al., in litt., 1991).

The existence of only 13 known plants of this species causes the species to be threatened by over-collecting for scientific purposes, stochastic extinction, and/or reduced reproductive vigor. The alien strawberry guava grows in the area and is a potential threat (Hara and Beardsley 1979; K. Wood, pers. comm., 1991; D. Lorence et al., in litt., 1991).

Forbes collected specimens of a tree on Kauai in 1916 that he described the following year (1917b) as *Tetraplasandra racemosa*. The specific epithet describes the inflorescence that

Forbes considered a raceme. Sherff (1952) transferred the species to the new endemic, monotypic genus *Munroidendron*, named in honor of George C. Munro, who was apparently the first to recognize the plant as a new taxon. Sherff (1952) also published two varieties, *Munroidendron racemosum* var. *forbesii* and *M. racemosum* var. *macdanielsii*. In the current treatment of the species, Porter P. Lowrey II (1990) recognizes no subspecific taxa.

Munroidendron racemosum, a member of the ginseng family (Araliaceae), is a tree up to about 23 ft (7 m) in height with a straight gray trunk crowned with spreading branches. The leaves are 6 to 12 in (15 to 30 cm) long and comprise five to nine oval or elliptical leaflets with clasping leaf stalks. Each leaflet is 3.1 to 6.7 in (8 to 17 cm) long and usually 1.6 to 3.9 in (4 to 10 cm) wide. About 250 pale yellow flowers are borne about a stout hanging stalk 10 to 24 in (25 to 60 cm) long. Each flower has five or six lance-shaped petals 0.3 to 0.4 in (8 to 10 mm) long emerging from a cup-shaped or ellipsoid calyx tube. Both the lower surface of the petals and the calyx tube are covered with whitish scaly hairs. The fruit is an egg-shaped drupe 0.3 to 0.5 in (8 to 12 mm) long and nearly as wide, situated atop a flat, dark red disk (stylopodium). This species is the only member of a genus endemic to Hawaii, differing from other closely related Hawaiian genera of the family primarily in its distinct flower clusters and corolla (Forbes 1917b, Lamoureux 1982, Lowrey 1990, St. John 1981b, Sherff 1952).

Historically, *Munroidendron racemosum* was known from scattered locations throughout the island of Kauai (HHP 1991s1, 1991s3, 1991s6, 1991s13). Fifteen populations are now found at elevations of 390 to 1,310 ft (120 to 400 m) on private and State land in the following areas: Along the Na Pali Coast within Na Pali Coast State Park and Hono O Na Pali NAR; in the Poomau and Koaie branches of Waimea Canyon; in the Haupu Range area; and on Nounou Mountain (HHP 1991s1 to 1991s12, 1991s14, 1991s15; Lamoureux 1982). Although widely distributed, the largest population contains fewer than 50 individuals, with most populations numbering only 1 or 2 individuals. Estimates of the total number of individuals range from 57 to 100 (HHP 1991s1 to 1991s15). Most populations are found on steep exposed cliffs or on ridge slopes in coastal to lowland mesic forests (Lowrey 1990), but a few populations are in mesic *Pandanus tectorius* (hala) forests, lantana-dominated shrubland, or *Eragrostis* grassland. Other associated plant taxa

include common guava, kopiko, kukui, and lama (Gagne and Cuddihy 1990; HHP 1991s1, 1991s3 to 1991s5, 1991s8 to 1991s11, 1991s15; Lamoureux 1982).

Competition with introduced plants is the major threat to *Munroidendron racemosum*. Kukui and ti, plants introduced by Polynesian immigrants to the Hawaiian Islands, compete with this species for space in the forests of Kauai. Other introduced plants threatening this species' habitat include Chinaberry, common guava, firetree, koa haole, lantana, and *Triumfetta semitriloba* (Sacramento bur). Feral goats degrade the habitat of *Munroidendron* and cattle were formerly present in areas where the trees grow. Fire is a threat to the habitat. Predation of the fruit by rats is probable. An introduced insect of the longhorned beetle family (Cerambycidae) that killed a mature, cultivated tree has the potential of affecting wild trees. Because each population of this species contains only one or a few trees, the total number of individuals is small, threatening the species through over-collecting for scientific or horticultural purposes, stochastic extinction, and/or reduced reproductive vigor (HHP 1991s1, 1991s3 to 1991s5, 1991s8 to 1991s11, 1991s15; HPCC 1990h; Lamoureux 1982).

First collected on Kauai before 1900, *Nothoestrum peltatum* was described by Carl J. F. Skottsberg in 1944, based on a specimen collected by Olof H. Selling in 1938. The specific epithet refers to the peltate leaves, attached to the stalk by the lower surface, inside the leaf margin rather than at its edge. St. John (1986) later described *N. inconcinnum*, but David E. Symon (1990), in the currently accepted treatment of the genus, regards that name as a synonym of *N. peltatum*.

Nothoestrum peltatum, a member of the nightshade family (Solanaceae), is a small tree up to 26 ft (8 m) tall with ash-brown bark and woolly stems. The leathery leaves are usually peltate, measure 2.4 to 9.1 in (6 to 23 cm) long and 1.4 to 3 in (3.5 to 7.5 cm) wide and vary in shape from oval or elliptic to oblong. The densely hairy flowers number up to 10 per cluster. The corolla is greenish yellow fading to yellow orange and 0.5 to 0.6 in (12 to 14 mm) long. The orange berries are 0.5 to 0.6 in (13 to 14 mm) long and contain numerous irregularly shaped seeds about 0.1 in (2.5 mm) in diameter. The usually peltate leaves and shorter leaf stalks separate this species from others in the genus (St. John 1986, Selling 1947, Skottsberg 1944, Symon 1990).

Historically, *Nothoestrum peltatum* was known from Kauai at Kumuwela, Kaholuamanu, and the region of

Nualolo (HHP 1991t3, 1991t5, 1991t6). This species is now known from five populations on Kauai located near the Kalalau Lookout area, in Awaawapuhi and Makaha Valleys, and in Waimea Canyon (HHP 1991t1, 1991t2, 1991t4, 1991t7; HPCC 1990i1, 1990i2, 1990i4; S. Perlman, pers. comm., 1991, 1993), scattered over a 5.5 by 2.5 mi (8.9 by 4 km) area. These populations, totalling about 15 individuals (CPC 1989b, 1990; S. Perlman, pers. comm., 1993), are on State owned land between 3,000 and 4,000 ft (915 and 1,220 m) elevation (Symon 1990). This species generally grows in rich soil on steep slopes in montane mesic forests dominated by koa or a mixture of 'ohi'a and koa, with associates such as hame, uluhe, *Bohea brevipes* ('ahakea lau li'i), *Elaeocarpus bifidus* (kalia), and more common *Melicope* species (alani) (HHP 1991t1, 1991t7; Sohmer and Gustafson 1987; J. Lau, pers. comm., 1991).

Competition with alien plants and habitat degradation by introduced animals constitute the major threats to *Nothoestrum peltatum*. Introduced plants competing with this species include banana poka, daisy fleabane, lantana, prickly Florida blackberry, and *Passiflora edulis* (passion fruit). Animals disturbing the habitat of this species include feral goats, feral pigs, mule deer, and red jungle fowl (*Gallus gallus*). Although plants of this species flower, they rarely set fruit; this could be the result of a loss of pollinators, reduced genetic variability, or self-incompatibility (S. Perlman, pers. comm., 1991; D. Lorence *et al.*, *in litt.*, 1991). This species is threatened by fire, over-collecting for scientific or horticultural purposes, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals (HHP 1991t7; HPCC 1990i3, 1990i4).

Hillebrand (1888) described *Peucedanum sandwicense* based on a specimen collected on Molokai and *P. kauaiense* based on a specimen collected on Kauai. He also referred to an unnamed variety of *P. sandwicense* from Maui. Otto and Isa Degener (1960) later named the Maui plant *P. sandwicense* var. *hiroi*. In their current treatment, Lincoln Constance and James Affolter (1990) recognize only *P. sandwicense* for all populations of the genus in the Hawaiian Islands.

Peucedanum sandwicense, a member of the parsley family (Apiaceae), is a parsley-scented, sprawling herb usually 20 to 40 in (0.5 to 1 m) tall. Hollow stems arise from a short, vertical, perennial stem with several fleshy roots. The compound leaves are generally three-parted with stalkless leaflets, each

egg- or lance-shaped and toothed. The larger terminal leaflet is usually one- to three-lobed and 2.8 to 5.1 in (7 to 13 cm) long. The other leaflets have leaf stalks 4 to 20 in (10 to 50 cm) long or are stalkless. Flowers are clustered in a compound umbel of 10 to 20 flowers. The round petals are white and bent inward at the tips. The flat, dry, oval fruits are 0.4 to 0.5 in (10 to 13 mm) long and 0.2 to 0.3 in (5 to 8 mm) wide, splitting in half to release a single flat seed. This species is the only member of the genus in the Hawaiian Islands, one of three genera of the family with taxa endemic to the island of Kauai. This species differs from the other Kauai members of the parsley family in having larger fruit and pinnately compound leaves with broad leaflets (Constance and Affolter 1990, Degener and Constance 1959, Degener and Degener 1960, Hillebrand 1888).

Historically, *Peucedanum sandwicense* was known from three islands: Kalaupapa, Pauonuakea Kui, Waikolu, and Wailau Valley on Molokai; Wailuku and Waiehu on Maui; and various locations in the Waimea Canyon and Olokele regions of Kauai (HHP 1991u1, 1991u2, 1991u4, 1991u7, 1991u9 to 1991u12; HPCC 1991h1, 1991h2). Discoveries in 1990 extended the known distribution of this species to the island of Oahu, where 2 populations totalling about 85 individuals exist in the Waianae Mountains on County and State land (J. Lau, *in litt.* and pers. comm., 1991; J. Obata, pers. comm., 1990). One population of 20 to 30 individuals is known from State owned Keopuka Rock, an islet off the coast of Maui (HHP 1991u8; Hobdy 1982; R. Hobdy, pers. comm., 1991). On Molokai, 3 populations totalling fewer than 30 individuals are found on private and State owned land in Pelekunu Preserve, Kalaupapa National Historical Park, and Huelo, an islet off the coast of Molokai (HHP 1991u7, 1991u16, 1991u20; S. Perlman, pers. comm., 1991). The 10 Kauai populations of 130 to 190 individuals are distributed in Waimea Canyon and along the Na Pali Coast within 1.5 mi (2.4 km) of the ocean (HHP 1991u1, 1991u3, 1991u5, 1991u6, 1991u13 to 1991u15, 1991u17 to 1991u19; T. Flynn, pers. comm., 1991). These populations are found within a 7 by 8 mi (11 by 13 km) area on private and State land. The total number of plants in the known populations of this species is estimated to exceed 1,000 and possibly 5,000 individuals (CPC 1992; S. Perlman, pers. comm., 1993). This species grows in cliff habitats from sea level to above 3,000 ft (900 m) (Constance and Affolter 1990) with such

plant associates as 'akoko, kawelu, lama, 'ohi'a, *Artemisia australis* ('ahinahina), and alien species such as common guava and lantana (HHP 1991u1 to 1991u3, 1991u5 to 1991u8, 1991u14 to 1991u18, 1991u20; J. Lau, *in litt.* and pers. comm., 1991; D. Lorence *et al.*, *in litt.*, 1991).

Competition with introduced plants and habitat degradation and browsing by feral goats are the major threats to *Peucedanum sandwicense*. Kauai populations are affected by alien plant species such as *Kalanchoe pinnata* (air plant), banana poka, common guava, daisy fleabane, firetree, introduced grasses, Java plum, and lantana, as well as by feral goats. The Hanakapiai population on Kauai is close enough to the trail that it is potentially affected by hikers and trail clearing. Oahu populations are threatened by alien plants such as Christmas berry, common guava, daisy fleabane, Hamakua pamakani, silk oak, and *Stachytarpheta*; feral goats; fire; and landslides. The Kalaupapa, Molokai, population of *P. sandwicense* competes with Christmas berry, common guava, and molasses grass. The Pelekunu, Molokai, population is threatened by common guava, Hamakua pamakani, *Ageratina adenophora* (Maui pamakani), and potentially by axis deer. Plants of this species on Huelo are vulnerable to natural rock slides. The population on Keopuka Rock is threatened by alien grasses, lantana, and sourbush (Clarke and Cuddihy 1980; HHP 1991u1, 1991u3, 1991u5, 1991u15, 1991u16; HPCC 1990j1 to 1990j3; R. Hobdy, J. Lau, J. Obata, and S. Perlman, pers. comms., 1991; D. Lorence *et al.*, *in litt.*, 1991).

Peucedanum sandwicense is not in immediate danger of extinction, but if these threats are not curtailed, this species will become endangered in the future.

Wawra collected a specimen of *Phyllostegia waimeae* on Kauai in 1870 while he was a member of the Austrian East Asiatic Exploring Expedition. In 1872, he described the species, naming it for Waimea Canyon where he collected it. St. John (1987c) recently published many species, varieties, and combinations in *Phyllostegia*, one or more of which may fit into this species (Wagner *et al.* 1990).

Phyllostegia waimeae, a nonaromatic member of the mint family (Lamiaceae), is a climbing perennial plant with hairy four-angled stems that are woody at the base. The oval leaves are 2 to 5 in (5 to 13 cm) long, 1 to 2.4 in (2.5 to 6 cm) wide, and have rounded, toothed margins. They are wrinkled and sparsely dotted with oil glands. Flowers

grow in groups of six along an unbranched leafy stalk usually 3.9 to 5.9 in (10 to 15 cm) long. The bracts below each flower stalk are broad and partially overlap the flowers. The calyx resembles an inverted cone with broad lobes. The corolla, 0.3 to 0.5 in (8 to 12 mm) long, is pinkish or may be white. The fruits, probably nutlets, have not been observed. Characteristics that distinguish this species from others in the genus are the nearly stalkless bracts that partially overlap and cover the flowers and relatively fewer oil glands on the leaves (Hillebrand 1888, Sherff 1935a, Wagner *et al.* 1990, Wawra 1872).

Historically, *Phyllostegia waimeae* was known from Kaholuamanu and Kaaha on Kauai (HHP 1991v2, 1991v3). In recent years, it is known from Statq land on Kauai in the Halemanu and Waimea Canyon areas (HHP 1991v1, 1991v4). Because the Halemanu population has not been seen for almost 40 years (HHP 1991v1), the number of extant individuals is unknown. The Waimea Canyon population consists of a single plant which has not been observed recently (R. Hobdy, pers. comm., 1991; S. Perlman, pers. comm., 1993). This species typically grows on shallow to deep, well-drained soils in clearings (HHP 1991v1) or along the banks of streams of diverse montane mesic to wet forests at elevations from 3,000 to 3,600 ft (915 m to 1,100 m) (Wagner *et al.* 1990). Associated taxa include 'ohi'a and *Pritchardia minor* (loulou) (HHP 1991v4).

Habitat destruction by feral goats, erosion, and competition with introduced grasses are the major threats to *Phyllostegia waimeae*. The species is also threatened by over-collecting for scientific purposes, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals (R. Hobdy, pers. comm., 1991).

Based on a specimen collected by Duvel and Harold L. Lyon in 1925, Edward L. Caum (1933) described *Pteralyxia kauaiensis*, named for the island where it grows. St. John (1981a) later published *P. elliptica*, but the authors of the current treatment of the genus (Wagner *et al.* 1990) regard that name to be synonymous with *P. kauaiensis*.

Pteralyxia kauaiensis, a member of the dogbane family (Apocynaceae), is a tree 10 to 26 ft (3 to 8 m) tall. The leaves are dark green and shiny on the upper surfaces but pale and dull on the lower surfaces. They are generally egg-shaped and usually 4.3 to 8.7 in (11 to 22 cm) long and 1.6 to 2.6 in (40 to 65 mm) wide. The pale yellow flowers are

trumpet-shaped, 0.3 to 0.5 in (8 to 12 mm) long, with each of the five lobes 0.1 to 0.2 in (3 to 4 mm) long. The paired fruits, of which usually only one matures, are drupe-like, bright red, and fleshy. The woody endocarp that encloses the single seed has two prominent central wings and two reduced lateral wings. This species differs from the only other taxa in this endemic Hawaiian genus in having reduced lateral wings on the seed (Caum 1933; Degener 1933, 1936; Lamb 1981; St. John 1981a; Wagner *et al.* 1990).

Historically, *Pteralyxia kauaiensis* was known from the Wahiawa Mountains in the southern portion of Kauai (HHP 1991w8). This species is now known from the following scattered locations on private and State land on Kauai at elevations between 820 and 2,000 ft (250 and 610 m) (Wagner *et al.* 1990): Mahanaloa-Kuia Valley in Kuia NAR; Haeleele Valley; Na Pali Coast State Park; Limahuli Valley; the Koaie branch of Waimea Canyon; Haupu Range; Wailua River; and Moloaa Forest Reserve (HHP 1991w1 to 1991w7, 1991w9, 1991w10, 1991w11; HPCC 1990k1; HPCC 1991j1, 1991j2; T. Flynn and S. Montgomery, pers. comms., 1991). There is an undocumented sighting of one individual at Makaleha, above the town of Kapaa (T. Flynn, pers. comm., 1991). The 13 known populations, totaling 170 to 300 individuals, typically grow on the sides of gulches in diverse lowland mesic forests and sometimes lowland wet forests (Wagner *et al.* 1990). Associated plant taxa include hame, lama, lantana, 'ohi'a, and *Pouteria sandwicensis* ('ala'a) (Degener 1936; HHP 1991w1 to 1991w7, 1991w10; D. Herbst, pers. comm., 1991).

The major threats to *Pteralyxia kauaiensis* are habitat destruction by feral animals and competition with introduced plants. Animals affecting the survival of this species include feral goats, feral pigs, and possibly rats, which may eat the fruits. Fire and over-collecting for scientific purposes could threaten some populations. Introduced plants competing with this species include common guava, daisy fleabane, kukui, lantana, strawberry guava, and ti (HHP 1991w1, 1991w4, 1991w5, 1991w7; HPCC 1990k1, 1990k2; T. Flynn and S. Perlman, pers. comms., 1991).

Gray (1854) described *Schiedea spergulina* based on a specimen collected in 1840 on Kauai during the United States Exploring Expedition. The specific epithet means "resembling *Spargula*," another genus in the same plant family. Two varieties of *S. spergulina* are recognized in the current

treatment of the genus (Wagner *et al.* 1990). The typical variety, which includes var. *degeneriana*, was named by Sherff (1956) and var. *leiopoda* (Sherff 1944), which includes var. *major*, was also named by Sherff (1944).

Schiedea spergulina, a member of the pink family (Caryophyllaceae), is a 1 to 2 ft (30 to 60 cm) tall subshrub. The opposite leaves are very narrow, usually 1.2 to 2.6 in (30 to 65 mm) long and about 0.04 in (1.4 mm) wide, one-veined, and attached directly to the stem. The flowers are unisexual, with male and female flowers on different plants. Flowers occur in compact clusters of three. The sepals usually number five and are green and purple-tinged, 0.08 to 0.13 in (2 to 3.3 mm) long. The capsular fruits are about 0.08 to 0.12 in (2 to 3 mm) long and contain nearly smooth, kidney-shaped seeds. Of the 22 species in this endemic genus, only 2 other species have smooth seeds. This species differs from those two in having very compact flower clusters. The two weakly defined varieties differ primarily in the degree of hairiness (Heller 1897; Hillebrand 1888; Sherff 1944, 1945; Wagner *et al.* 1990).

Historically, *Schiedea spergulina* var. *leiopoda* was found on a ridge on the east side of Hanapepe on Kauai (HHP 1991x1). One population of 50 to 100 individuals of this variety is now known to grow in Lawai Valley on Kauai on privately owned land (HHP 1991x2; HPCC 1991k; T. Flynn, J. Lau, and S. Perlman, pers. comms., 1991). *Schiedea spergulina* var. *spergulina* is more numerous, once found in Olokele Canyon but now known from Kalalau Rim and four locations in Waimea Canyon on State land (HHP 1991y1 to 1991y5). One population contains only five plants, whereas others number in the thousands. However, these populations are estimated to total no more than 5,000 individuals (HHP 1991y1 to 1991y5; T. Flynn, pers. comm., 1991; S. Perlman, pers. comm., 1993). This taxon is usually found on bare rock outcrops or sparsely vegetated portions of rocky cliff faces or cliff bases in diverse lowland mesic forests at elevations between 590 and 3,000 ft (180 and 800 m) (Wagner *et al.* 1990). Plants associated with the Lawai population of *S. spergulina* var. *leiopoda* are *Bidens sandwicensis* (ko'oko'olau), *Doryopteris* (kumuniu), *Peperomia leptostachya*, and *Plectranthus parviflorus* ('ala'ala wai nui) (T. Flynn and J. Lau, pers. comms., 1991; D. Lorence *et al.*, *in litt.*, 1991). Plant taxa associated with *S. spergulina* var. *spergulina* include 'ahinahina, Chinaberry, lantana, Sacramento bur,

and *Nototrichium sandwicense* (kulu'i) (HHP 1991y5, Sherff 1956).

The major threats to *Schiedea spergulina* are habitat destruction by feral goats and competition with introduced plants. Variety *leiopoda* is threatened by competition with alien plant taxa such as koa haole, lantana, and *Furcraea foetida* (Mauritius hemp), and individuals are also damaged and destroyed by rock slides. This variety is potentially threatened by pesticide use in nearby sugarcane fields. This variety is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (CPC 1990; D. Lorence, T. Flynn, pers. comms., 1991). Variety *spergulina* is threatened by competition with alien taxa, including daisy fleabane and lantana. The area in which this variety grows is used heavily by feral goats and there is evidence that plants are being browsed and trampled (HHP 1991y2, 1991y5; T. Flynn, J. Lau, and S. Perlman, pers. comms., 1991; D. Lorence *et al.*, *in litt.*, 1991).

The intensity of threats and small number of populations known for *Schiedea spergulina* var. *leiopoda* indicate that this taxon is in serious danger of extinction. *Schiedea spergulina* var. *spergulina* has significantly more individuals and populations and is facing less intense threats since it is found on more protected cliffs. However, while the latter taxon is not now in danger of extinction, if these threats are not curtailed, the taxon will become endangered in the future.

William Jackson Hooker and G.A.W. Arnott (1830–1841) described *Solanum sandwicense* based on a specimen collected in 1826 or 1827 on Oahu during the voyage of H.M.S. *Blossom*. The plant was named for the Sandwich Islands, an older name for the Hawaiian Islands. Other names by which portions of this species have been known include *S. hillebrandii* (St. John 1969a), *S. kauaiense* (Hillebrand 1888), *S. sandwicense* var. ? *kawaiense* (Gray 1862), *S. woahense* (Symon 1990), and *S. woahense* var. *eroso-crenulatum* (Symon 1990). In the current treatment of this genus, Symon (1990) considers the Oahu and Kauai populations as *Solanum sandwicense* and recognizes no subspecific taxa.

Solanum sandwicense, a member of the nightshade family, is a large sprawling shrub that grows up to 13 ft (4 m) tall. The younger branches are more densely hairy than older branches. The oval leaves are usually 4 to 6 in (10 to 15 cm) long and 2 to 5.5 in (5 to 14 cm) wide and have up to four lobes along the margins. Leaf stalks are 0.8 to

1.6 in (2 to 4 cm) long. On the flowering stem, a few to as many as 40 flowers are grouped in threes, with each flower on a stalk about 0.6 in (15 mm) long, bent at the end so that the flower faces downward. The corolla is white with a faint purplish stripe, each lobe is curved somewhat backward. Stamens are attached low on the corolla tube, with anthers curved inward. The fruit is a berry 0.5 to 0.6 in (13 to 15 mm) in diameter, black when ripe. This species differs from others of the genus in having dense hairs on young plant parts, a greater height, and its lack of prickles (Gray 1862, St. John 1969a, Sohmer and Gustafson 1987, Symon 1990).

Historically, *Solanum sandwicense* was known from widely scattered populations throughout the Waianae Mountains and southern portions of the Koolau Mountains on Oahu (HHP 1991z1 to 1991z5, 1991z7 to 1991z10). On Kauai, this species was known from locations in the Kokee region bounded by Kalalau Valley to the north, Milolii Ridge to the west, and Kawaikoi to the east, extending southward to the Hanapepe River (HHP 1991z13 to 1991z17, 1991z21, 1991z22, 1991z24). On Oahu, this species is known from a single population on privately owned land in what is now Honouliuli Preserve (HPCC 1991l). One other recent population was destroyed by a landslide in 1986 (HHP 1991z6; J. Obata, pers. comm., 1991; D. Lorence *et al.*, *in litt.*, 1991). The Kauai populations are on private and State land and most are from Kokee and Na Pali Coast State Parks. Of the 12 known populations, only 4 are currently extant; they total about 20 plants (Brueggemann 1990; CPC 1990; HHP 1991z11, 1991z12, 1991z19, 1991z20, 1991z26; D. Herbst, pers. comm., 1991; S. Perlman, pers. comm., 1993). This species is typically found in open, sunny areas at elevations between 2,500 and 4,000 ft (760 and 1,220 m) in diverse lowland to montane mesic forests and occasionally in wet forests (HHP 1991z1, 1991z11, 1991z16, 1991z19 to 1991z26; Symon 1990). Associated plant taxa include koa, 'ohi'a, uluhe, and wet forest plants such as kopiko, ho'i'o, and more common *Melicope* species (alani) (HHP 1991z11, 1991z18, 1991z20, 1991z26).

The major threats to populations of *Solanum sandwicense* on Kauai are habitat degradation by feral pigs and competition with alien plant taxa. Alien taxa that have heavily invaded this species' habitat on Kauai include banana poka, prickly Florida blackberry, strawberry guava, *Hedychium gardnerianum* (kahili ginger), and *Lonicera japonica* (Japanese honeysuckle). This species is also

threatened by fire, over-collecting for scientific purposes, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals. All Oahu populations of *Solanum sandwicense* except one are now apparently extinct, the result of its habitat being destroyed by urbanization, landslides, feral pigs, and weedy alien taxa (Brueggemann 1990; HHP 1991z1 to 1991z7, 1991z18, 1991z25; HPCC 1990m; R. Hobdy, J. Lau, J. Obata, and S. Perlman, pers. comms., 1991; D. Lorence *et al.*, in litt., 1991).

Previous Federal Action

Federal action on these plants began as a result of section 12 of the Endangered Species Act (16 U.S.C. 1531 *et seq.*), which directed the Secretary of the Smithsonian Institution to prepare a report on plants considered to be endangered, threatened, or extinct in the United States. This report, designated as House Document No. 94-51, was presented to Congress on January 9, 1975. In that document, *Brighamia insignis* (as *B. insignis* and *B. citrina* var. *napaliensis*), *Delissea rhytidosperma*, *Exocarpos luteolus*, *Hibiscus clayi* (as *H. clayi* and *H. newhousei*), *Lipochaeta fauriei*, *Lipochaeta micrantha* (as *L. exigua*), *Melicope haupuensis* (as *Pelea haupuensis*), *Melicope knudsenii* (as *Pelea multiflora*), *Melicope pallida* (as *Pelea pallida* and *P. leveillei*), *Melicope quadrangularis* (as *Pelea quadrangularis*), *Nothoestrum peltatum*, *Peucedanum sandwicense* (as *P. kauaiense*), *Pteralyxia kauaiensis*, and *Solanum sandwicense* were considered to be endangered. *Diellia pallida* (as *D. laciniata*), *Lipochaeta fauriei*, *Lipochaeta micrantha*, *Lipochaeta waimeaensis*, *Lysimachia filifolia*, and *Solanum sandwicense* (as *S. kauaiense*) were considered to be threatened. *Hedyotis cookiana*, *Melicope knudsenii* (as *Pelea knudsenii* and *P. tomentosa*), *Munroidendron racemosum* (as *M. racemosum* var. *macdanielsii*), and *Solanum sandwicense* (as *S. hillebrandii*) were considered to be extinct.

On July 1, 1975, the Service published a notice in the **Federal Register** (40 FR 27823) of its acceptance of the Smithsonian report as a petition within the context of section 4(c)(2) (now section 4(b)(3)) of the Act, and giving notice of its intention to review the status of the plant species named therein. As a result of that review, on June 16, 1976, the Service published a proposed rule in the **Federal Register** (41 FR 24523) to determine endangered status pursuant to section 4 of the Act for approximately 1,700 vascular plant

species, including all of the above species considered to be endangered or thought to be extinct. The list of 1,700 plant species was assembled on the basis of comments and data received by the Smithsonian Institution and the Service in response to House Document No. 94-51 and the July 1, 1975, **Federal Register** publication.

General comments received in response to the 1976 proposal are summarized in an April 26, 1978, **Federal Register** publication (43 FR 17909). In 1978, amendments to the Act required that all proposals over two years old be withdrawn. A one-year grace period was given to proposals already over two years old. On December 10, 1979, the Service published a notice in the **Federal Register** (44 FR 70796) withdrawing the portion of the June 16, 1976, proposal that had not been made final, along with four other proposals that had expired. The Service published updated notices of review for plants on December 15, 1980 (45 FR 82479), September 27, 1985 (50 FR 39525), and February 21, 1990 (55 FR 6183). In these notices, 10 of the species (including synonymous species) that had been in the 1976 proposed rule were treated as Category 1 candidates for Federal listing. Category 1 species are those for which the Service has on file substantial information on biological vulnerability and threats to support preparation of listing proposals. Other than *Diellia pallida* (as *D. laciniata*), *Hedyotis cookiana*, *Lipochaeta fauriei*, *Lipochaeta micrantha* (as *L. exigua*), *Lysimachia filifolia*, *Melicope knudsenii* (as *Pelea knudsenii*), *Melicope pallida*, *M. quadrangularis*, *Peucedanum sandwicense*, and *Solanum sandwicense* (as *S. hillebrandii*), all the aforementioned species that were either proposed as endangered or thought to be extinct in the June 16, 1976, proposed rule were considered Category 1 candidates on all three notices of review.

In the 1980 and 1985 notices, *Lipochaeta fauriei*, *Melicope knudsenii* (as *Pelea knudsenii*), and *Solanum sandwicense* (as *S. hillebrandii*) were considered Category 1* species. Category 1* species are those that are possibly extinct. *Lysimachia filifolia* appeared as a Category 2 species and *Hedyotis cookiana* as a Category 3A species in the 1980 and 1985 notices. Category 2 species are those for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at the time. Category 3A species are those for which the Service has persuasive evidence of extinction. Because new information

indicated their current existence or provided support for listing, the above five species were conferred Category 1 status in the 1990 notice. *Lipochaeta exigua* appeared as a Category 3B species in the 1980 and 1985 notices; in the 1990 notice, it was considered synonymous with *L. micrantha*, a Category 1 species. Category 3B species are those which, on the basis of current taxonomic understanding, do not represent distinct taxa meeting the Act's definition of "species." *Diellia pallida* (as *D. laciniata*), *Melicope pallida*, and *M. quadrangularis* were accorded Category 1* status in the 1990 notice, but because new information regarding their existence has become available, they are included herein for listing. In 1980, *Peucedanum sandwicense* appeared as a Category 2 species and retained that status in the 1985 and 1990 notices. Information obtained since the 1990 notice suggests that its numbers and distribution are sufficiently restricted to warrant listing. *Schiedea spergulina* first appeared on the 1985 notice of review as a Category 1 species. In the 1990 notice, two varieties were recognized: Variety *spergulina* as a Category 1 species; and variety *leiopoda* as a Category 1* species for which recently obtained information indicates that it is extant. *Cyrtandra limahuliensis* first appeared in the 1990 notice of review as Category 1 species after it was described in 1987. The 1990 notice also recognized *Cyanea asarifolia* and *Phyllostegia waimeae* as Category 1 species for the first time.

Section 4(b)(3)(B) of the Act requires the Secretary to make findings on certain pending petitions within 12 months of their receipt. Section 2(b)(1) of the 1982 amendments further requires all petitions pending on October 13, 1982, be treated as having been newly submitted on that date. On October 13, 1983, the Service found that the petitioned listing of these species was warranted, but precluded by other pending listing actions, in accordance with section 4(b)(3)(B)(iii) of the Act; notification of this finding was published on January 20, 1984 (49 FR 2485). Such a finding requires the petition to be recycled, pursuant to section 4(b)(3)(C)(i) of the Act. The finding was reviewed in October of 1984, 1985, 1986, 1987, 1988, 1989, and 1990. The proposed rule published on October 30, 1991 (56 FR 55862) to list 23 plant species primarily from the island of Kauai as endangered species constituted the final 1-year finding that was required for the species discussed above.

Based on comments and recommendations received in response

to the proposal (see Comments and Recommendations, below), the Service now determines 21 plant species to be endangered and 3 plant species to be threatened with the publication of this rule. One of the species proposed in 1991 is now being listed as two separate entities: *Schiedea spergulina* var. *spergulina* (as threatened); and *Schiedea spergulina* var. *leiopoda* (as endangered). This results in the apparent increase from 23 species in the proposed rule to 24 species in the final rule.

Summary of Comments and Recommendations

In the October 30, 1991, proposed rule and associated notifications, all interested parties were requested to submit factual reports or information that might contribute to the development of a final listing decision. The public comment period ended on December 30, 1991. Appropriate State agencies, county governments, Federal agencies, scientific organizations, and other interested parties were contacted and requested to comment. A newspaper notice inviting public comment was published in "The Garden Island" on November 10, 1991. Fifteen letters of comment, including 2 from State agencies, 11 from organizations, and 2 from individuals, were received and are discussed below. A public hearing was requested by Kamehameha Schools/Bernice Pauahi Bishop Estate on December 1, 1992. On January 13, 1993, the Service published a notice (58 FR 4145) reopening the comment period until February 20, 1993, to accommodate the requested public hearing which was held in Kapaa, Kauai, on February 10, 1993. A newspaper notice announcing the public hearing was published in "The Garden Island" on February 10, 1993. Eleven people presented oral comments; their testimony is included in the following summary.

Two respondents acknowledged receipt of the proposed rule but had no comments. Of the remaining 13 letters, 7 supported the listing of these taxa from the island of Kauai and 6 opposed 1 or more of the listings. Additional information included in the letters has been incorporated into this final rule. Comments of similar content were grouped into a number of general issues for discussion. These issues and the Service's response to each are discussed below.

Issue 1: Status of *Cyrtandra limahuliensis*: Two respondents stated that more populations of *Cyrtandra limahuliensis* exist than were discussed in the proposed rule and that there is a

good possibility that more populations await discovery. One respondent asked whether this species should still be considered endangered, while the second stated that this species does not warrant listing as endangered.

Response: At the time the proposed rule was written, only 9 populations of *Cyrtandra limahuliensis* were known; however, 3 additional populations were subsequently discovered in Waioli Valley, bringing the total number of plants to 2,800 to 3,000 (D. Lorence, *in litt.*, 1993). This information has been included in the final rule. Based on additional information, the Service determines that *Cyrtandra limahuliensis* is not now in danger of extinction, but that *Cyrtandra limahuliensis* is likely to become endangered in the foreseeable future if the threats posed by competition from alien species are not curbed. Thus, *Cyrtandra limahuliensis* is designated a threatened species.

Issue 2: Status of *Peucedanum sandwicense*: One respondent stated that more populations of *Peucedanum sandwicense* exist than were discussed in the proposed rule and that this species is not immediately threatened with extinction. The proposed rule indicated that only 16 populations of the species were known, 2 on Oahu, 3 on Molokai, 10 on Kauai, and 1 on Maui. Additional populations are now known from the Wailau sea cliffs on Molokai and the Kalalau Valley rim on Kauai (D. Lorence *et al.*, *in litt.*, 1991).

Response: At the time the proposed rule was written, 250 to 350 individuals of *Peucedanum sandwicense* were known; however, several additional colonies were subsequently brought to the Service's attention, bringing the totals to between 1,000 to 5,000 individuals (CPC 1992; D. Lorence *et al.*, *in litt.*, 1991). This information has been included in the final rule. Based on the above information, the Service determines that *Peucedanum sandwicense* is not now in danger of extinction, but that it is likely to become endangered in the foreseeable future if the threats posed by competition from alien plant species and feral goats are not curbed. Thus, *Peucedanum sandwicense* is designated a threatened species.

Issue 3: Status of *Schiedea spergulina*: One respondent stated that one variety of *Schiedea spergulina*, var. *spergulina*, is not immediately threatened with extinction. The proposed rule treated the species as one entity in terms of listing.

Response: *Schiedea spergulina* var. *leiopoda* is known from only 1 population of 50 to 100 individuals (HHP 1991x2; T. Flynn, J. Lau, and S.

Perlman, pers. comms., 1991). The numbers of plants and populations of this variety are sufficiently small that, given its threats, it is in immediate danger of extinction and meets the definition of an endangered species as defined in the Act. *Schiedea spergulina* var. *spergulina* is known from 5 locations with from 1,000 to 5,000 individuals total. Based on the above information, the Service determines that *Schiedea spergulina* var. *spergulina* is not now in danger of extinction, but that it is likely to become endangered in the foreseeable future if the threats posed by competition from alien taxa and feral goats are not curbed. Thus, *Schiedea spergulina* var. *spergulina* is designated a threatened species and *S. spergulina* var. *leiopoda* is designated as an endangered species.

Issue 4: Changes to the Act: Several concerns were expressed in letters of comment and in testimony at the public hearing about the Endangered Species Act and its effect on private citizens and landowners. One individual asked both during testimony at the hearing and in multiple letters of comment that the ability of the Federal government to seize land with endangered species be removed from the Act. Concern was expressed by four individuals during their testimony and in three letters of comment that the Endangered Species Act does not allow private citizens to grow and propagate endangered species. Many respondents asked that the permit process be streamlined for propagation and scientific research purposes.

Response: The Act does not require the seizure or acquisition of private lands containing endangered species. The Act also does not restrict the growth and propagation of endangered plant taxa by private citizens as long as the plants are not collected from Federal lands, are not transported between states or outside of the U.S., and that these actions do not violate State laws. A Federal permit for collecting is only required if the collection involves Federal actions, Federal funding, or activities on Federal lands.

Issue 5: Changes to State regulations: Concern was expressed by four individuals during their testimony and in three letters of comment that State regulations might make the propagation or cultivation of these 24 taxa more difficult if they were listed as endangered, since State regulations prohibit possessing endangered plants or collecting their propagules. Permits to collect or possess endangered plants may be issued by the State to enhance the propagation or survival of the species, but the respondents believe that it is difficult and burdensome to obtain

these permits. One individual was also concerned about the seizure of private lands by the State to protect endangered species. Another individual stated that rezoning for conservation districts should be limited to public lands.

Response: Hawaii Administration Rule 13-124-4(a) allows for "Permits to * * * possess * * * any endangered or threatened species of wildlife or plants" to be issued "to enhance the propagation or survival of the species." To date, the State has worked with private landowners to reach a cooperative agreement for management of endangered species habitat or to reach a fair purchase price. Concerns about the State's endangered species law and how it affects private citizens, and any requests to change State requirements, should be addressed to State authorities. The Service believes that existing State policies should not delay or prevent the Federal protection that listing would afford the species.

Issue 6: Threat of game mammals: One individual at the hearing was concerned that there is inadequate information on the effects of feral ungulates to indicate that their eradication would truly benefit the proposed plants.

Response: The Service is not proposing the eradication of feral ungulates from the island of Kauai. However, several studies verify that feral ungulates damage native plants and habitats. Feral goats have been implicated in the damage of native vegetation ranging from lowland to subalpine areas (Mueller-Dombois and Spatz 1972, Spatz and Mueller-Dombois 1973, Scowcroft and Sakai 1983). Goat browsing damage has been observed on individuals of *Exocarpos luteolus*,

Lipochaeta micrantha, and *Schiedea spergulina* var. *spergulina* (HHP 1991k5; T. Flynn, pers. comm., 1991; S. Perlman, pers. comm., 1993). Goats threaten 12 other species through habitat degradation.

Pigs have been similarly implicated in damaging native habitats. Specific studies have demonstrated that native vegetation recovers significantly after the exclusion of pigs in rainforests and subalpine grasslands (Spatz and Mueller-Dombois 1975, Stone 1985). Eleven species in this rule are threatened by habitat degradation caused by pigs. Elimination or reduction of habitat damage by feral ungulates will be addressed during the recovery process for these species.

Issue 7: Lack of adequate management: Four respondents and three individuals in their testimony stated that inadequate management of State and Federal lands in the past has caused the decline of many of the 24 taxa.

Response: Listing a species as either endangered or threatened does enable States, such as Hawaii, to apply for Federal funds to undertake programs aimed at conserving endangered species. Additional concerns about the management of State lands should be addressed to State authorities. None of the 24 taxa are found on federally owned lands. Populations of one species, *Peucedanum sandwicense*, are found on State land managed under a cooperative agreement with the National Park Service. The National Park Service assumed management of the area in 1980. A natural resource management plan will be developed for the area soon, but must be approved by the State before it can be implemented (Cary

Barbano, National Park Service, pers. comm., 1993).

Summary of Factors Affecting the Species

After a thorough review and consideration of all information available, the Service has determined that *Brighamia insignis* ('olulu), *Cyanea asarifolia* (haha), *Delissea rhytidosperma* (no common name (NCN)), *Diellia pallida* (NCN), *Exocarpos luteolus* (heau), *Hedyotis cookiana* ('awiwi), *Hibiscus clayi* (Clay's hibiscus), *Lipochaeta fauriei* (nehe), *Lipochaeta micrantha* (nehe), *Lipochaeta waimeaensis* (nebe), *Lysimachia filifolia* (NCN), *Melicope haupuensis* (alani), *Melicope knudsenii* (alani), *Melicope pallida* (alani), *Melicope quadrangularis* (alani), *Munroidendron racemosum* (NCN), *Nothoecstrum peltatum* ('aiea), *Phyllostegia waimeae* (NCN), *Pteralyxia kauaiensis* (kaulu), *Schiedea spergulina* var. *leiopoda* (NCN), and *Solanum sandwicense* (popolo'aiakeakua) should be classified as endangered species; and that *Cyrtandra limahuliensis* (ha'iwale), *Peucedanum sandwicense* (makou), and *Schiedea spergulina* var. *spergulina* (NCN) should be classified as threatened species. The provisions of section 4 of the Endangered Species Act (16 U.S.C 1533) and regulations (50 CFR part 424) promulgated to implement the listing provisions of the Act were followed in making these determinations. A species may be determined to be an endangered or threatened species due to one or more of the five factors described in section 4(a)(1). The threats facing these 24 taxa are summarized in Table 1.

TABLE 1.—SUMMARY OF THREATS

Species	Alien mammals					Insects	Alien plants	Fire	Natural disaster*	Human impacts	Limited numbers**
	Cattle	Deer	Goats	Pigs	Rats						
<i>Brighamia insignis</i>			X			X	X	X	X	X	X1,3
<i>Cyanea asarifolia</i>				P	P			X	X	X	X1,2
<i>Cyrtandra limahuliensis</i>				X	X		X		P	P	
<i>Delissea rhytidosperma</i>		X	X	X	X		X	X	X	X	X1,2
<i>Diellia pallida</i>		X	X	X			X		X	X	X1,2
<i>Exocarpos luteolus</i>			X	X	X		X	X	X	P	
<i>Hedyotis cookiana</i>			P	P			P		P	P	X1,3
<i>Hibiscus clayi</i>				P			X			X	X1,2
<i>Lipochaeta fauriei</i>			X	P			X	X		P	X1,3
<i>Lipochaeta micrantha</i> var. <i>exigua</i>				X			X			P	X1
<i>Lipochaeta micrantha</i> var. <i>micrantha</i>			X	X			X			P	X1
<i>Lipochaeta waimeaensis</i>			X				X		X	X	X1,2
<i>Lysimachia filifolia</i>				P			X		X	P	X1
<i>Melicope haupuensis</i>			X			P	X			X	X1,2
<i>Melicope knudsenii</i>	X	P	X	X		P	X	P		P	X1,3
<i>Melicope pallida</i>			X	X		P	X	X		P	X3
<i>Melicope quadrangularis</i>						P	P			P	X1,3
<i>Munroidendron racemosum</i>			X		P	P	X	X	X	P	X3

TABLE 1.—SUMMARY OF THREATS—Continued

Species	Alien mammals					Insects	Alien plants	Fire	Natural disaster*	Human impacts	Limited numbers**
	Cattle	Deer	Goats	Pigs	Rats						
<i>Nothocestrum peltatum</i>		X	X	X			X	X		X	X1,3
<i>Peucedanum sandwicense</i> .		P	X				X	X	X	X	
<i>Phyllostegia waimeae</i>			X				X		X	X	X1,2
<i>Pteralyxia kauaiensis</i>			X	X	P		X	X		P	
<i>Schiedea spergulina</i> var. <i>leiopoda</i>			X				X		X	P	X1,3
<i>Schiedea spergulina</i> var. <i>spergulina</i>			X				X			P	X1
<i>Solanum sandwicense</i>				X			X	X	X	X	X1,3

X=Immediate and significant threat.

P=Potential threat.

*=Natural disasters include hurricanes, erosion, rock slides, and landslides.

**=No more than 100 individuals and/or no more than 5 populations.

1=No more than 5 populations.

2=No more than 10 individuals.

3=No more than 100 individuals.

These factors and their application to *Brighamia insignis* A. Gray ('olulu), *Cyanea asarifolia* St. John (haha), *Cyrtandra limahuliensis* St. John (ha'iwale), *Delissea rhytidosperra* H. Mann (no common name (NCN)), *Diellia pallida* W.H. Wagner (NCN), *Exocarpos luteolus* C. Forbes (heau), *Hedyotis cookiana* (Cham. and Schlechtend.) Stehd. ('awiwi), *Hibiscus clayi* Degener and I. Degener (Clay's hibiscus), *Lipochaeta fauriei* H. Levl. (nehe), *Lipochaeta micrantha* (Nutt.) A. Gray (nehe), *Lipochaeta waimeae* St. John (nehe), *Lysimachia filifolia* C. Forbes and Lydgate (NCN), *Melicope haupuensis* (St. John) Hartley and Stone (alani), *Melicope knudsenii* (Hillebr.) Hartley and Stone (alani), *Melicope pallida* (Hillebr.) Hartley and Stone (alani), *Melicope quadrangularis* (St. John and E. Hume) T. Hartley and B. Stone (alani), *Munroidendron racemosum* (C. Forbes) Sherff (NCN), *Nothocestrum peltatum* Skotts. ('aiea), *Peucedanum sandwicense* Hillebr. (makou), *Phyllostegia waimeae* Wawra (NCN), *Pteralyxia kauaiensis* Caum (kaulu), *Schiedea spergulina* var. *leiopoda* Sherff (NCN), *Schiedea spergulina* A. Gray var. *spergulina* (NCN), and *Solanum sandwicense* Hook. and Arnott. (popolo'aiakeakua) are as follows:

A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

The habitats of the plants included in this rule have undergone extreme alteration because of past and present land management practices, including deliberate alien animal and plant introductions, agricultural development, and recreational use. Natural disturbances such as storms and landslides also destroy habitat and can

have a significant effect on small populations of plants. Destruction and modification of habitat by introduced animals and competition with alien plants are the primary threats facing the 24 plant taxa in this rule (see Table 1).

When Polynesian immigrants settled in the Hawaiian Islands, they brought with them water-control and slash-and-burn systems of agriculture and encouraged plants that they introduced to grow in valleys. Their use of the land resulted in erosion, changes in the composition of native communities, and a reduction of biodiversity (Cuddihy and Stone 1990; HHP 1990b; Kirch 1982; Wagner *et al.* 1985). Hawaiians settled and altered many areas of Kauai including areas in which some of the taxa in this rule grew (DLNR 1981a; HHP 1990a, 1990b). Many forested slopes were denuded in the mid-1800s to supply firewood to whaling ships, plantations, and Honolulu residents. Native plants, such as the historic population of *Lipochaeta micrantha* var. *micrantha* in Koloa District (HHP 1991k4), were undoubtedly affected by this practice. Also, sandalwood and tree fern harvesting occurred in many areas, changing forest composition and affecting native taxa (Cuddihy and Stone 1990).

Beginning with Captain James Cook in 1792, early European explorers introduced livestock, which became feral, increased in number and range, and caused significant changes to the natural environment of Hawaii. The 1848 provision for land sales to individuals allowed large-scale agricultural and ranching ventures to begin. So much land was cleared for these enterprises that climatic conditions began to change and the amount and distribution of rainfall were altered (Wenkam 1969). Plantation

owners supported reforestation programs that resulted in many alien trees being introduced in the hope that the watershed could be conserved. Beginning in the 1920s, water collection and diversion systems were constructed in upland areas to irrigate lowland fields. It is probable that individuals and populations of native plants were destroyed. Some of the taxa, such as a Kokee population of *Exocarpos luteolus* and a Waimea Canyon population of *Schiedea spergulina* var. *spergulina*, which now occur near ditches of the irrigation system, may have been affected (HHP 1991f4, 1991y2). The irrigation system also opened new routes for the invasion of alien plants and animals into native forests (Cuddihy and Stone 1990, Culliney 1988, Wagner *et al.* 1990, Wenkam 1969).

Past and present activities of introduced alien mammals are the primary factor in altering and degrading vegetation and habitats on Kauai, Niihau, Oahu, Molokai, and Maui. Feral ungulates trample and eat native vegetation and disturb and open new areas. This causes erosion and allows the entry of alien plant taxa (Cuddihy and Stone 1990, Wagner *et al.* 1990). Nineteen taxa in this proposal are directly threatened by habitat degradation resulting from introduced ungulates: 17 taxa are threatened by goats; 10 by pigs; 3 by deer; and 1 by cattle. In addition, an introduced ground-nesting bird potentially threatens one taxon by disturbing its habitat.

Goat (*Capra hircus*), a species originally native to the Middle East and India, was successfully introduced to the Hawaiian Islands in 1792 and there currently are populations on Kauai, Oahu, Molokai, Maui, and Hawaii. All

feral goats were removed from Niihau about 1910, but by that time they had caused considerable damage to the island's dry and mesic forests. On Kauai, feral goats have been present in drier, more rugged areas since the 1820s. They still occur in Waimea Canyon and along the Na Pali Coast, as well as in the drier perimeter of Alakai Swamp and even in its wetter areas during periods with low rainfall. Goats have been on Oahu since about 1820 and they currently occur in the northern Waianae Mountains. On Molokai, goats degrade dry forests at low elevations and they are expanding their range (J. Lau, pers. comm., 1991). On Maui, goats have been widespread for 100 to 150 years and are common throughout the south slope of Haleakala (Medeiros *et al.* 1986). Goats are managed in Hawaii as a game animal, but many herds populate inaccessible areas where hunting has little effect on their numbers (HHP 1990c). Goat hunting is allowed year-round or during certain months, depending on the area (DLNR n.d.-a, n.d.-b, n.d.-c, 1990). Goats browse on introduced grasses and native plants, especially in drier and more open ecosystems. Feral goats eat native vegetation, trample roots and seedlings, cause erosion, and promote the invasion of alien plants. They are able to forage in extremely rugged terrain and have a high reproductive capacity (Clarke and Cuddihy 1980, Cuddihy and Stone 1990, Culliney 1988, Scott *et al.* 1986, Tomich 1986, van Riper and van Riper 1982).

Although many of the plants survive on steep cliffs inaccessible to goats, their original range was probably much larger. Plants are vulnerable to the long-term, indirect effects of goats, such as large-scale erosion (Corn *et al.* 1979). The habitats of many of the 24 plant taxa in this rule were damaged in the past by goats and these effects are still apparent today in the form of alien vegetation and erosion. One or more populations of 17 of the following taxa are currently threatened by direct damage from feral goats, such as trampling of plants and seedlings and erosion of substrate: *Brighamia insignis*; *Delissea rhytidosperra*; *Diellia pallida*; *Exocarpos luteolus*; *Lipochaeta fauriei*; *Lipochaeta micrantha* var. *micrantha*; *Lipochaeta waimeensis*; *Melicope haupuensis*; *Melicope knudsenii*; *Melicope pallida*; *Munroidendron racemosum*; *Nothoestrup peltatum*; *Peucedanum sandwicense*; *Phyllostegia waimeae*; *Pteralyxia kauaiensis*, and both varieties of *Schiedea spergulina*. In addition, it is probable that goats have invaded the area in which the only

known population of *Hedyotis cookiana* occurs (Bruegmann 1990; Clarke and Cuddihy 1980; Culliney 1988; HHP 1991a1, 1991e3, 1991f6, 1991i3, 1991k5, 1991o1, 1991o2, 1991p1 to 1991p4, 1991q6, 1991q8, 1991s1, 1991s8 to 1991s10, 1991s15, 1991t7, 1991u14, 1991w5, 1991y5; HPCC 1990a, 1990i4, 1990j2, 1990j3, 1990k1, 1990k2; Lammers 1990; Lamoureux 1982; Medeiros *et al.* 1986; Perlman 1979; St. John 1981b; Scott *et al.* 1986; Takeuchi 1982; van Riper and van Riper 1982; C. Christensen, T. Flynn, R. Hobdy, J. Lau, D. Lorence, S. Montgomery, S. Perlman, and K. Wood, pers. comms., 1991).

Pig (*Sus scrofa*) is a species originally native to Europe, northern Africa, Asia Minor, and Asia. European pigs, introduced to Hawaii by Captain James Cook in 1778, became feral and invaded forested areas, especially wet and mesic forests and dry areas at high elevations. They are currently present on Kauai, Oahu, Molokai, Maui, and Hawaii, and inhabit rain forests and grasslands. Pig hunting is allowed on all islands either year-round or during certain months, depending on the area (DLNR n.d.-a, n.d.-b, n.d.-c, 1990). While rooting in the ground in search of the invertebrates and plant material they eat, feral pigs disturb and destroy vegetative cover, trample plants and seedlings, and threaten forest regeneration by damaging seeds and seedlings. They disturb soil substrates and cause erosion, especially on slopes. Alien plant seeds are dispersed on their hooves and coats as well as through their digestive tracts. The disturbed soil is fertilized by their feces, helping these plants to establish. Pigs are a major vector in the spread of banana poka, firetree, and strawberry guava and enhance populations of common guava, kahili ginger, Hamakua pamakani, prickly Florida blackberry, sweet granadilla, and yellow ginger, all of which threaten one or more of the taxa (Cuddihy and Stone 1990, Medeiros *et al.* 1986, Scott *et al.* 1986, Smith 1985, Stone 1985, Tomich 1986, Wagner *et al.* 1990).

Feral pigs pose an immediate threat to 1 or more populations of 11 of the taxa. At least one population of each of the following taxa is threatened by feral pigs: *Pteralyxia kauaiensis*; *Soianum sandwicense*; both varieties of *Lipochaeta micrantha*; *Cyrtandra limahuliensis*; *Delissea rhytidosperra*; *Diellia pallida*; *Exocarpos luteolus*; *Lipochaeta fauriei*; *Melicope knudsenii*; *Melicope pallida*; and *Nothoestrup peltatum*. Pigs also constitute a potential threat to *Cyanea asarifolia*, *Hedyotis cookiana*, *Hibiscus clayi*, *Lipochaeta fauriei*, and *Lysimachia*

filifolia (Bruegmann 1990; HHP 1991f6, 1991p1, 1991p3; HPCC 1990i3, 1990i4; J. Obata, pers. comm., 1990; C. Christensen, T. Flynn, R. Hobdy, J. Lau, D. Lorence, and S. Perlman, pers. comms., 1991).

Cattle (*Bos taurus*), the wild progenitor of which was native to Europe, north Africa, and southwestern Asia, were introduced to the Hawaiian Islands in 1793. Large feral herds developed as a result of restrictions on killing cattle decreed by King Kamehameha I. Feral cattle formerly occurred on Niihau and, along with goats and sheep (*Ovis aries*), caused much damage on the island (Stone 1985). On Kauai, parts of Kokee were leased for cattle grazing in the 1850s and both sides of Waimea Canyon were supporting large cattle ranching operations by the 1870s (Joesting 1984, Ryan and Chang 1985). Cattle grazing began about 1920 in the Na Pali region (DLNR 1981a). Cattle roamed lowland areas and eventually began invading wet forests from adjacent mesic areas. Around 1900, Augustus Knudsen, the district forester of Kauai and a rancher, realizing the amount of destruction being caused to the forests by cattle, initiated some fencing (Daehler 1973). Sugar company interests funded additional fencing as well as feral cattle removal to protect the forest from further degradation and to safeguard water reserves for their crops (Wenkam 1989). On Kauai, feral cattle were still present in Kokee as late as 1960 and in the Puu Ka Pele area in the 1980s. Feral cattle roamed Oahu, but most were removed by the early 1960s. Today, only a few can be found in the northwestern part of the island (J. Lau, pers. comm., 1990). Feral cattle were formerly found on Molokai and Maui and damaged the forests there. Hunting of feral cattle is no longer allowed in Hawaii (DLNR 1985). Cattle eat native vegetation, trample roots and seedlings, cause erosion, create disturbed areas into which alien plants invade, and spread seeds of alien plants in their feces and on their bodies. The forest, in areas grazed by cattle, becomes degraded to grassland pasture. Plant cover is reduced for many years following removal of cattle from an area. Several alien grasses and legumes purposely introduced for cattle forage have become noxious weeds (Cuddihy and Stone 1990, Scott *et al.* 1986, Tomich 1986). The habitats of many of the plants included in this rule were degraded in the past by feral cattle. This has had effects which still persist. Examples of plant taxa whose habitats have been altered by feral cattle include *Hibiscus clayi* and *Munroidendron racemosum*.

The Maui population of *Melicope knudsenii*, growing in an area currently used as a domestic cattle pasture, is directly threatened by trampling by this animal (Degener and Degener 1959a; HHP 1991b3, 1991p1; Lamoureux 1982).

Individuals of mule deer or black-tailed deer (*Odocoileus hemionus*), native from western North America to central Mexico, were brought to Kauai from Oregon in the 1960s for game hunting and have not been introduced to any other Hawaiian island. In part, mule deer were introduced to provide another animal for hunting, since the State had planned to reduce the number of goats on Kauai because they were so destructive to the landscape (Kramer 1971). There are about 400 animals in and near Waimea Canyon, with some invasion into Alakai Swamp in drier periods. Mule deer, legally hunted during only one month each year, trample native vegetation and cause erosion by creating trails and removing vegetation (Cuddihy and Stone 1990, DLNR 1985, Tomich 1986). They are a threat to *Delissea rhytidosperra*, *Diellia pallida*, and *Nothoestrum peltatum* (Bruegmann 1990; HPCC 1990b, 1990i3, 1990i4; S. Perlman, pers. comm., 1991).

Axis deer (*Axis*), native to Sri Lanka and India, were first introduced to the Hawaiian Islands in 1868 as a game animal on Molokai, later to Oahu and Lanai, and finally to East Maui in 1960. Hunting of axis deer is allowed only on Molokai and Lanai during two months of the year. Considerable damage has been done to the forests on Molokai and Lanai by this animal, especially through browsing of vegetation and compaction of the soil (Cuddihy and Stone 1990, Culliney 1988, DLNR 1985, Scott et al. 1986, Tomich 1986). With a population of about 100 animals on the lower southwest slope of Haleakala, the range of the axis deer is expanding on East Maui and constitutes a potential threat to *Melicope knudsenii* (Medeiros et al. 1986). On Molokai, axis deer are encroaching on Pelekunu Valley and are already present in Kalaupapa, thus posing a potential threat to populations of *Peucedanum sandwicense* in these areas (HHP 1991u7, 1991u16; J. Lau, pers. comm., 1990).

Red jungle fowl (*Gallus*), ground-nesting chickens native to India and southeast Asia, were introduced to Hawaii by the Polynesian immigrants and became feral in the forests. A current threat to the Makaha Valley, Kauai, population of *Nothoestrum peltatum*, red jungle fowl disturb the ground cover while searching for seeds, fruits, and small invertebrates, thus disrupting seedling establishment

(Cuddihy and Stone 1990, HPCC 1990i3, Scott et al. 1986).

Substrate loss due to agriculture, grazing animals (especially goats), hikers, and vegetation change results in habitat degradation and loss. This particularly affects plant populations located on cliffs or steep slopes, including *Lipochaeta waimeaensis*, *Brighamia insignis*, *Diellia pallida*, *Exocarpos luteolus*, *Peucedanum sandwicense*, and *Phyllostegia waimeae* (Bruegmann 1990; Christensen 1979; HHP 1991f6; Takeuchi 1982; G. Carr, R. Hobdy, and J. Obata, pers. comms., 1991).

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.

Unrestricted collecting for scientific or horticultural purposes and excessive visits by individuals interested in seeing rare plants could result from increased publicity. This is a potential threat to all 24 of the taxa, but especially to *Cyanea asarifolia*, *Delissea rhytidosperra*, *Diellia pallida*, *Hibiscus clayi*, *Lipochaeta waimeaensis*, *Melicope haupeensis*, and *Phyllostegia waimeae*, each of which has only 1 or 2 populations and a total of 10 or fewer individuals. Collection of whole plants or reproductive parts of any of these seven taxa could cause an adverse impact on the gene pool and threaten the survival of the taxa. Some taxa, such as *Brighamia insignis*, *Exocarpos luteolus*, *Hibiscus clayi*, *Nothoestrum peltatum*, *Peucedanum sandwicense*, and *Solanum sandwicense*, have populations close to trails or roads and are, thus, easily accessible to collectors (HHP 1991a3, 1991f6, 1991h1, 1991t1, 1991t2, 1991t4, 1991t7, 1991u1, 1991u3, 1991u5, 1991u7, 1991u15, 1991z11, 1991z12, 1991z18, 1991z20, 1991z23, 1991z25, 1991z26; HPCC 1990c, 1990i1 to 1990i4, 1990m).

Many of the plants occur in recreational areas used for hiking, camping, and hunting. Tourism is a growing industry in Hawaii and as more people seek recreational activities, they are more likely to come into contact with rare native plants. People can transport or introduce alien plants through seeds on their footwear and they can cause erosion, trample plants, and start fires (Corn et al. 1979). *Brighamia insignis*, *Hibiscus clayi*, and *Peucedanum sandwicense* have populations next to trails and are considered to be immediately threatened by recreational use of the areas in which they occur (Clarke and Cuddihy 1980; Takeuchi 1982; T. Flynn, pers. comm., 1991).

C. Disease or Predation

Browsing damage by goats has been verified for the following taxa: *Brighamia insignis*; *Exocarpos luteolus*; *Peucedanum sandwicense*; and *Schiedea spergulina* var. *spergulina* (HHP 1991y5; Takeuchi 1982; T. Flynn, J. Lau, and S. Perlman, pers. comms., 1991; L. Mehrhoff, pers. comm., 1993). The remaining taxa are not known to be unpalatable to goats, deer, or cattle and, therefore, predation is a probable threat where those animals have been reported, potentially affecting 15 additional taxa. These taxa include *Delissea rhytidosperra*, *Diellia pallida*, *Hedyotis cookiana*, *Hibiscus clayi*, *Lipochaeta fouriei*, *Lipochaeta micrantha*, *Lipochaeta waimeaensis*, *Melicope haupeensis*, *Melicope knudsenii*, *Melicope pallida*, *Munroidendron racemosum*, *Nothoestrum peltatum*, *Phyllostegia waimeae*, *Pteralyxia kauaiensis*, and *Solanum sandwicense*. The lack of seedlings of many of the taxa and the occurrence of individuals of several taxa only on inaccessible cliffs appear to indicate the effect that browsing mammals, especially goats, have had in restricting the distribution of these plants (HHP 1990b, Takeuchi 1982).

Of the four species of rodents that have been introduced to the Hawaiian Islands, the species with the greatest impact on the native flora and fauna is probably the black or roof rat (*Rattus rattus*), which now occurs on all the main Hawaiian Islands around human habitations, in cultivated fields, and in dry to wet forests. Black rats, and to a lesser extent house mouse (*Mus musculus*), Polynesian rat (*Rattus exulans*), and Norway rat (*R. norvegicus*) eat the fruits of some native plants, especially those with large, fleshy fruits. Many native Hawaiian plants produce their fruit over an extended period of time and this produces a prolonged food supply that supports rodent populations. Black rats strip bark from some native plants (Cuddihy and Stone 1990, Tomich 1986). Rats threaten *Delissea rhytidosperra* by damaging the fruits and stems (Bruegmann 1990). Rats eat fruits of *Exocarpos luteolus*, threatening this species as well. It is probable that rats damage the fruit and stems of *Cyanea asarifolia*, *Munroidendron racemosum*, and *Pteralyxia kauaiensis*, which have fleshy fruits and populations in areas where rats occur (Lamoureux 1982; T. Flynn and D. Herbst, pers. comms., 1991).

Black twig borer (*Xylosandrus compactus*) is a small beetle about 1.6 mm (0.06 in) in length that burrows into

branches, introduces a pathogenic fungus as food for its larvae, and lays its eggs. Twigs, branches, and even the entire plant can be killed from such an infestation. In the Hawaiian Islands, black twig borer has many hosts, disperses easily, and is probably present at most elevations up to 2,500 ft (670 m). It is known to attack species of *Melicope* and is a potential threat to *Melicope haupuensis*, *M. knudsenii*, *M. pallida*, and *M. quadrangularis*, all of which grow in areas where the insect is believed to be present (Davis 1970; Hara and Beardsley 1979; Hill 1987; Medeiros *et al.* 1986; Samuelson 1981; S. Montgomery, pers. comm., 1991).

D. The Inadequacy of Existing Regulatory Mechanisms

Hawaii's Endangered Species Act states, "Any species of aquatic life, wildlife, or land plant that has been determined to be an endangered species pursuant to the [Federal] Endangered Species Act shall be deemed to be an endangered species under the provisions of this chapter * * *" (HRS, sect. 195D-4(a)). Federal listing would automatically invoke listing under Hawaii State law, which prohibits taking of endangered plants in the State and encourages conservation by State agencies (HRS, sect. 195D-4).

None of the 24 taxa in this final rule are listed by the State. Twelve taxa have populations located on privately owned land. Two taxa, *Melicope quadrangularis* and *Schiedea spergulina* var. *leiopoda*, are found exclusively on private land. *Peucedanum sandwicense* is found on City and County of Honolulu land and federally managed land, as well as State land. At least one population of each taxon except *Schiedea spergulina* var. *leiopoda* and *Melicope quadrangularis* occur on State land. Eleven of the taxa are located in State parks, NARs, or the seabird sanctuary, which have rules and regulations for the protection of resources (DLNR 1981b; HRS, sects. 183D-4, 184-5, 195-5, and 195-8). One or more populations of each of the 24 taxa except *Schiedea spergulina* var. *leiopoda* is located on land classified within conservation districts and owned by the City and County of Honolulu, the State of Hawaii, or private companies or individuals. Regardless of the owner, lands within these districts are regarded as necessary for the protection of endemic biological resources and for the maintenance, enhancement, or conservation of natural resources. Activities permitted in conservation districts are chosen by considering how best to make multiple use of the land (HRS, sect. 205-2). Some uses, such as

maintaining animals for hunting, are based on policy decisions, while others, such as preservation of endangered species, are mandated by both Federal and State laws.

Requests for amendments to district boundaries or variances within existing classifications can be made by government agencies and private landowners (HRS, sect. 205-4). Before decisions about these requests are made, the impact of the proposed reclassification on "preservation or maintenance of important natural systems or habitat" (HRS, sects. 205-4, 205-17), as well as the maintenance of natural resources, is required to be taken into account (HRS, sects. 205-2, 205-4). Before any land use change proposed to occur on county or State lands and funded, in part or in whole, by county or State funds, or would occur within land classified as conservation district, an environmental assessment is required to determine whether or not the environment would be significantly affected (HRS, chapt. 343). If it is found that an action would have a significant effect, preparation of a full Environmental Impact Statement is required. Hawaii environmental policy and, thus, approval of land use, is required by law to safeguard " * * * the State's unique natural environmental characteristics * * *" (HRS, sect. 344-3(1)) and includes guidelines to "Protect endangered species of individual plants and animals * * *" (HRS, sect. 344-4(3)(A)). Federal listing, because it automatically invokes State listing, would trigger operation of these other State regulations protecting the plants.

State laws relating to the conservation of biological resources allow for the acquisition of land as well as the development and implementation of programs concerning the conservation of biological resources (HRS, sect. 195D-5(a)). The State also may enter into agreements with Federal agencies to administer and manage any area required for the conservation, management, enhancement, or protection of endangered species (HRS, sect. 195D-5(c)). If listing were to occur, funds for these activities could be made available under section 6 of the Federal Endangered Species Act (State Cooperative Agreements). The DLNR is mandated to initiate changes in conservation district boundaries to include "the habitat of rare native species of flora and fauna within the conservation district" (HRS, sect. 195D-5.1).

Ten of the taxa are threatened by plants considered by the State of Hawaii to be noxious weeds. The State has provisions for eradication and control of

noxious weeds on State and private land in conservation districts and other areas (HRS, chapt. 152; DOA 1981, 1991). State and Federal agencies have programs to locate, eradicate, and deter marijuana cultivation, which is a potential threat to six taxa (HHP 1990c). Federal listing of these 24 plant taxa would reinforce and supplement the protection available under the Hawaii State Endangered Species Act and other laws. The Federal Endangered Species Act would offer additional protection to these 24 taxa because, if they were to be listed as endangered or threatened, it would be a violation of the Federal Endangered Species Act for any person to remove, cut, dig up, damage, or destroy any such plant in an area not under Federal jurisdiction in knowing violation of State law or regulation or in the course of any violation of a State criminal trespass law.

E. Other Natural or Manmade Factors Affecting Its Continued Existence

One or more of the almost 50 taxa of introduced plants threaten 21 of the 24 plant taxa in this rule and potentially threaten the other three. The original native flora of Hawaii consisted of about 1,000 taxa, 89 percent of which were endemic. Of the total native and naturalized Hawaiian flora of 1,817 taxa, 47 percent were introduced from other parts of the world and nearly 100 taxa have become pests (Smith 1985, Wagner *et al.* 1990). Naturalized, introduced taxa degrade the Hawaiian landscape and compete with native plants for space, light, water, and nutrients (Cuddihy and Stone, 1990; D. Lorence, pers. comm., 1991). Some of these taxa were brought to Hawaii by various groups of people, including the Polynesian immigrants, for food or cultural reasons. Plantation owners, alarmed at the reduction of water resources for their crops caused by the destruction of native forest cover by grazing feral animals, supported the introduction of alien tree taxa for reforestation. Ranchers intentionally introduced pasture grasses and other taxa for agriculture and sometimes inadvertently introduced weed seeds as well. Other plants were brought to Hawaii for their potential horticultural value (Cuddihy and Stone 1990, Scott *et al.* 1986, Wenkam 1969).

A small tree, *Acacia confusa* (Formosa koa), was introduced to Hawaii for reforestation purposes and is naturalized in dry to mesic, disturbed habitats on most of the Hawaiian Islands (Smith 1985, Wagner *et al.* 1990). *Acacia mearnsii* (black wattle) was introduced as a cultivated plant and has naturalized on five islands in pastures

and dry to mesic forests (Wagner *et al.* 1990). It threatens *Exocarpos luteolus* (T. Flynn, pers. comm., 1991). Two subshrubs in the genus *Ageratina* have naturalized in the Hawaiian Islands and are classified as noxious weeds by the State (Hawaii, Department of Agriculture (DOA) 1981). *Ageratina adenophora* (Maui pamakani), naturalized in dry areas to wet forests on four islands, is also classified as a noxious weed by the Federal government (7 CFR 360). It threatens *Peucedanum sandwicense* (HHP 1991u16; Wagner *et al.* 1990). *Ageratina riparia* (Hamakua pamakani) is naturalized in disturbed, dry to mesic areas and wet forest on four islands and is a threat to *Lysimachia filifolia*, as well as to *Peucedanum sandwicense* (HHP 1991u16; HPCC 1990g2, 1990j1, 1990j3; Wagner *et al.* 1990). *Ageratum conyzoides* (maile hohono), an herb that is a common weed in many areas of the main Hawaiian Islands, threatens *Brighamia insignis* in some areas (HHP 1991a1; Wagner *et al.* 1990).

Although it is the official State tree of Hawaii, *Aleurites moluccana* (kukui) is not a native Hawaiian plant. It was originally native to Malesia. It was brought to Hawaii by the Polynesian immigrants and is now a component of mesic valley ecosystems on all of the main islands except Kahoolawe (Wagner *et al.* 1990). One or more populations of *Hibiscus clayi*, *Lipochaeta fauriei*, *Munroidendron racemosum*, and *Pteralyxia kauaiensis* grow in areas with kukui, which may compete with these native species for space. *Hibiscus clayi* and *Lipochaeta fauriei* do not grow under a dense canopy, so kukui could prevent them from regenerating in an area. *Munroidendron racemosum* and *Pteralyxia kauaiensis*, overstory trees in native forests, are displaced when kukui dominates (HHP 1991b2, 1991s1, 1991s4, 1991s5, 1991s8, 1991s10, 1991s15, 1991w1, 1991w4, 1991w5; HPCC 1990d3; Lamoureux 1982; T. Flynn, J. Lau, and S. Perlman, pers. comms., 1991). *Araucaria columnaris* (columnar araucaria), planted in Hawaii for reforestation and timber production and now found on all the main islands, is reseeding and threatens *Hibiscus clayi* (Little and Skolman 1989; Neal 1965; D. Bates, pers. comm., 1991). *Bidens pilosa* (Spanish needle), an annual herb naturalized on all the main Hawaiian Islands, is a threat to *Peucedanum sandwicense* (Ganders and Nagata 1990, HHP 1991u15).

Classified as a noxious weed by the State of Hawaii, *Clidemia hirta* (Koster's curse) is an aggressive shrub found in mesic to wet forests on at least five islands in Hawaii (Almeda 1990, DOA

1981). It is a threat to *Melicope pallida* and *Peucedanum sandwicense*. It is a potential threat to *Cyrtandra limahuliensis* (HHP 1990c; T. Flynn and S. Montgomery, pers. comms., 1991). *Cordylone fruticosa* (ti) is a shrub that was brought to Hawaii by the Polynesian immigrants. Its original range is unknown, but in Hawaii it is now naturalized on all the main islands except Kahoolawe in hala forest and mesic valleys and forests, sometimes forming dense stands (Wagner *et al.* 1990; J. Lau, pers. comm., 1991). One or more populations of the following taxa compete for space with ti: *Delissea rhytidosperra*; *Hibiscus clayi*; *Lipochaeta micrantha* var. *exigua*; *Lysimachia filifolia*; *Munroidendron racemosum*; and *Pteralyxia kauaiensis* (HHP 1991d2, 1991h1, 1991h2, 1991j1, 1991s1, 1991w7; HPCC 1990c, 1990e, 1990g2; J. Lau, T. Flynn, and S. Perlman, pers. comms., 1991). *Corynocarpus laevigatus* (karakanut), a tree introduced to Hawaii for reforestation, is now found on four islands and is a threat to *Exocarpos luteolus* (Wagner *et al.* 1990; T. Flynn, pers. comm., 1991).

Brought to Hawaii as a cultivated herbaceous plant, *Erigeron karvinskianus* (daisy fleabane) is naturalized in wetter areas of four islands (Wagner *et al.* 1990). Invasion by daisy fleabane threatens *Exocarpos luteolus*, *Lipochaeta micrantha* var. *micrantha*, *Melicope pallida*, *Nothoctrum peltatum*, and *Peucedanum sandwicense* (HHP 1991k1; HPCC 1990f, 1990i4, 1990j2; T. Flynn and K. Wood, pers. comms., 1991). *Furcraea foetida* (Mauritius hemp), a large rosette plant naturalized on most islands in Hawaii on rocky ledges, slopes, and in pastures, threatens *Schiedea spergulina* var. *leiopoda* (Wagner *et al.* 1990; T. Flynn, pers. comm., 1991). *Grevillea banksii* (kahili flower), considered a noxious weed by the State of Hawaii, was introduced as a cultivated tree and has naturalized in disturbed, dry to wet forests on most of the main Hawaiian Islands (DOA 1981, Wagner *et al.* 1990). It threatens *Cyrtandra limahuliensis* (T. Flynn, pers. comm., 1991). *Grevillea robusta* (silk oak) was extensively planted in Hawaii for timber and is now naturalized on most of the main islands (Smith 1985, Wagner *et al.* 1990). Silk oak threatens *Lipochaeta waimeanaensis* and *Peucedanum sandwicense* (HPCC 1990j1; S. Perlman, pers. comm., 1991).

Three species of *Hedychium* (ginger), native to the Himalayas and surrounding areas, were brought to Hawaii as ornamentals and are now naturalized in mesic or wet forests. Two

of these species threaten one or more of the 24 taxa in this rule. Their rhizomes produce rapid, vegetative growth, forming dense ground cover that excludes other plants. The Wainiha population of *Cyrtandra limahuliensis* is threatened by *H. flavescens* (yellow ginger) (T. Flynn and K. Wood, pers. comms., 1991). *Hedychium gardnerianum* (kahili ginger) produces red seeds that are distributed by alien fruit-eating birds; it threatens *Solanum sandwicense* (Cuddihy and Stone 1990; HPCC 1990m; Nagata 1990; Smith 1985; T. Flynn and K. Wood, pers. comms., 1991). *Kalanchoe pinnata* (air plant) is an herb that occurs on all the main islands except Niihau and Kahoolawe, especially in dry to mesic areas (Wagner *et al.* 1990). Populations of *Brighamia insignis* and *Peucedanum sandwicense* are threatened by competition with air plant (HHP 1991u15, Takeuchi 1982).

Lantana camara (lantana), brought to Hawaii as an ornamental plant, is an aggressive, thicket-forming shrub that can now be found on all of the main islands in mesic forests, dry shrublands, and other dry, disturbed habitats (Wagner *et al.* 1990). One or more populations of each of the following taxa are threatened by lantana: *Brighamia insignis*; *Delissea rhytidosperra*; *Diellia pallida*; *Hibiscus clayi*; *Lipochaeta fauriei*; both varieties of *Lipochaeta micrantha*; *Melicope haupeensis*; *Melicope knudsenii*; *Munroidendron racemosum*; *Nothoctrum peltatum*; *Peucedanum sandwicense*; *Pteralyxia kauaiensis*; and both varieties of *Schiedea spergulina* (HHP 1991a1 to 1991a3, 1991e3, 1991i1, 1991j1, 1991k1, 1991o1, 1991p2 to 1991p4, 1991s1, 1991s5, 1991s11, 1991s15, 1991t7, 1991u1, 1991u3, 1991u5, 1991w4, 1991w7, 1991y5; HPCC 1990a, 1990d1, 1990d2, 1990e, 1990f, 1990k1, 1990k2; T. Flynn, R. Hobdy, D. Lorence, and S. Perlman, pers. comms., 1991).

Leucaena leucocephala (koa haole), a shrub naturalized and sometimes the dominant species in low elevation, dry, disturbed areas on all of the main Hawaiian Islands, threatens the following plants: *Lipochaeta waimeanaensis*; *Munroidendron racemosum*; and *Schiedea spergulina* var. *leiopoda* (Geesnick *et al.* 1990; HHP 1991s3; Lamoureux 1982; T. Flynn and S. Perlman, pers. comms., 1991). *Lonicera japonica* (Japanese honeysuckle) is becoming naturalized in mesic to wet areas on Kauai and Hawaii and threatens *Solanum sandwicense* (Brueggemann 1990, HPCC 1990m, Wagner *et al.* 1990). *Melastoma candidum*, a small cultivated tree that is now naturalized in mesic to wet areas of

Kauai, threatens some populations of *Cyrtandra limahuliensis*. *Melia azedarach* (Chinaberry), a small tree widely cultivated and naturalized on most of the main Hawaiian Islands, threatens *Diellia pallida*, *Munroidendron racemosum*, and *Schiedea spergulina* var. *spergulina* (HHP 1991e3, 1991y5; HPCC 1990h; Wagner *et al.* 1990). The aggressive *Myrica faya* (firetree) has become a dominant plant in many mesic to wet forests on five Hawaiian Islands. Populations of *Exocarpos luteolus*, *Munroidendron racemosum*, and *Peucedanum sandwicense* are threatened by firetree (HHP 1991u3; HPCC 1990h; S. Perlman, pers. comm., 1991). *Opuntia ficus-indica* (prickly pear, panini) is a cactus found in dry, disturbed habitats on five islands and poses a threat to *Lipochaeta waimeaensis* (Solomon 1990; S. Perlman, pers. comm., 1991).

Passiflora edulis (passion fruit) is a woody vine that occurs on five Hawaiian Islands in mesic forests and shrublands and threatens *Nothoecstrum peltatum* (Escobar 1990, HPCC 1990i3). *Passiflora ligularis* (sweet granadilla) is a woody vine that now occurs in diverse mesic forest and wet forest on four islands and threatens *Delissea rhytidosperra* (Escobar 1990; S. Perlman, pers. comm., 1991). *Passiflora mollissima* (banana poka), another woody vine, poses a serious problem to mesic forests on Kauai and Hawaii by covering trees, reducing the amount of light that reaches trees as well as understory. It causes damage and death to trees by the weight of the vines. Animals, especially feral pigs, eat the fruit and distribute the seeds (Cuddihy and Stone 1990, Escobar 1990). Banana poka threatens *Delissea rhytidosperra*, *Nothoecstrum peltatum*, *Peucedanum sandwicense*, *Pteralyxia kauaiensis*, and *Solanum sandwicense* (HHP 1991d1, 1991u5; HPCC 1990i3, 1990m; D. Herbst, R. Hobdy, and J. Lau, pers. comms., 1991). *Pluchea carolinensis* (sourbush), a shrub naturalized in dry, coastal areas and mesic and wet forest on all of the main Hawaiian Islands, threatens *Lysimachia filifolia* and *Peucedanum sandwicense* (HPCC 1990g2; Wagner *et al.* 1990; R. Hobdy, pers. comm., 1991).

Two shrubs or small trees, *Psidium cattleianum* (strawberry guava) and *Psidium guajava* (common guava) were brought to Hawaii and have become widely naturalized on all the main islands, forming dense stands in disturbed areas. Strawberry guava, found in mesic and wet forests, develops into stands in which few other plants grow, physically displacing

natural vegetation and greatly affecting Hawaiian plants, many of which are narrowly endemic taxa. Pigs use strawberry guava for food and, in turn, disperse the plant's seeds through the forests (Smith 1985, Wagner *et al.* 1990). Strawberry guava is considered to be the greatest weed problem in Hawaiian rain forests and is known to pose a threat to *Brighamia insignis*, *Cyrtandra limahuliensis*, *Hibiscus clayi*, *Lipochaeta fauriei*, and *Lipochaeta micrantha* var. *exigua*, and it is a potential threat to *Melicope quadrangularis* (HHP 1991a1; HPCC 1990c, 1990e; Smith 1985; T. Flynn, pers. comm., 1991; D. Lorence *et al.*, *in litt.*, 1991). Common guava invades disturbed sites, forming dense thickets in dry as well as mesic and wet forests (Smith 1985, Wagner *et al.* 1990). Common guava threatens *Brighamia insignis*, *Cyrtandra limahuliensis*, *Hibiscus clayi*, *Lipochaeta fauriei*, *Melicope pallida*, *Munroidendron racemosum*, *Peucedanum sandwicense*, and *Pteralyxia kauaiensis* (Lamoureux 1982; HHP 1991a1, 1991a4, 1991s1, 1991s4, 1991s5, 1991u3, 1991u16; HPCC 1990d1, 1990h; T. Flynn, R. Hobdy, and J. Lau, pers. comms., 1991).

Rubus argutus (prickly Florida blackberry), an aggressive alien species in disturbed mesic to wet forests and subalpine grasslands on four islands, is considered a noxious weed by the State of Hawaii (DOA 1981, Smith 1985, Wagner *et al.* 1990). Prickly Florida blackberry threatens *Exocarpos luteolus*, *Melicope pallida*, *Melicope quadrangularis*, *Nothoecstrum peltatum*, and *Solanum sandwicense* (HHP 1991z18, 1991z25; HPCC 1990i3, 1990i4, 1990m; T. Flynn, D. Herbst, R. Hobdy, J. Lau, S. Perlman, and K. Wood, pers. comms., 1991). *Schefflera actinophylla* (octopus tree), brought to Hawaii as a cultivated tree, is shade tolerant and becomes established in undisturbed forests (Lowrey 1990, Smith 1985). It is now naturalized on at least four islands and is a threat to *Lysimachia filifolia* as well as a potential threat to *Peucedanum sandwicense* (HHP 1990c, HPCC 1990g2).

After escaping from cultivation, *Schinus terebinthifolius* (Christmas berry) became naturalized on most of the main Hawaiian Islands (Wagner *et al.* 1990). It threatens *Hibiscus clayi* and is a potential threat to *Peucedanum sandwicense* (HHP 1990c, 1991h1; HPCC 1990j1, 1990j3; T. Flynn, pers. comm., 1991). Four species of the genus *Stachytarpheta* have naturalized in the Hawaiian Islands, usually in disturbed areas (Wagner *et al.* 1990). These alien herbs or subshrubs threaten *Brighamia*

insignis and *Peucedanum sandwicense* (HHP 1991a1, HPCC 1990j1). *Syzygium cumini* (Java plum), a tree naturalized in disturbed mesic forests on most of the main Hawaiian Islands, threatens *Brighamia insignis*, *Hibiscus clayi*, *Melicope quadrangularis*, and *Peucedanum sandwicense* (HHP 1991a1, 1991a2, 1991h1, 1991h2, 1991u1, 1991u3; HPCC 1990a; Wagner *et al.* 1990; K. Wood, pers. comm., 1991). *Triumfetta semitriloba* (Sacramento bur) is a subshrub now found on four Hawaiian Islands and considered to be a noxious weed by the State of Hawaii (DOA 1981, Wagner *et al.* 1990). Populations of *Munroidendron racemosum* and *Schiedea spergulina* var. *spergulina* are threatened by Sacramento bur (HHP 1991y5, HPCC 1990h). *Toona ciliata* (Australian red cedar), a tree now naturalized on four Hawaiian Islands, is quickly spreading in forests of the Waianae Mountains on Oahu and threatens *Melicope pallida* (Wagner *et al.* 1990; S. Montgomery, pers. comm., 1991).

Several hundred species of grasses have been introduced to the Hawaiian Islands, many for animal forage. Approximately 100 grass species have become naturalized. *Melinis minutiflora* (molasses grass), a perennial grass brought to Hawaii for cattle fodder, is now naturalized in dry to mesic, disturbed areas on most of the main Hawaiian Islands. Formed mats smother out other plants and fuel more intense fires than would normally affect an area (Cuddihy and Stone 1990, O'Connor 1990, Smith 1985). Plants threatened by molasses grass are *Brighamia insignis*, *Lipochaeta fauriei*, and populations of *Peucedanum sandwicense* (HHP 1991a1, 1991a3, 1991u3; HPCC 1990a; R. Hobdy and S. Perlman, pers. comms., 1991). *Oplismenus hirtellus* (basketgrass) is a perennial grass that is naturalized in shaded mesic valleys and forests and sometimes in wet forests on most of the main Hawaiian Islands (O'Connor 1990). *Diellia pallida*, *Hibiscus clayi*, and *Lipochaeta fauriei* are threatened by basketgrass (HHP 1991h1; HPCC 1990c, 1990d3; W.H. Wagner, pers. comm., 1991). The perennial grass, *Paspalum conjugatum* (Hilo grass), naturalized in moist to wet, disturbed areas on most Hawaiian Islands, produces a dense ground cover, even on poor soil, and threatens *Cyrtandra limahuliensis* and *Hibiscus clayi* (Cuddihy and Stone 1990, O'Connor 1990, Smith 1985; T. Flynn and R. Hobdy, pers. comms., 1991).

Pennisetum clandestinum (Kikuyu grass), an aggressive, perennial grass introduced to Hawaii as a pasture grass,

withstands trampling and grazing and has naturalized on four Hawaiian Islands in dry to mesic forest. It produces thick mats that choke out other plants and prevent their seedlings from establishing and has been declared a noxious weed by the U.S. Department of Agriculture (7 CFR 360) (DOA 1991, Medeiros *et al.* 1986, O'Connor 1990, Smith 1985). Kikuyu grass threatens *Melicope knudsenii* (R. Hobdy, pers. comm., 1991). *Rhynchelytrum repens* (Natal redtop) is an annual or perennial grass that is naturalized in disturbed, usually dry areas on all the main Hawaiian Islands and threatens *Lipochaeta waimeaensis* (O'Connor 1990; S. Perlman, pers. comm., 1991). *Setaria gracilis* (yellow foxtail), a perennial grass naturalized in wet to dry, disturbed habitat on most of the main Hawaiian Islands, threatens *Brighamia insignis*, *Melicope haupuensis*, and *Peucedanum sandwicense* (HHP 1991a1, 1991a3, 1991o1, 1991u3; O'Connor 1990). A perennial grass naturalized in disturbed areas on most of the main Hawaiian Islands, *Sporobolus africanus* (smutgrass) threatens *Brighamia insignis* and *Peucedanum sandwicense* (HHP 1991a1, 1991a3, 1991u15; O'Connor 1990).

Because Hawaiian plants were subjected to fire during their evolution only in areas of volcanic activity and from occasional lightning strikes, they are not adapted to recurring fire regimes and are unable to recover well following a fire. Alien plants are often better adapted to fire than native plant taxa and some fire-adapted grasses have become widespread in Hawaii. The presence of such taxa in Hawaiian ecosystems greatly increases the intensity, extent, and frequency of fire. Fire-adapted alien taxa can reestablish in a burned area, resulting in a reduction in the amount of native vegetation after each fire. Fire is a serious, immediate threat along the Na Pali coast, especially during drier months. Fires are caused by people pursuing recreational activities and prevailing winds spread fires to inland areas. Fire could destroy dormant seeds as well as plants, even on steep cliffs (Clarke and Cuddihy 1980, Corn *et al.* 1979, Cuddihy and Stone 1990). Fire is a threat to *Brighamia insignis*, *Exocarpos luteolus*, *Melicope pallida*, *Munroidendron racemosum*, *Nothoctrum peltatum*, *Peucedanum sandwicense*, *Pteralyxia kauaiensis*, and *Solanum sandwicense*. In addition, *Lipochaeta fauriei* is threatened by fire because it occurs with molasses grass, a fire-adapted alien plant. The only

population of *Delissea rhytidosperra* is also considered to be threatened by fire. The Maui population of *Melicope knudsenii* is potentially threatened by fire, since it grows in a pasture area covered by a thick mat of Kikuyu grass (Brueggemann 1990; Cuddihy and Stone 1990; HHP 1991a1, 1991a3, 1991f3, 1991f6, 1991q6, 1991s2, 1991s5 to 1991s8, 1991s10, 1991s14, 1991s15, 1991t1, 1991t2, 1991u1, 1991u5, 1991u6, 1991u15, 1991u17, 1991w2, 1991w4, 1991z11, 1991z12, 1991z18, 1991z25; HPCC 1990i4; Medeiros *et al.* 1986; St. John 1981b; R. Hobdy, pers. comm., 1991).

Illegal cultivation of *Cannabis sativa* (marijuana) occurs in isolated portions of public and private lands in the Hawaiian Islands. This agricultural practice opens areas in native forests into which alien plants invade after the patches are abandoned (HHP 1990c). Marijuana cultivation is considered a management problem in Hono O Na Pali and Kuia NARs and is a potential threat to the following taxa, which have populations in those areas: *Brighamia insignis*; *Delissea rhytidosperra*; *Munroidendron racemosum*; *Peucedanum sandwicense*; *Pteralyxia kauaiensis*; and *Solanum sandwicense* (HHP 1991a1, 1991d1, 1991s5, 1991s6, 1991u6, 1991w1, 1991z25; HHP and DOFAW 1989).

The small numbers of populations and individuals of most of these taxa increase the potential for extinction from stochastic events. The limited gene pool may depress reproductive vigor or a single human-caused or natural environmental disturbance could destroy a significant percentage of the individuals or the only known extant population. Eight of the taxa, *Cyanea asarifolia*, *Delissea rhytidosperra*, *Hedyotis cookiana*, *Hibiscus clayi*, *Lipochaeta waimeaensis*, *Melicope haupuensis*, *Melicope quadrangularis*, and *Schiedea spergulina* var. *leiopoda* are known from a single population. Ten other taxa are known from only two to five populations (see Table 1). Seventeen of the taxa are estimated to number no more than 100 known individuals (see Table 1). Seven of these taxa, *Cyanea asarifolia*, *Delissea rhytidosperra*, *Diellia pallida*, *Hibiscus clayi*, *Lipochaeta waimeaensis*, *Melicope haupuensis*, and *Phyllostegia waimeae*, number no more than 10 individuals.

Erosion, landslides, and rock slides due to natural weathering, result in the death of individual plants as well as habitat destruction. This especially affects the continued existence of taxa with limited numbers and/or narrow ranges, such as *Cyanea asarifolia*,

Delissea rhytidosperra, *Lysimachia filifolia*, *Schiedea spergulina* var. *leiopoda*, and *Solanum sandwicense* (CPC 1990; HHP 1991b2; HPCC 1990g1, 1990g2; T. Flynn and W.L. Wagner, pers. comms., 1991; D. Lorence *et al.* in litt., 1991). Individuals of other species, such as *Hedyotis cookiana* and *Cyrtandra limahuliensis*, are potentially threatened by substrate loss. This process is often exacerbated by human disturbance and land use practices (see Factor A).

In November 1982, Hurricane Iwa struck the Hawaiian Islands and caused extensive damage, especially on the island of Kauai. Many forest trees were destroyed, opening the canopy and, thus, allowing the invasion of light-loving alien plants. These plants are a threat to the continued existence of many of the taxa in this rule. Hurricane Iniki hit the island of Kauai in September 1992 and caused significant damage to rare plant populations on that island. Populations of at least four taxa in this rule were seriously damaged by this hurricane. *Cyanea asarifolia*, *Brighamia insignis*, *Lysimachia filifolia*, and *Delissea rhytidosperra*. Damage by additional hurricanes could further decrease the already reduced habitat of all 24 taxa.

The Service has carefully assessed the best scientific and commercial information available regarding the past, present, and future threats faced by these taxa in determining to make this rule final. Based on this evaluation, the preferred action is to list 21 of these plant taxa as endangered, *Brighamia insignis* ('olulu), *Cyanea asarifolia* (haha), *Delissea rhytidosperra* (no common name (NCN)), *Diellia pallida* (NCN), *Exocarpos luteolus* (heau), *Hedyotis cookiana* ('awiwii), *Hibiscus clayi* (Clay's hibiscus), *Lipochaeta fauriei* (nehe), *Lipochaeta micrantha* (nehe), *Lipochaeta waimeaensis* (nehe), *Lysimachia filifolia* (NCN), *Melicope haupuensis* (alani), *Melicope knudsenii* (alani), *Melicope pallida* (alani), *Melicope quadrangularis* (alani), *Munroidendron racemosum* (NCN), *Nothoctrum peltatum* ('aiea), *Phyllostegia waimeae* (NCN), *Pteralyxia kauaiensis* (kaulu), *Schiedea spergulina* var. *leiopoda* (NCN), and *Solanum sandwicense* (popolo'aiakeakua). The preferred action for the remaining three plant taxa is to list them as threatened, *Cyrtandra limahuliensis* (ha'iwale), *Peucedanum sandwicense* (makou), and *Schiedea spergulina* var. *spergulina* (NCN). Nineteen of the taxa determined to be endangered either number no more than 100 individuals or are known from 5 or fewer populations. Small population size and limited distribution

make these taxa particularly vulnerable to extinction and/or reduced reproductive vigor from stochastic events. The 21 taxa are threatened by 1 or more of the following: Habitat degradation and/or predation by feral goats, feral cattle, feral pigs, rats, and deer; competition from alien plants; natural disaster; human impacts; and lack of legal protection or difficulty in enforcing laws that are already in effect. Because these 21 taxa are in danger of extinction throughout all or a significant portion of their ranges, they fit the definition of endangered as defined in the Act.

Populations of three taxa (*Cyrtandra limahuliensis*, *Peucedanum sandwicense*, and *Schiedea spergulina* var. *spergulina*) are threatened to some degree by fire, competition with alien plant taxa, and predation by feral animals. The widespread distribution of populations and total number of individuals reduces the likelihood that these taxa will become extinct in the near future. For these reasons, these taxa are not now in immediate danger of extinction throughout all or a significant portion of their ranges. However, *Cyrtandra limahuliensis*, *Peucedanum sandwicense*, and *Schiedea spergulina* var. *spergulina* are likely to become endangered in the foreseeable future if these threats are not curtailed. As a result, *Cyrtandra limahuliensis*, *Peucedanum sandwicense*, and *Schiedea spergulina* var. *spergulina* fit the definition of threatened species as defined in the Act.

Critical habitat is not being designated for the 24 taxa included in this rule, for reasons discussed in the "Critical Habitat" section of this rule.

Critical Habitat

Section 4(a)(3) of the Act, as amended, requires that, to the maximum extent prudent and determinable, the Secretary designate critical habitat at the time the taxa is listed. The Service finds that designation of critical habitat is not presently prudent for these species. As discussed under Factor B in the "Summary of Factors Affecting the Species," the species face numerous anthropogenic threats. The publication of precise maps and descriptions of critical habitat in the **Federal Register**, as required for the designation of critical habitat, would increase the degree of threat to these plants from take or vandalism and, therefore, could contribute to their decline and increase enforcement problems. The listing of these species under the Act publicizes the rarity of the plants and, thus, can make these plants attractive to researchers, curiosity seekers, or

collectors of rare plants. All involved parties and the major landowners have been notified of the importance of protecting the habitat of these species. Protection of the habitat of the species will be addressed through the recovery process and through the section 7 consultation process. There is only one Federal activity within the currently known habitats of these plants. One species is located on land owned by the Department of Hawaiian Home Lands and is currently under a cooperative management agreement with the National Park Service in Kalaupapa National Historical Park on the island of Molokai. As protection of the species is now under the jurisdiction of the National Park Service, Federal laws protect all plants in the park from damage or removal. Therefore, the Service finds that designation of critical habitat for these species is not prudent at this time, because such designation would increase the degree of threat from vandalism, collecting, or other human activities and because it is unlikely to aid in the conservation of these species.

Available Conservation Measures

Conservation measures provided to species listed as endangered or threatened under the Endangered Species Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain activities. Recognition through listing encourages and results in conservation actions by Federal, State, and private agencies, groups, and individuals. The Endangered Species Act provides for possible land acquisition and cooperation with the State and requires that recovery actions be carried out for all listed species. The protection required of Federal agencies and the prohibitions against certain activities involving listed plants are discussed, in part, below.

Section 7(a) of the Act, as amended, requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to its critical habitat, if any is being designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR part 402. Section 7(a)(2) of the Act requires Federal agencies to insure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species or to destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service. One population of *Peucedanum*

sandwicense is located in Kalaupapa National Historical Park. Laws relating to national parks prohibit damage or removal of any plants growing in the parks. There are no other known Federal activities that occur within the present known habitat of these 24 plant species.

The Act and its implementing regulations found at 50 CFR 17.61, 17.62, and 17.63 for endangered plants and 17.71 and 17.72 for threatened plants not covered by a special rule, set forth a series of prohibitions and exceptions that apply to listed plant species. With respect to the 24 plant species listed as endangered or threatened in this rule, the prohibitions of section 9(a)(2) of the Act, implemented by 50 CFR 17.61 or 17.71, apply. These prohibitions, in part, make it illegal for any person subject to the jurisdiction of the United States to import or export; transport in interstate or foreign commerce in the course of a commercial activity; sell or offer for sale in interstate or foreign commerce; remove and reduce to possession any such species from areas under Federal jurisdiction; maliciously damage or destroy any such species on any area under Federal jurisdiction; or remove, cut, dig up, damage, or destroy any such species on any other area in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law. Seeds from cultivated specimens of threatened plant species are exempt from these prohibitions provided that a statement of "cultivated origin" appears on their containers. Section 4(d) of the Act allows for the provision of such protection to threatened species. Certain exceptions apply to agents of the Service and State conservation agencies. The Act and 50 CFR 17.62, 17.63, and 17.72 also provide for the issuance of permits to carry out otherwise prohibited activities involving endangered or threatened plant species under certain circumstances. It is anticipated that few trade permits would ever be sought or issued because the species are not common in cultivation or in the wild.

Requests for copies of the regulations concerning listed plants and inquiries regarding prohibitions and permits may be addressed to the U.S. Fish and Wildlife Service, Ecological Services, Permits Branch, 911 N.E. 11th Avenue, Portland, Oregon 97232-4181 (503/231-6241; FAX 503-231-6243).

National Environmental Policy Act

The Fish and Wildlife Service has determined that an Environmental Assessment, as defined under the authority of the National Environmental

Policy Act of 1969, need not be prepared in connection with regulations adopted pursuant to section 4(a) of the Endangered Species Act of 1973, as amended. A notice outlining the Service's reasons for this determination was published in the **Federal Register** on October 25, 1983 (48 FR 49244).

References Cited

A complete list of all references cited herein is available upon request from the Pacific Islands Office (see ADDRESSES above).

Author

The authors of this final rule are Loyal A. Mehrhoff, Marie M. Brueggemann, Derral R. Herbst, Joan E. Canfield, Z.E. Ellshoff, and Joan M. Yoshioka, Ecological Services, Pacific Islands

Office, U.S. Fish and Wildlife Service, 300 Ala Moana Boulevard, room 6307, P.O. Box 50167, Honolulu, Hawaii 96850 (808/541-3441). Substantial data was generously contributed by Tim Flynn and David Lorence, National Tropical Botanical Garden; and Steve Perlman and Ken Woods, Hawaii Plant Conservation Center, and Joel Lau, Hawaii Heritage Program.

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, and Transportation.

Regulation Promulgation

Accordingly, part 17, subchapter B of chapter I, title 50 of the Code of Federal

Regulations, is amended as set forth below:

PART 17—[AMENDED]

1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361-1407; 16 U.S.C. 1531-1544; 16 U.S.C. 4201-4245; Pub. L. 99-625, 100 Stat. 3500; unless otherwise noted.

2. Section 17.12(h) is amended by adding the following, in alphabetical order under the families indicated, to the List of Endangered and Threatened Plants:

§ 17.12 Endangered and threatened plants.

* * * * *
(h) * * *

Species		Historic range	Status	When listed	Critical habitat	Special rules
Scientific name	Common name					
Apiaceae—Parsley family:						
<i>Peucedanum sandwicense</i>	Makou	U.S.A. (HI)	T	530	NA	NA
Apocynaceae—Dogbane family:						
<i>Pteralyxia kauaiensis</i>	Kaulu	U.S.A. (HI)	E	530	NA	NA
Araliaceae—Ginseng family:						
<i>Munroidendron racemosum</i>	None	U.S.A. (HI)	E	530	NA	NA
Aspleniaceae—Spleenwort family:						
<i>Diellia pallida</i>	None	U.S.A. (HI)	E	530	NA	NA
Asteraceae—Aster family:						
<i>Lipochaeta fauriei</i>	Nehe	U.S.A. (HI)	E	530	NA	NA
<i>Lipochaeta micrantha</i>	Nehe	U.S.A. (HI)	E	530	NA	NA
<i>Lipochaeta waimeaensis</i>	Nehe	U.S.A. (HI)	E	530	NA	NA
Campanulaceae—Bellflower family:						
<i>Brighamia insignis</i>	'Oulu	U.S.A. (HI)	E	530	NA	NA
<i>Cyanea asarifolia</i>	Haha	U.S.A. (HI)	E	530	NA	NA
<i>Delissea rhytidosperma</i>	None	U.S.A. (HI)	E	530	NA	NA

Species		Historic range	Status	When listed	Critical habitat	Special rules
Scientific name	Common name					
Caryophyllaceae—Pink family:						
<i>Schiedea spergulina</i> var. <i>leiopoda</i>	None	U.S.A. (HI)	E	530	NA	NA
<i>Schiedea spergulina</i> var. <i>spergulina</i>	None	U.S.A. (HI)	T	530	NA	NA
Gesneriaceae—African Violet family:						
<i>Cyrtandra limahuliensis</i>	Ha'iwale	U.S.A. (HI)	T	530	NA	NA
Lamiaceae—Mint family:						
<i>Phyllostegia waimeae</i>	None	U.S.A. (HI)	E	530	NA	NA
Malvaceae—Mallow family:						
<i>Hibiscus clayi</i>	Clay's hibiscus	U.S.A. (HI)	E	530	NA	NA
Primulaceae—Primrose family:						
<i>Lysimachia filifolia</i>	None	U.S.A. (HI)	E	530	NA	NA
Rubiaceae—Coffee family:						
<i>Hedyotis cookiana</i>	'Awiwi	U.S.A. (HI)	E	530	NA	NA
Rutaceae—Citrus family:						
<i>Melicope haupuensis</i>	Alani	U.S.A. (HI)	E	530	NA	NA
<i>Melicope knudsenii</i>	Alani	U.S.A. (HI)	E	530	NA	NA
<i>Melicope pallida</i>	Alani	U.S.A. (HI)	E	530	NA	NA
<i>Melicope quadrangularis</i>	Alani	U.S.A. (HI)	E	530	NA	NA
Santalaceae—Sandalwood family:						
<i>Exocarpos luteolus</i>	Heau	U.S.A. (HI)	E	530	NA	NA
Solanaceae—Nightshade family:						
<i>Nothocestrum peltatum</i>	'Aiea	U.S.A. (HI)	E	530	NA	NA
<i>Solanum sandwicense</i>	Popolo 'aiakeakua.	U.S.A. (HI)	E	530	NA	NA

Dated: February 10, 1994.

Mollie H. Beattie,

Director, Fish and Wildlife Service.

[FR Doc. 94-4038 Filed 2-24-94; 8:45 am]

BILLING CODE 4310-05-P