

rhytidosperra (no common name (NCN)), *Diellia laciniata* (NCN), *Exocarpos luteolus* (heau), *Hedyotis cookiana* ('awiwi), *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), *Nothocephalum peltatum* ('aiea), *Peucedanum sandwicense* (makou), *Phyllostegia waimeae* (NCN), *Pteralyxia kauaiensis* (kaulu), *Schiedea spergulina* (NCN), and *Solanum sandwicense* (popolo'aiakeakua). All but seven of the species are or were endemic to the island of Kauai, Hawaiian Islands; the exceptions are or were found on the islands of Niihau, Oahu, Molokai, Maui, and/or Hawaii as well as Kauai. The 23 plant species and their habitats have been variously affected or are currently threatened by 1 or more of the following: Habitat degradation by wild, feral, or domestic animals (goats, pigs, 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 species and most of their populations are subject to an increased likelihood of extinction and/or reduced reproductive vigor from stochastic events. This proposal, if made final, would implement the Federal protection and recovery provisions provided by the Act. If made final, it would also implement State regulations protecting these plants as endangered species. Comments and materials related to this proposal are solicited.

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

RIN 1018—AB69

Endangered and Threatened Wildlife and Plants; Proposed Endangered Status for 23 Plants From the Island of Kauai, Hawaii

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Proposed rule.

SUMMARY: The U.S. Fish and Wildlife Service (Service) proposes endangered status pursuant to the Endangered Species Act of 1973, as amended (Act), for 23 plants: *Brighamia insignis* ('olulu), *Cyanea asarifolia* (haha), *Cyrtandra limahuliensis* (ha'iwale), *Delissea*

DATES: Comments from all interested parties must be received by December 30, 1991. Public hearing requests must be received by December 16, 1991.

ADDRESSES: Comments and materials concerning this proposal should be sent to Robert P. Smith, Field Supervisor, Pacific Islands Office, U.S. Fish and Wildlife Service, 300 Ala Moana Boulevard, room 6307, P.O. Box 50167, Honolulu, Hawaii 96850. Comments and materials received will be available for public inspection, by appointment, during normal business hours at the above address.

FOR FURTHER INFORMATION CONTACT:

Derral R. Herbst, at the above address (808/541-2749 or FTS 551-2749).

SUPPLEMENTARY INFORMATION:**Background**

Brighamia insignis, *Cyanea asarifolia*, *Cyrtandra limahuliensis*, *Delissea rhytidosperma*, *Diellia laciniata*, *Exocarpos luteolus*, *Hedyotis cookiana*, *Hibiscus clayi*, *Lipochaeta fauriei*, *Lipochaeta micrantha*, *Lipochaeta waimeaensis*, *Lysimachia filifolia*, *Melicope haupuensis*, *Melicope knudsenii*, *Melicope pallida*, *Melicope quadrangularis*, *Munroidendron racemosum*, *Nothoctrum peltatum*, *Peucedanum sandwicense*, *Phyllostegia waimeae*, *Pteralyxia kauaiensis*, *Schiedea spergulina*, and *Solanum sandwicense* are endemic to or have the majority of their populations on the island of Kauai, Hawaii. Sixteen of these species are endemic to the island of Kauai, Hawaii; two additional species are now found only on Kauai. One of these species 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 (Dept. 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 (Dept. of Geography 1983). Because the highest point of Kauai, at Kawaikini Peak, is only 5,243 feet (ft) (1,598 meters (m)) in elevation (Walker 1990), 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 in elevation (1,569 m) (Walker 1990) and 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 (Gagne and Cuddihy 1990) or pasture. Intentional or inadvertent introduction of alien plant and animal species 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 23 species proposed in this rule occur in that district, between 400 and 4,000 ft (120 and 1,200 m) in elevation in the western and northwestern portions of the island within large State-owned tracts of natural area reserves, forest reserves, and parks. Most of the proposed species 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 species.

The 23 species proposed 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 species 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 23 proposed species 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 species,

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).

Eighteen of the 23 species 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) in 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 that 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) in 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. *Nothoctrum peltatum* and *Phyllostegia waimeae* are the only proposed species found strictly within these montane communities, which typically occur above 3,000 ft (1,000 m) in elevation (HHP 1991). The annual rainfall in montane communities may exceed 280 in (700 cm) (Gagne and Cuddihy 1990).

The land that supports these 23 plant species 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 23 Species Proposed for Listing

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 Ezechiele 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 which Thomas G. Lammers (1990), in the currently accepted treatment of the family, 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 three to eight 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 which contains 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 Honolulu and Waiauakua 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). The 5 populations grow on State and private land and total fewer than 100 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, and John Fay, U.S. Fish and Wildlife Service, pers. comms., 1991). This species grows predominantly on the rocky ledges, with little soil, of steep sea cliffs in lowland dry grassland and shrubland from sea level to 1,300 ft (400 m) in elevation (Gagne and Cuddihy 1990, Lammers 1990). Associated plant species include *Canthium odoratum* (alahe'e), *Chamaesyce celastroides* ('akoko), *Eragrostis variabilis* (kawelu), and *Heteropogon contortus* (pili grass) (Gagne and Cuddihy 1990; HHP 1991a1 to 1991a3).

Feral individuals of *Capra hircus* (goats) pose the major threat to *Brighamia insignis* by causing defoliation and stem damage, restricting populations to inaccessible cliffs, and probably causing rock slides which degrade the plant's habitat. Alien plant species 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 posing a threat are *Lantana camara* (lantana), *Psidium cattleianum* (common guava), and *Syzygium cumini* (Java plum). Hikers transport weed seeds to areas where *Brighamia insignis* grows and dislodge rocks which can damage plants. 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. *Tetranychus cinnarbarinus* (carmine spider mite), 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; Hawaii Plant Conservation Center (HPCC) 1990a; Perlman 1979; St. John 1969b, 1981b; Stone 1957; Takeuchi 1982; Wagner *et al.* 1990; Tim Flynn, National Tropical Botanical Garden, pers. comm., 1991).

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 to 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, it 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; Steven Perlman, HPCC, 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 species 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 natural rock slides. Habitat degradation by feral individuals of *Sus scrofa* (pigs), at least one of which has invaded the plant's habitat, is a potential threat (T. Flynn, David Lorence, National Tropical Botanical

Garden, 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 locations on Kauai: Wainiha and Lumahai Valleys and near Kilauea River (HHP 1991c4, 1991c5, 1991c8). One population remains in Wainiha Valley and eight others exist on Kauai: In Limahuli Valley, Waipa Valley, on Mount Kahili, along the north fork of Wahiawa Stream, along Anahola Stream, and near Powerline Trail on private and State land (HHP 1991c1 to 1991c3, 1991c5 to 1991c7; T. Flynn, R. Hobdy, S. Perlman, and Warren L. Wagner, Smithsonian Institution, pers. comms., 1991). The 9 known populations, distributed over a 13 by 18 mi (20 by 30 km) area, range in size from solitary trees to between 50 and 100 plants (HHP 1991c1 to 1991c3, 1991c5 to 1991c7). The largest population, of "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). 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 species include 'ohi'a, *Dicranopteris linearis* (uluhe), *Gunnera kauaiensis* ('ape'ape), *Hedyotis* (manono), and *Psychotria*

(kopiko) (HHP 1991c1, 1991c7; T. Flynn, pers. comm., 1991).

The major threat to *Cyrtandra limahuliensis* is competition with invasive alien species, especially strawberry guava. Each population has additional threats: Competition with the introduced grasses *Paspalum conjugatum* (Hilo grass) and *Sacciolepis indica* (Glenwood grass) at the Mount Kahili population; competition with the alien species *Leptospermum scoparium* (tea tree) and *Grevillea banksii* (kahili flower) at the Waipa Valley population; competition with common guava and habitat degradation by feral pigs at the Anahola Stream population; and competition with *Hedyochium 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 (HHP 1991c1; T. Flynn, R. Hobdy, D. Lorence, and W.L. Wagner, pers. comms., 1991).

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 species 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 rhytidosperra* 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 five individuals, located in State-owned Kuia NAR, is known to exist (HHP 1991d1). The only other population seen in recent years was a single plant in Limahuli Valley which is now dead (Bruegmann 1990; HHP 1991d2; S. Perlman, pers. comm., 1991). 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 species include *Dianella sandwicensis* ('uki'uki), *Diospyros sandwicensis* (lama), *Nestegis sandwicensis* (olopua), and *Styphelia tameiameia* (pukiawe) (HHP 1991d1, 1991d2).

Habitat degradation by *Odocoileus hemionus* (mule deer), feral goats, and feral pigs is the major threat affecting the survival of *Delissea rhytidosperra*. Other threats are predation by *Rattus* spp. (rats) 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 five individuals, is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (Bruegmann 1990; HHP 1991d1; HPCC 1990b; John Obata, HPCC, and S. Perlman, pers. comms., 1991).

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 currently in use (Lamoureux 1988). Work in progress (Warren H. Wagner, University of Michigan, *in litt.* and pers. comm., 1991) indicates the possibility of a future taxonomic change, but one which will not affect the endangered status of this taxon.

Diellia laciniata, 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 laciniata was known historically from Halemanu on Kauai (Hillebrand 1888). It is currently known from three populations on State land on the island of Kauai; Paaiki and Mahanaloa Valleys within Kuia NAR, Koaie Canyon, and the west side of Waimea Canyon within Puu Ka Pele Forest Reserve (CPC 1989a, 1990; HHP 1991e1 to 1991e3; Wagner 1952; D. Lorence, pers. comm., 1991). The three known populations extend over a 7 by 3 mi (11 by 5 km) area. This species had not been seen since 1949, when a collection was made in Kuia NAR (Warren H. Wagner, University of Michigan, pers. comm., 1991). 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 the National Tropical Botanical Garden have since discovered 2 plants in Puu Ka Pele Forest Reserve on the west side of Waimea Canyon on State land, and in July 1991, revisited the Kuia NAR population and found 5 to 10 plants there, giving a total of fewer than 20 extant individuals for this species (J. Lau, D. Lorence, and S. Perlman, pers. comms., 1991). 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 species include koa, *Alectryon macrococcus* (mahoe), *Aleurites moluccana* (kukui), *Antidesma platyphyllum* (hame), and *Rauwolfia sandwicensis* (hao) (HHP 1991e1 to 1991e3; S. Perlman, pers. comm., 1991).

Competition with alien plants, especially lantana and *Melia azedarach* (Chinaberry), constitutes the major threat to *Diellia laciniata*. Introduced grasses, such as *Stenotaphrum secundatum* (St. Augustine grass) and *Oplismenus hirtellus* (basketgrass), and two naturalized species of Polynesian introduction, kukui and *Cordyline fruitcosa* (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 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 2 years later. The species 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 Kumuweia Ridge (HHP 1991f1, 1991f5, 1991f7). This species is now known to grow on Kumuweia Ridge as well as in Kuaikina Valley, near Honopu Trail, and on the rim of Kalalau Valley within or on the boundary of Kokee State Park (HHP 1991f3 to 1991f6) in a 3 sq mi (5 sq km) area and also on Kamalii Ridge in Kealia Forest Reserve (HHP 1991f2), roughly 16 mi (26 km) away. All 5 known populations are on State land and are estimated not to exceed 50 individuals (HHP 1991f2, 1991f4, and 1991f6; Derral Herbst, U.S. Fish and Wildlife Service, and S. Perlman, (pts. comms., 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 in lowland to montane, 'ohi'a-dominated wet forest communities (HHP 1991f1, 1991f3, 1991f4, 1991f6; Wagner *et al.* 1990). Associated species include koa, pukiawe, and uluhe (HHP 1991f2 to 1991f5).

Destruction of habitat by feral goats and pigs is the major threat to *Exocarpos luteolus*. Aggressive alien species 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 which displace native Hawaiian taxa. Other threats to this species are rats, which eat the fruits; goats, which browse the plants; and stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (HHP 1991f6; T. Flynn and S. Perlman, pers. comms., 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 Kalawaa 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, which have been observed in the area. Individuals of *Hedyotis cookiana* grown in a stream bed and on the side of a waterfall, and these areas are vulnerable to flooding and other natural disturbances (HHP 1991u6; C. Christensen and T. Flynn, pers. comms., 1991).

In 1928, Albert W. Duvel discovered several trees of *Hibiscus clayi* that had been damaged by cattle 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 Hali Stream (HHP 1991h1 to 1991h5). The 4 known populations total between 14 and 20 individuals (HHP 1991h2, 1991h3; David Bates, Cornell University, T. Flynn, and S. Perlman, pers. comms., 1991). It is unclear whether the individual in the Kokee region was a cultivated plant. One individual growing at the Wailua Agricultural Experiment Station, 1.5 mi (2.4 km) west of the Nounou population, is believed to be cultivated (T. Flynn and S. Perlman, pers. comms., 1991). This lowland dry forest species generally grows on slopes at an elevation of 750 to 1,150 ft (230 to 350 m). Associated species 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 species currently threatens this species. Strawberry guava is the greatest threat, but common guava, Hilo grass, Java plum, kukui, lantern, ti, *Acacia confusa* (Formosa koa), 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 preventing regeneration of native plants. The close proximity of most of the plants to a hiking trail makes them prone to disturbance. 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, and 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

(Wagner *et al.* 1990) of the current treatment place this name in synonymy with *L. fauriei*.

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 and Poopooiki, Haelele, and lower Hikimoe Valleys (HHP 1991i1 to 1991i4; HPCC 1990d2; 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 species include basketgrass, kukui, lama, and *Hibiscus waimeae* (Koki'o ke'oke'o); the major alien associate is lantern (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 species, especially lantern. 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 upon 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 upon 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 upon 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 flowers separates this species from the other two species of this genus that are found only on the island of Kauai (Gardner 1976, 1979; Degener and Degener 1959b, 1962; Sherff 1935b; Wagner *et al.* 1990).

Only one historical collection of *Lipochaeta micrantha* var. *exigua* is known, from "0.75 mi [1.2 km] SW of Hokunui," in the vicinity of Haupu Range on the island of Kauai (HHP 1991j3). The 2 existing 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; T. Flynn, pers. comm., 1991). *Lipochaeta micrantha* var. *micrantha* appears to have been more widely distributed historically on Kauai: Olokele Canyon, Hanapepe Valley, and in the Koloa District (HHP 1991k1,

1991k5; T. Flynn and S. Perlman, pers. comms., 1991). This variety is now only known from 2 populations located on State land in Koaie Canyon on Kauai and totalling 55 to 70 individuals (HHP 1991k1, 1991k5; S. Perlman, pers. comm., 1991). The two populations are 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 species include *alaha'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 species. 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 species such as *lantana* affect the habitats of both varieties. *Pluchea carolinensis* (sourbush) is found near var. *exigua*, and *Erigeron karvinskianus* (daisy fleabane) is a component of the habitat of var. *micrantha*. Variety *micrantha* is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (HHP 1991j1, 1991j2, 1991k1, 1991k5; HPCC 1990e, 1990f; T. Flynn, pers. comm., 1991).

Hobby collected the first specimen of *Lipochaeta waimeaensis* in 1967, and St. John named it five years later (1972). He chose the specific epithet to refer to Waimea Canyon where the plant grows.

Lipochaeta waimeaensis, 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

proposed species of the genus (*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 waimeaensis is known only from the type locality, along the rim of Kauai's Waimea Canyon on State land (HHP 1991m1). 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 shrubby 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, the native species *Dodonaea viscosa* ('a'ali'i) and *Lipochaeta connata* (nehe) (CPC 1989b, 1990; S. Perlman, pers. comm., 1991) also occur here.

Alien plant species competing with and threatening *Lipochaeta waimeaensis* include *koa haole*, *Natal redtop*, *silk tree*, and *Opuntia ficus-indica* (prickly pear). The existing soil erosion problem is exacerbated by the presence of feral pigs. 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 (G. Carr and S. Perlman, pers. comms., 1991).

In 1912 Lydgate collected a plant specimen on Kauai which 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 species 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 small a 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 species 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 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 of 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 species include mosses, ferns, liverworts, pili grass, tarweed, and *Pilea peploides* (HHP 1991n3; J. Lau, pers. comm., 1991).

The major threat to *Lysimachia filifolia* is competition with alien plant species. 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. Marsh pennywort, tarweed, and thimbleberry, although not invasive weeds, are present in this near-pristine area of Wailua Stream and degrade the native ecosystem. A small amount of damage by feral pigs have been noticed in the area as well, 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 fleabane, 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 (HHP 1991n3; HPCC 1990g2; D. Lorence and S. Perlman, pers. comms., 1991).

In 1927 MacDaniels collected a plant specimen on Kauai which 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 (9 to 11 mm) long, with a hairless exocarp and endocarp (outermost and innermost layers of the fruit wall, respectively). Unlike other species 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). These plants grow on moist talus slopes in 'ohi'a-dominated lowland mesic forests (Stone *et al.* 1990) with such associated species 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 species such as lantana and yellow foxtain threaten *Melicope haupuensis*. A potential threat to members of this genus is their known susceptibility to *Xylosandrus compactus* (black twig borer), 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 and 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 area of Maui (R. Hobby 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. comm., 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 species and habitat degradation by feral and domestic animals are the major threats to *Melicope knudsenii*. On Kauai, this species competes with lantana and is affected by feral goats and pigs. On Maui, *M. 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, and *Axis axis* (axis deer), 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 which 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 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, Fuu mahoe Arboretum, R. Hobdy, A. Medeiros, and Steve Montgomery, Bishop Museum, pers. comms., 1991).

Hillebrand (1888) described *Pelea pallida* based upon 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 upon 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; 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). One population of about 65 plants was discovered in 1991 near the rim of Kalalau Valley (Kenneth Wood, HPCC, pers. comm., 1991), giving a total of about 75 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 2,000 ft (490 to 610 m) (Stone *et al.* 1990; J. Lau, pers. comm., 1991). Associated plant species include *Alyxia oliviformis* (maile), *Pipturus albidus* (mamaki), and *Sapindus oahuensis* (lonomea) (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 species. On Kauai, feral goats and feral pigs destroy habitat of *Melicope pallida*, and weeds such as common guava, 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*

An additional threat to *Melicope pallida* is 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).

St. John and Edward P. Hume described *Melicope quadrangularis*, based upon 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 1991rl, Stone *et al.* 1990). Previously thought to be extinct, this plant was rediscovered when one adult plant and two seedlings were found in 1991 in that area by Ken Wood of HPCC. The plants were found on an east-facing slope of Wahiawa ridge at 2,800 ft (850 m) in elevation on privately-owned land. The plants are growing in a diverse lowland forest that ranges from mesic to wet conditions with other plants, such as opuhe, uluhe, *Broussaisia arguta* (kanawao), *Cyrtandra pickeringsii* (ha'iwale), and other *Melicope* species (alani), and abundant ferns and mosses (K. Wood, pers. comm., 1991).

Melicope quadrangularis is threatened by competition with Java

plum and prickly Florida blackberry. The existence of only three known plants of this species, of which only one is a mature individual, causes the species to be threatened by stochastic extinction and/or reduced reproductive vigor (Hara and Beardsley 1979; K. Wood pers. comm., 1991).

Forbes collected specimens of a tree on Kauai in 1916 which he described the following year (1917b) as *Tetraplasandra racemosa*. The specific epithet describes the inflorescence, which 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 along 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. The genus differs 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 1,301 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 and 119s12, 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 species include common guava, kopiko, kukui, and lama (Gagne and Cuddihy 1990; HHP 1991s1, 1991s3 to 1991s5, 1991s8 to 1991s11, 1991s15); Lamoureux 1982; Stone 1967).

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. Predation of the fruit by rats is probable, and an introduced insect of the family Cerambycidae (longhorned beetles) 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 by stochastic extinction and/or reduced reproductive vigor (HHP 1991s1, 1991s3 to 1991s5, 1991s8 to 1991s11, 1991s15; HPCC 1990kl; Lamoureux 1982).

First collected on Kauai before 1990, *Nothocestrum 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*.

Nothocestrum peltatum, a member of the nightshade family (Solanaceae), is a small tree up to 16 ft (5 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 believed to be greenish yellow 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, *Nothocestrum peltatum* was known from Kauai at Kumuweia, Kaholuamanu, and the region of Nualolo (HHP 1991t3, 1991t5, 1991t6). This species is now known from seven populations on Kauai located near the Kalalau Lookout area, in Awaawapuhi and Makaha Valleys, and in Waimea Canyon (HHP 1991t1, 1991t2, 1991t4, 1991t7; HPCC 1990il, 1990i2, 1990i4; S. Perlman, pers. comm., 1991), scattered over a 5.5 by 2.5 mi (8.9 by 4 km) area. All 7 populations, totalling about 12 individuals (CPC 1989b, 1990), are on State-owned land between 3,000 and 4,000 ft (915 and 1,220 m) in 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, *Bobea 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 *Nothocestrum 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 *Gallus gallus* (red jungle fowl). Although plants of this species flower, they rarely set fruit; this could be the result of a loss of pollinators or reduced genetic variability (S. Perlman, pers. comm. 1991). This species is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (HHP 1991t7; HPCC 1990i3, 1990i4).

Hillebrand (1988) described *Peucedanum sandwicense* based upon a specimen collected on Molokai and *P. kauaiense* based upon 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 and Waikolu 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). 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, three 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 18 known populations of this species is estimated

to be between 250 and 350. This species grows in cliff habitats (Constance and Affolter 1990) in coastal to lowland, dry to mesic shrublands and forests 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).

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 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 tree, and *Stachytarpheta*; feral goats; 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. comm., 1991).

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). More recently, it has been observed from State land on Kauai in the Halemanu and Waimea Canyon areas (HHP 1991v1, 1991v4). Because the Halemanu population had 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 (R. Hobdy, pers. comm., 1991). 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 species 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 stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (R. Hobdy, pers. comm., 1991).

Based upon 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 species 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, Haelele Valley, Na Pali Coast State Park, Limahuli Valley, the Koaie branch of Waimea Canyon, Haupua Range, Wailua River, and Molooa Forest Reserve (HHP 1991w1 to 1991w7, 1991w9, 1991w10, 1991w11; HPCC 1990k1; 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 species include hamea, lama, lantana, 'ohi'a, and *Pouteria sandwicensis* ('ala'ala) (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. 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 upon a specimen collected in 1840 on Kauai during the United States Exploring Expedition. The specific epithet means "resembling *Spergula*," 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*, named by Sherff (1956); and var. *leiopoda* (Sherff 1944), which includes var. *major*, 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 (0.8 to 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; 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 to grow at four locations in Waimea Canyon on State land (HHP 1991y1 to 1991y5). One population contains only five plants, whereas others number in the thousands (HHP 1991y1 to 1991y5; T. Flynn, pers. comm., 1991). However, these 4 populations are estimated to total no more than 5,000 individuals. This taxon is usually found on bare rock outcrops, sparsely vegetated portions of rocky cliff faces, or cliff bases in diverse lowland mesic forests at elevations between 590 and 820 ft (180 and 250 m) (Wagner *et al.* 1990). Plants associated with the Lawai population of *S. spergulina* var. *leiopoda* are *Bidens sandwicensis* (ko'oko'olau), *Dryopteris*, and *Plectranthus parviflorus* ('ala'ala wai nui) (T. Flynn and J. Lau, pers. comms., 1991). Plant species 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* competes with alien plant species such as koa haole, lantana, and *Furcraea foetida* (Mauritius hemp). Individuals are also damaged and destroyed by rock slides. This variety is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (CPC 1990; T. Flynn, pers. comm., 1991).

Variety *spergulina* competes with alien species, including Chinaberry, lantana, and Sacramento bur. 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).

William Jackson Hooker and G.A.W. Arnott (1830-1841) described *Solanum sandwicense* based upon 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 taxon have been known include: *S. hillebrandii* (St. John 1969a), *S. kauaiense* (Hillebrand 1888), *S. sandwicense* var. ? *kawaiense* (Gray 1862), *S. woahense* (Dunal 1852), and *S. woahense* var. *eroso-crenulatatum* (Dunal 1852). In the current treatment of this genus, Symon (1990) considers both 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 up to 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 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 was known from a single population in what is now Honouliuli Preserve until

about 1986, when it was discovered that the last remaining plant had been destroyed by a landslide (HHP 1991z6; J. Obata, pers. comm., 1991). All extant populations are now found on the island of Kauai; they are on private and State land, and most are from Kokee and Na Pali Coast State Parks. Of the 11 known populations, only 7 have been observed since 1960; they total about 15 plants (Bruegmann 1990; CPC 1990; HHP 1991z11, 1991z12, 1991z19, 1991z20, 1991z26; D. Herbst, pers. comm., 1991). This species is typically found in open, sunny areas at elevations between 2,500 and 4,000 ft (760 and 1,226 m) in diverse lowland to montane mesic forests and occasionally in wet forests (HHP 1991z1, 1991z11, 1991z16, 1991z19 to 1991z26; Symon 1990). Associated plant species include koa, 'ohi'a, uluhe, and wet forest plants such as kopiko, *Athyrium sandwicensis* (ho'i'o), and more common *Melicope* species (alani) (HHP 1991z11, 1991z18, 1991z20, 1991z26).

The major threats to *Solanum sandwicense* on Kauai are habitat degradation by feral pigs and competition with alien plant species. Alien species that have heavily invaded this species' habitat on Kauai include: Banana poka, prickly Florida blackberry, *Hedychium gardnerianum* (kahili ginger), and *Lonicera Japonica* (honeysuckle). This species is also threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals. All Oahu populations of *Solanum sandwicense* are now apparently extinct, the result of its habitat being destroyed by urbanization, feral pigs, and weedy alien species (Bruegmann 1990; (HHP 1991z1 to 1991z7, 1991z18, 1991z25; HPCC 1990m; R. Hobdy, J. Lau, J. Obata, and S. Perlman, pers. comms., 1991).

Previous Federal Action

Federal action on these plants began as a result of section 12 of the Act, 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*), *Nothocestrum peltatum*, *Peucedanum sandwicense* (as *P. kauaiense*), *Pteralyx kauaiensis*, and *Solanum sandwicense* were considered to be endangered. *Diellia laciniata*, *Lipochaeta micrantha*, *Lipochaeta waimeaensis*, *Lysimachia filifolia*, and *Salonum 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 27832) 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 taxa 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 taxa considered to be endangered or thought to be extinct. The list of 1,700 plant taxa 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 2 years old be withdrawn. A 1-year grace period was given to proposals already over 2 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, 1979, 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 taxa (including synonymous taxa) that had been in the 1976 proposed rule were treated as Category 1 candidates for Federal listing. Category 1 taxa 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*

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 taxa 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* taxa are those which 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 taxa 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 taxa 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 taxa 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 taxa are those which, on the basis of current taxonomic understanding, do not represent distinct taxa meeting the Act's definition of "species." *Diellia 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 proposed herein for listing. In 1980, *Peucedanum sandwicense* appeared as a Category 2 species and retained that status in the 1985 and 1990 notices. Since the last notice, new information 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 taxon and variety *leiopoda* as a Category 1* taxon. Recently obtained information indicates that it is extant. *Cyrtandra limahuliensis* first appeared in the 1990 notice of review as a 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 taxa 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. Publication of the present proposal constitutes the final 1-year finding for these taxa.

Summary of Factors Affecting the Species

Section 4 of the Endangered Species Act (16 U.S.C. 1533) and regulations (50 CFR part 424) promulgated to implement the Act set forth the procedures for adding species to the Federal Lists. A species may be determined to be an endangered species due to one or more of the five factors described in section 4(a)(1). The threats facing these 23 species are summarized in Table 1.

TABLE 1.—SUMMARY OF THREATS

Species	Alien mammals					Alien plants	Fire	Substrate loss*	Human impacts	Limited numbers**
	Cattle	Deer	Goats	Pigs	Rats					
<i>Brighamia insignis</i>			X			X	X	X	X	X ^{1,2}
<i>Cyanea asarifolia</i>				P		P		X		X ^{1,2}
<i>Cyrtandra limahuliensis</i>				X		X		X		
<i>Delissea rhytidosperra</i>		X	X	X		X	X	X	P	X ^{1,2}
<i>Diellia laciniata</i>		X	X	X		X		X		X ^{1,2}
<i>Exocarpos luteolus</i>			X	X	X	X	X	X	P	X ^{1,2}
<i>Hedyotis cookiana</i>			P	P		P				X ^{1,2}
<i>Hibiscus clayi</i>				P		X			X	X ^{1,2}
<i>Lipochaeta fauriei</i>			X	X		X	X			X ^{1,2}
<i>Lipochaeta micrantha</i>			X	X		X				X ¹
<i>Lipochaeta waimeaeensis</i>						X		X	P	X ^{1,2}
<i>Lysimachia filifolia</i>				P		X		X		X ¹
<i>Melicope haupeensis</i>			X			X			P	X ^{1,2}
<i>Melicope Knudsenii</i>	X	P	X	X		X	P			X ^{1,2}
<i>Melicope pallida</i>			X	X		X	X			X ²
<i>Melicope quadrangularis</i>						X			P	X ^{1,2}
<i>Munroidendron racemosum</i>			X			X	X			X ²
<i>Nothocestrum peltatum</i>		X	X	X		X	X		P	X ²
<i>Peucedanum sandwicense</i>		P	X			X	X	X		X ²
<i>Phyllostegia waimeae</i>			X			X		X	P	X ^{1,2}
<i>Pteralyxia kauaiensis</i>			X	X		X	X			
<i>Schiedea spergulina</i>			X			X		X		X ¹
<i>Solanum sandwicense</i>				X		X	X		P	X ²

X=Immediate and significant threat

P=Potential threat

*=Substrate loss includes 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 100 individuals

³=No more than 10 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 laciniata* (Hillebr.) Diels (NCN), *Exocarpos luteolus* C. Forbes (heau), *Hedyotis cookiana* (Cham. and Schlechtend.) Steud. ('awiwi), *Hibiscus clayi* Degener and I. Degener (Clay's hibiscus), *Lipochaeta fauriei* H. Levi. (nehe), *Lipochaeta micrantha* (Nutt.) A. Gray (nehe), *Lipochaeta waimeaeensis* St. John (nehe), *Lysimachia filifolia* C. Forbes and Lydgate (NCN), *Melicope haupeensis* (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* Skottsb. ('aiea), *Peucedanum sandwicense* Hillebr. (makou), *Phyllostegia waimeae* Wawra (NCN), *Pteralyxia kauaiensis* Cuam (kaulu), *Schiedea spergulina* A. Gray (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 proposed 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 23 species being proposed. (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 which 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 proposed species 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 species (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 (Wenkham 1969). Plantation owners supported reforestation programs which 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, and this undoubtedly destroyed individuals and populations of native plants. Some of the proposed 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 species (Cuddihy and Stone 1990, Wagner *et al* 1990). Eighteen species in this proposal are directly threatened by habitat degradation resulting from introduced ungulates. 15 species are threatened by goats, 11 by pigs, 3 by deer, and 1 by cattle. In addition, an introduced ground-nesting bird threatens one species by disturbing its habitat.

Capra hircus (goat), 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 dry and mesic forests there. 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 1920, 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, Culliney 1988, Cuddihy and Stone 1990, Scott *et al* 1986, Tomich 1986, van Riper and van Riper 1982).

Although many of the proposed plants survive on steep cliffs inaccessible to goats, their original range was probably much larger. They 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 23 proposed plants 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 15 of the species are currently threatened by direct damage from feral goats, such as trampling of plants and seedlings and erosion of substrate (Clarke and Cuddihy 1980, Culliney 1988, Scott *et al* 1986, van Riper and van Riper 1982).

All known populations of the following taxa are threatened by goats. *Delissea rhytidosperma*, *Lipochaeta micrantha* var. *micrantha*, *Melicope haupuensis*, *Melicope knudsenii*, and both varieties of *Schiedea spergulina*. Populations of other proposed taxa

threatened by goats are: The Kalalau population of *Brighamia insignis*, the Koaie Canyon and Waimea Canyon rim populations of *Diellia laciniata*, the Kalalau rim population of *Exocarpos luteolus*, the Hikimoe Valley and Koaie Canyon populations of *Lipochaeta fauriei*, the 3 Kauai populations of *Melicope pallida*, at least half of the 17 populations of *Munroidendron racemosum*, the Kalalau and Waimea Canyon populations of *Nothoecstrum peltatum*, the Na Pali and Waimea Canyon populations and the Oahu populations of *Peucedanum sandwicense*, the Waimea Canyon population of *Phyllostegia waimeae*, and at least 5 of the 13 populations of *Pteralyxia kauaiensis*. In addition, goats have probably invaded the area in which the only known population of *Hedyotis cookiana* occurs (Bruegmann 1990; 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, Takeuchi 1982; C. Christensen, T. Flynn, R. Hobdy, J. Lau, D. Lorence S. Montgomery, S. Perlman, and K. Wood, pers. comm., 1991).

Sus scrofa (pig) 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, and 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

proposed species (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 one or more populations of 13 of the proposed species. At least one population of each of the following taxa is threatened by feral pigs. *Pteralyxia kauaiensis*, *Solanum sandwicense*, and each of the two varieties of *Lipochaeta micrantha*. Populations of other taxa threatened by feral pigs are: The Anahola Stream population of *Cyrtandra limahuliensis*; the only population of *Delissea rhytidosperma*; the Koate Canyon population of *Diellia laciniata*; three of the five populations of *Exocarpos luteolus*; the Hikimoe Valley population of *Lipochaeta fauriei*; two populations of *Melicope knudsenii*, one each on both Kauai and Maui, the Kalalau rim population of *Melicope pallida*, and the Kalalau rim and Makaha Valley populations of *Nothoestrum peltatum*. Pigs also constitute a potential threat to the Wailua Stream populations of *Cyanea asarifolia* and *Cyrtandra limahuliensis*, the only population of *Hedyotis cookiana*, one of the four populations of *Hibiscus clayi*, and the only Kauai population of *Lysimachia filifolia* (Brueggmann 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).

Bos taurus (cattle), the wild progenitor of which was native to Europe, north Africa, and southwestern Asia, was 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 *Ovis aries* (sheep), they 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 safeguard water reserves for their crops

(Wenkam 1969). 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 was once permitted, but 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, and 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 being proposed were degraded in the past by feral cattle, and this has had effects which still persist. Examples of plants 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 1991h3, 1991p1; Lamoureux 1982).

Individuals of *Odocolleus hemionus* (mule deer or black-tailed deer), 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 the only population of *Delissea rhytidosperma*, the Mahanaloa Valley population of *Diellia laciniata*, and the Waimea Canyon populations of *Nothoestrum peltatum* (Brueggmann 1990; HPCC 1990b, 1990i3, 1990i4; S. Perlman, pers. comm., 1991).

Axis axis (axis deer), native to Sri Lanka and India, was 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).

Gallus gallus (red jungle fowl), ground-nesting chickens native to India and southeast Asia, was 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).

One or more species of almost 50 introduced plants directly threaten 21 of the proposed species and potentially threaten the other 2. The original native flora of Hawaii consisted of about 1,000 species, 89 percent of which were endemic. Of the total native and naturalized Hawaiian flora of 1,817 species, 47 percent were introduced from other parts of the world and nearly 100 species have become pests (Smith 1985, Wagner *et al* 1990). Naturalized, introduced species 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 species 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 species for reforestation. Ranchers intentionally introduced pasture grasses and other species 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.*, 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). It threatens the Nounou Mountain population of *Hibiscus clayi* (T. Flynn, pers. comm., 1991). *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 the Kumuweia Ridge population of *Exocarpos luteolus* (T. Flynn, pers. comm., 1991). Two shrubs 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 and also classified as a noxious weed by the Federal government (7 CFR part 360), threatens the Molokai population of *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 the Oahu population of *Lysimachia filifolia* as well as the Molokai and Oahu populations of *Peucedanum sandwicense* (HHP 1991u16; HPCC 1990g2, 1990j1, 1990j3; Wagner *et al.* 1990). *Ageratum conyzoides* (maile hohono), an herb which is a common weed in many areas of the main Hawaiian Islands, threatens *Brighamia insignis* in some areas along the Kalalau Trail (HHP 1991a1, Wagner *et al.* 1990).

Although it is the official state tree of Hawaii, *Aleurites moluccana* (kukui) is not a native Hawaiian plant but was originally native to Malasia. 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 kuku, which competes with these native species for space. *Hibiscus clayi* and *Lipochaeta fauriei* do not grow under a dense canopy, so kuku could prevent them from remaining in an area. *Munroidendron racemosum* and *Pteralyxia kauaiensis* overstory trees in

native forests, are displaced when kukui is an element of their habitat (HHP 1991h2, 1991s1, 1991s4, 1995s, 1991s8, 1991s10, 1991s15, 1991w1, 1991w4, 1991w5; HPCC 1990d3; Lamoureux 1982; T. Flynn, J. Lau, and S. Perlman, pers. comms., 1991). *Arucaria columnaris* (columnar araucaria), planted in Hawaii for reforestation and timber production and now found on all the main islands, is reseeding and threatens the Nounou Mountain population of *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* along some sections of the Kalalau Trail (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* on Oahu and a Na Pali coast population of *Peucedanum sandwicense*. It is a potential threat to the Wahiawa Bog population of *Cyrtandra limahuliensis* (HHP 1990c; T. Flynn and S. Montgomery, pers. comms., 1991). *Cordylone fruticosa* (ti) is a shrub which 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* (kakaeanut), a tree introduced to Hawaii for reforestation, is now found on four islands and is a threat to the Kumuweia Ridge population of *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). An invasion of daisy fleabane threatens *Lipochaeta micrantha* var. *micrantha* in Koaie Canyon, the Kalalau rim populations of *Melicope pallida* and *Nothoestrum peltatum* and a Na Pali

coast population of *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 the only known population of *Schiedea spergulina* var. *leopoda* (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 the Waipa Valley population of *Cyrtandra limahuliensis* (T. Flynn, pers. comm., 1991). *Grevillea robusta* (silk tree) was extensively planted in Hawaii for timber and is now naturalized on most of the main islands (Smith 1985, Wagner *et al.* 1990). Silk tree threatens the only known population of *Lipochaeta waimeaensis* and the Oahu population of *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. 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 which are distributed by alien fruit-eating birds; it threatens the Kumuweia Ridge population of *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 which occurs on all the main islands except Nihoa and Kahoolawe, especially in dry to mesic areas (Wagner *et al.* 1990). Populations of *Brighamia insignis* and *Peucedanum sandwicense* along the Kalalau Trail 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 which 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 species are threatened by lantana: *Brighamia insignis*, *Delissea rhytidosperra*, *Diellia laciniata*,

Hibiscus clayi, *Lipochaeta fauriei*, both subspecies of *Lipochaeta micrantha*, *Melicope haupuensis*, *Melicope knudsenii*, *Munroidendron racemosum*, *Nothoecstrum 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). *Leptospermum scoparium* (tea tree), brought to Hawaii as an ornamental plant and now naturalized in disturbed mesic to wet forest on three islands, threatens the Waipa population of *Cyrtandra limahuliensis* (Wagner *et al.* 1990; T. Flynn, pers. comm., 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. The only population of *Lipochaeta waimeaensis*, the Haupu Range population of *Munroidendron racemosum*, and the single extant population of *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 the Kokee population of *Solanum sandwicense* (Brueggmann 1990, HPCC 1990m, Wagner *et al.* 1990). *Melia azedarach* (Chinaberry), a small tree widely cultivated and naturalized on most of the main Hawaiian Islands, threatens Koaie Canyon populations of *Diellia laciniata*, *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 and is in the process of being added to Hawaii's noxious weed list. This tree's ability to fix nitrogen allows it to produce lush growth in spite of the nutritionally poor Hawaiian volcanic soils. It thus outcompetes native species as well as enriching the soil so that other alien plants can invade (DOA 1991, Wagner *et al.* 1990). Populations of *Exocarpos luteolus* in Kokee State Park, *Munroidendron racemosum* in Koaie Valley, and *Peucedanum sandwicense* in Waiahuakua Valley are threatened by firetree (HHP 1991u3; HPCC 1990h, S. Perlman, pers. comm., 1991). *Opuntia ticus indica* (prickly pear, panini) is a

cactus found in dry, disturbed habitats on five islands which poses a threat to the only known population of *Lipochaeta waimeaensis* (Solomon 1990; S. Perlman, pers. comm., 1991).

Passiflora edulis (passion fruit) is a woody vine which occurs on five Hawaiian Islands in mesic forests and shrublands and threatens the Makaha Valley population of *Nothoecstrum peltatum* (Escobar 1990, HPCC 1990i3). *Passiflora ligularis* (sweet granadilla) is a woody vine which now occurs in diverse mesic forest and wet forest on four islands and threatens the only known population of *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 which reaches trees as well as understory, and causing 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 is in the process of being added to Hawaii's list of noxious weeds (DOA 1991) and threatens the only known population of *Delissea rhytidosperra*, the Makaha Valley population of *Nothoecstrum peltatum*, the Nualolo Valley population of *Peucedanum sandwicense*, some individuals of *Pteralyxia kauaiensis*, and the Kokee State Park populations of *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 the Oahu population of *Lysimachia filifolia* and the Maui population of *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 depend on 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

direct threat to *Brighamia insignis* near the Kalalau Trail, over half the populations of *Cyrtandra limahuliensis*, the Nounou Mountain population of *Hibiscus clayi*, the Haeleele Valley population of *Lipochaeta fauriei*, and the Haupu Range population of *Lipochaeta micrantha* var. *exigua* (HHP 1991a1; HPCC 1990c, 1990e; Smith 1985, T. Flynn, pers. comm., 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 the Kalalau populations of *Brighamia insignis*, the Anahola Stream population of *Cyrtandra limahuliensis*, the Nounou Mountain and Hali Stream population of *Hibiscus clayi*, the Haeleele Valley population of *Lipochaeta fauriei*, the Hanakapiai Valley population of *Melicope pallida*, several populations of *Munroidendron racemosum*, some Kauai and Molokai populations of *Peucedanum sandwicense*, and the Limahuli Valley population of *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).

Pterolepis glomerata, an herb or subshrub locally naturalized in mesic to wet disturbed sites on Kauai, Oahu, and Hawaii, threatens the Wahiawa Bog population of *Cyrtandra limahuliensis* (Almeda 1990; T. Flynn, pers. comm., 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 two populations of *Exocarpos luteolus* in and near Kokee State Park, the Kalalau rim population of *Melicope pallida*, the only known population of *Melicope quadrangularis* the Kalalau rim and Makaha Valley populations of *Nothoecstrum peltatum* and several Na Pali coast populations of *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 the Oahu population of *Lysimachia filifolia* as well as a potential threat to one of the Kalalau populations of *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 the Nounou Mountain population of *Hibiscus clayi* and the Oahu populations of *Peucedanum sandwicense*. It is a potential threat to a population of *Peucedanum sandwicense* near the Kalalau Trail (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 distributed areas (Wagner *et al.* 1990). These alien herbs or subshrubs threaten the Kalalau Trail populations of *Brighamia insignis* and individuals of *Peucedanum sandwicense* on Oahu (HHP 1991a1, HPCC 1990j1). *Syzygium cumini* (Java plum), a tree naturalized in mesic valleys to distributed mesic forests on most of the main Hawaiian Islands, threatens the Kalalau Trail and Haupu Range populations of *Brighamia insignis*, the Nounou Mountain and Moloaa Valley populations of *Hibiscus clayi*, the only known population of *Melicope quadrangularis*, and two Na Pali Coast State Park populations of *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* near Koaie Canyon 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* there (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. Of the approximately 100 grass species which have become naturalized, 9 species threaten 10 of the 23 proposed plants. *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. The mats it forms 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 the Kalalau Trail populations of *Brighamia*

insignis; the Hikimoe Valley population of *Lipochaeta fauriei*; and the Waiahuakua Valley and Kalaupapa, Molokai, populations of *Peucedanum sandwicense* (HHP 1991a1, 1991a3, 1991u3; HPCC 1990a; R. Hobdy and S. Perlman, pers. comm., 1991). *Oplismenus hirtellus* (basketgrass) is a perennial grass which is naturalized in shaded mesic valleys and forests and sometimes in wet forests on most of the main Hawaiian Islands (O'Connor 1990). The population of *Diellia laciniata* located in Paaiki and Mahanaloa Valleys, the Nounou Mountain population of *Hibiscus clayi*, and a Koaie Canyon population of *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 the Mount Kahili population of *Cyrtandra limahuliensis* and the Hali Stream population of *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 which 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 part 360) (Medeiros *et al.* 1986, O'Connor 1990, Smith 1985). Kikuyu grass threatens the Maui population of *Melicope knudsenii* (R. Hobdy, pers. comm., 1991). *Rhynchelytrum repens* (Natal redtop) is an annual or perennial grass which is naturalized in disturbed, usually dry areas on all the main Hawaiian Islands and threatens the only population of *Lipochaeta waimeaensis* (O'Connor 1990; Perlman, pers. comm., 1991). *Sacciolepis indica* (Glenwood grass), an annual or perennial grass naturalized on five islands in Hawaii in open, wet areas, threatens the Mount Kahili population of *Cyrtandra limahuliensis* (O'Connor 1990; T. Flynn, 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 the Kalalau populations of *Brighamia insignis*, one of the two known trees of *Melicope haupuensis*, and the Waiahuakua Valley population of *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 the Kalalau Trail populations of *Brighamia insignis* and *Peucedanum sandwicense* (HHP 1991a1, 1991a3, 1991u15; O'Connor 1990). *Stenotaphrum secundatum* (St. Augustine grass), a creeping perennial grass naturalized on beaches and dunes and along roads on five of the main Hawaiian Islands, threatens *Diellia laciniata* below the rim of Waimea Canyon (O'Connor 1990; D. Lorence, pers. comm., 1991).

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 species, and some fire-adapted grasses have become widespread in Hawaii. The presence of such species in Hawaiian ecosystems greatly increases the intensity, extent, and frequency of fire. Fire-adapted alien species 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. Along the way, 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 Na Pali coast populations of *Brighamia insignis*, *Exocarpos luteolus*, *Melicope pallida*, *Munroidendron racemosum*, *Nothoecstrum 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 rhytidosperma* 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).

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: The only known population of *Lipochaeta waimeaensis*, most populations of *Brighamia insignis*, all populations of *Diellia laciniata*, the largest known population of *Exocarpos luteolus*, Oahu populations of *Peucedanum sandwicense*, and the Waimea Canyon rim population of *Phyllostegia waimeae* Bruegmann 1990; Christensen 1979; HHP 1991f6; Takeuchi 1982; G. Carr, R. Hobdy, and J. Obata, pers. comms., 1991).

Illicit 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 forest 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).

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 of the proposed species, but especially to *Delissea rhytidosperra*, *Lipochaeta waimeaensis*, *Melicope haupuensis*, *M. quadrangularis*, and *Phyllostegia waimeae*, each of which has only 1 or 2 populations and a total of 10 or fewer individuals. Any collection of whole plants or reproductive parts of any of these five species would cause an adverse impact on the gene pool and threaten the survival of the species. Some taxa, such as *Brighamia insignis*, *Exocarpos luteolus*, *Hibiscus clayi*, *Nothocestrum 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 1990: 1990i1 to 1990i4, 1990m).

Many of the proposed 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 (Clark and Cuddihy 1980; Takeuchi 1982; T. Flynn, pers. comm., 1991).

C. Disease or Predation

Browsing damage by goats has been verified for the following proposed 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). The remaining proposed species 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 proposed species: *Delissea rhytidosperra*, *Diellia laciniata*, *Hedyotis cookiana*, *Hibiscus clayi*, *Lipochaeta fauriei*, *Lipochaeta micrantha*, *Lipochaeta waimeaensis*, *Melicope haupuensis*, *Melicope knudsenii*, *Melicope pallida*, *Munroidendron racemosum*, *Nothocestrum 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 seem 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 which have been introduced to the Hawaiian Islands, the species with the greatest impact on the native flora and fauna is probably *Rattus rattus* (black or roof rat), 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 *Mus musculus* (house mouse), *Rattus exulans* (Polynesian rat), and *R. norvegicus* (Norway rat) 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 which 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 of the species' only population (Bruegmann 1990). Rats eat fruits of *Exocarpos luteolus*, threatening the regeneration of this species as well. It is probable that rats damage the fruit of *Munroidendron racemosum* and *Pteralyxia kauaiensis*, both of which have fleshy fruits and have populations in areas where rats occur (Lamoureux 1982; T. Flynn and D. Herbst, pers. comms., 1991).

Xylosandrus compactus (black twig borer) is a small beetle about 1.6 mm (0.06 in) in length which 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). Because it is known to attack species of *Melicope*, it is a potential threat to *Melicope haupuensis*, *M. knudsenii*, and *M. pallida*, 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 23 proposed species are listed by the State. Twelve species 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 species except *Melicope quadrangularis* occurs on State land. Eleven of the proposed species 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). However, the regulations are difficult to enforce because of limited personnel. One or more population of each of the 23 proposed species 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 in these conservation districts, among other purposes, are regarded as necessary for the protection of endemic biological resources and the maintenance or enhancement of the 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). For any proposed land use change which will occur on county or State land, that will be funded in part or whole by county or State funds, or will occur within land classified as conservation district, an environmental assessment is required to determine whether or not the environment will be significantly affected (HRS, chapt. 343). If it is found that an action will 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 also trigger 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 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).

Twelve of the proposed species are threatened by six plants considered by the State of Hawaii to be noxious weeds and two others proposed to be added to the list. The State has provisions and funding available 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 proposed taxa (HHP 1990c). Despite the existence of various State laws and regulations which give protection to Hawaii's native plants, their enforcement is difficult due to limited funding and personnel. Listing of these 23 plant species would reinforce and supplement the protection available under the State Act and other laws. The Federal Act would offer additional protection to these 23 species because, if they were to be listed as endangered, it would be a violation of the 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

The small numbers of populations and individuals of most of these species 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. Five of the proposed species, *Cyanea asarifolia*, *Delissea rhytidosperma*, *Hedyotis cookiana*, *Lipochaeta waimeaensis*, and *Melicope quadrangularis*, are known from a single population. Eleven other proposed species are known from only two to five populations (see Table 1). Seventeen of

the proposed species are estimated to number no more than 100 known individuals (see Table 1). Five of these species, *Delissea rhytidosperma*, *Lipochaeta waimeaensis*, *Melicope haupuensis*, *Melicope quadrangularis* and *Phyllostegia waimea*, 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 or populations with limited numbers and/or narrow ranges, such as the Wailua populations of *Cyanea asarifolia* and *Cyrtandra himahuliensis*, the Kauai and Oahu populations of *Lysimachia filifolia*, and the only population of *Schiedea spergulina* var. *leiopoda* (CPC 1990; HHP 1991b2; HPC 1990g1, 1990g2; T. Flynn and W.L. Wagner, pers. comms., 1991). This process is often exacerbated by human disturbance and land use practices (see Factor A).

In November 1982, Typhoon 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, which are a threat to the continued existence of many of the proposed species. For example, because Honopu Trail was extensively damaged by this typhoon, a population of *Solanum sandwicense*, last visited in 1969, may no longer be in existence (R. Hobby, pers. comm., 1991). Damage by typhoons could further decrease the already reduced habitat of most of the 23 proposed species.

The Service has carefully assessed the best scientific and commercial information available regarding the past, present, and future threats faced by these species in determining to propose this rule. Based on this evaluation, the preferred action is to list these 23 plant species as endangered. Twenty of the species proposed for listing either number no more than about 100 individuals or are known from 5 or fewer populations. The 23 species 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; substrate loss; human impacts; and lack of legal protection or difficulty in enforcing laws which are already in effect. Small population size and limited distribution make these species particularly vulnerable to extinction and/or reduced reproductive vigor from stochastic events. Because these 23 species 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.

Critical habitat is not being proposed for the 23 species included in this rule, for reasons discussed in the "Critical Habitat" section of this proposal.

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 species is determined to be endangered or threatened. The Service finds that designation of critical habitat is not presently prudent for these species. Such a determination would result in no known benefit to the 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* and local newspapers as required in a proposal for 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 as endangered 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 general location and importance of protecting the habitat of these species. Protection of the habitat of the species will be addressed through the recovery process, and, in some cases, through the section 7 consultation process. There is only one Federal activity within the currently known habitats of these plants. One taxon is located on land owned by the State Department of Hawaiian Home Lands which 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 taxon 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 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 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)(4) of the Act requires Federal agencies to confer informally with the Service on any action that is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, section 7(a)(2) requires Federal agencies to insure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a 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 23 plant species.

The Act and its implementing regulations found at 50 CFR 17.61, 17.62, and 17.63 for endangered plants set forth a series of general prohibitions and exceptions that apply to all endangered plant species. With respect to the 23 plant species proposed to be listed as endangered, all trade prohibitions of section 9(a)(2) of the Act, implemented by 50 CFR 17.61 would apply. These prohibitions, in part, make it illegal with respect to any endangered plant 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. Certain exceptions apply to agents of the Service and State conservation agencies. The Act and 50 CFR 17.62 and 17.63 also provide for the issuance of permits to carry out otherwise prohibited activities involving endangered 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 nor in the wild.

Requests for copies of the regulations concerning listed plants and inquiries regarding prohibitions and permits may be addressed to the Office of Management Authority, U.S. Fish and Wildlife Service, 4401 North Fairfax Drive, room 432, Arlington, Virginia 22203-3507 (703/358-2104 or FTS 921-2104; FAX 703/358-2281).

Public Comments Solicited

The Service intends that any final action resulting from this proposal will be as accurate and as effective as possible. Therefore, comments or suggestions from the public, other concerned governmental agencies, the scientific community, industry, or any other interested party concerning this proposed rule are hereby solicited. Comments particularly are sought concerning:

(1) Biological, commercial trade, or other relevant data concerning any threat (or lack thereof) to these species;

(2) The location of any additional populations of these species and the reasons why any habitat should or should not be determined to be critical habitat as provided by section 4 of the Act;

(3) Additional information concerning the range, distribution, and population size of these species; and

(4) Current or planned activities in the subject area and their possible impacts on these species.

The final decision on this proposal will take into consideration the comments and any additional information received by the Service, and such communications may lead to a

final regulation that differs from this proposal.

The Endangered Species Act provides for at least one public hearing on this proposal, if requested. Hearing requests must be received within 45 days of the date of publication of the proposal. Such requests must be made in writing and addressed to the Field Supervisor (see ADDRESSES section).

National Environmental Policy Act

The Fish and Wildlife Service has determined that an Environmental Assessment or Environmental Impact Statement, 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 proposed rule are Z.E. Ellshoff, Joan M. Yoshioka, Joan E. Canfield, and Derral R. Herbst, Fish and Wildlife Enhancement, Pacific Islands Office, U.S. Fish and Wildlife Service, 300 Ala Moana Boulevard, room 6307, P.O. Box 50167, Honolulu, Hawaii 96850 (808/541-2749 or FTS 551-2749). Substantial data were generously contributed by Tim Flynn, National Tropical Botanical Garden; Joel Lau, Hawaii Heritage Program; and Steve Perlman, Hawaii Plant Conservation Center.

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and

recordkeeping requirements, and Transportation.

Proposed Regulations Promulgation

PART 17—(AMENDED)

Accordingly, it is hereby proposed to amended part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as set forth below:

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. It is proposed to amend § 17.12(h) 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	Scientific name	Common name	Historic range	Status	When listed	Critical habitat	Special rules
Apiaceae—Parsley family:							
~	<i>Peucedanum sandwicense</i>	Makou	U.S.A. (HI)	E		NA	NA
Apocynaceae—Dogbane family:							
~	<i>Pteralyxia kauaiensis</i>	Kaulu	U.S.A. (HI)	E		NA	NA
Araliaceae—Ginseng family:							
~	<i>Munroidendron racemosum</i>	None	U.S.A. (HI)	E		NA	NA
Aspleniaceae—Spleenwort family:							
~	<i>Diellia laciniata</i>	None	U.S.A. (HI)	E		NA	NA
Asteraceae—Aster family:							
~	<i>Lipochaeta faunei</i>	Nehe	U.S.A. (HI)	E		NA	NA
~	<i>Lipochaeta micrantha</i>	Nehe	U.S.A. (HI)	E		NA	NA
~	<i>Lipochaeta waimeensis</i>	Nehe	U.S.A. (HI)	E		NA	NA
Campanulaceae—Bellflower family:							
~	<i>Brighamia insignis</i>	'Oulu	U.S.A. (HI)	E		NA	NA
~	<i>Cyanea asarifolia</i>	Haha	U.S.A. (HI)	E		NA	NA
~	<i>Delissea rhytidosperma</i>	None	U.S.A. (HI)	E		NA	NA
Garyophyllaceae—Pink family:							
~	<i>Schiedea spergulina</i>	None	U.S.A. (HI)	E		NA	NA
Gesneriaceae—African Violent family:							
~	<i>Cyrtandra limahuliensis</i>	Ha'iwale	U.S.A. (HI)	E		NA	NA
Lamiaceae—Mint family:							
~	<i>Phyllostegia waimeae</i>	None	U.S.A. (HI)	E		NA	NA

Species		Historic range	Status	When listed	Critical habitat	Special rules
Scientific name	Common name					
Malvaceae—Mallow family:						
Hibiscus clayi	Glav's hibiscus	U.S.A. (HI)	E		NA	NA
Primulaceae—Primrose family:						
Lysimachia filifolia	None	U.S.A. (HI)	E		NA	NA
Rubiaceae—Coffee family:						
Hedyotis cookiana	'Awini	U.S.A. (HI)	E		NA	NA
Rutaceae—Citrus family:						
Melicope haupuensis	Alani	U.S.A. (HI)	E		NA	NA
Melicope knudsenii	Alani	U.S.A. (HI)	E		NA	NA
Melicope pallida	Alani	U.S.A. (HI)	E		NA	NA
Melicope quadrangularis	Alani	U.S.A. (HI)	E		NA	NA
Santalaceae—Sandalwood family:						
Exocarpos tuteolus	Heau	U.S.A. (HI)	E		NA	NA
Solanaceae—Nightshade family:						
Nonthocestrum petatum	Aiea	U.S.A. (HI)	E		NA	NA
Solenum sandwicense	Popolo'aiakeakua	U.S.A. (HI)	E		NA	NA

Dated: September 30, 1991.

Richard N. Smith,

Acting Director, Fish and Wildlife Service.

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