

ALIEN PLANTS ON THE NORTHWESTERN HAWAIIAN ISLANDS

Derral R. Herbst and Warren L. Wagner

ABSTRACT

The Northwestern Hawaiian Islands is a chain of approximately 40 emergent low islands extending in a west-northwesterly direction for a distance of nearly 750 mi (1,210 km). The islands are currently managed as a wildlife refuge for birds, sea turtles, and the Hawaiian monk seal (*Monachus schauinslandi*). The vegetation is composed primarily of Pacific Basin strand species, naturalized species, and, on Kure and Midway Atolls and Tern Island, cultivated plants. The present vascular flora consists of 317 taxa, of which 8 are endemic (2.5%), 42 are indigenous (13.2%), 114 are naturalized (36.0%), and 132 are cultivated (41.6%). The flora is summarized on an island by island basis in an appendix to this paper. Some alien species have been deliberate or unintentional introductions by humans; others have arrived by "natural" means. Ironwood (*Casuarina equisetifolia*), a species well adapted to dry conditions, is an example of an intentional introduction. It has been introduced on seven of the islands and has become naturalized on Tern Island and Midway Atoll; it is a management problem only on Midway. *Heliotropium procumbens*, introduced by military flights from O'ahu to two of the three leeward islands with runways, is an example of an accidental introduction that has not become a management problem. Little has been done to manage the alien plants of the Northwestern Hawaiian Islands other than to take precautions to prevent new ones from being introduced. There has been little need for management. Proposed management needs include monitoring the vegetation of the islands, producing a manual of plants, and developing a contingency plan for the control of any alien species of plant or animal impacting the vegetation or wildlife.

INTRODUCTION

The Northwestern Hawaiian Islands, or Leeward Islands as they are commonly (and hereafter) called, are a chain of islands stretching in a west-northwesterly direction from Nihoa Island to Kure Atoll, a distance of nearly 750 mi (1,210 km). Politically, all except Midway Atoll are part of the City and County of Honolulu; Midway is property of the U.S. Navy and is

not part of the State of Hawai'i. President Theodore Roosevelt signed Executive Order 1019 on February 3, 1909, setting them aside (except Midway) as a preserve and breeding ground for native birds. Today, all except Kure and Midway Atolls are in the Northwestern Hawaiian Islands National Wildlife Refuge and are managed by the U.S. Fish and Wildlife Service. President Franklin Roosevelt signed Executive Order 7299 on February 20, 1936, placing Kure Atoll under the jurisdiction of the Secretary of the Navy; however, there are no records of any activity on the Atoll during World War II. On November 17, 1952, President Harry Truman signed Executive Order 10413, giving Kure Atoll to the Territory of Hawai'i. Kure presently is maintained as a wildlife refuge by the State Division of Forestry and Wildlife, and the Coast Guard maintains a long-range navigation (LORAN) station on Green Island, the only permanent land mass in the Atoll.

The Leeward Islands (Fig. 1) comprise approximately 40 emergent islands; numbers vary as the small sand islets are built up, fuse, separate, or wash away over time. The islands total about 3.9 mi² (10.1 km²) of dry land, an amount less than 1% of the total land area of the Hawaiian Islands. They vary in elevation from 10 to 910 ft (3-277 m) (Table 1). The highest is Nihoa Island, and the lowest are French Frigate Shoals and Pearl and Hermes Atoll. The eastern islands (Nihoa, Necker, La P rouse Pinnacle of French Frigate Shoals, and Gardner Island) are eroded remnants of shield volcanoes, the last two being residual volcanic and limestone islands. The western islands (French Frigate Shoals except for La P rouse Pinnacle, Laysan and Lisianski Islands, and Pearl and Hermes, Midway, and Kure Atolls) are limestone islands resting on the summits of submerged volcanoes. More than a dozen other reefs and shoals mark volcanoes completely submerged below the surface of the ocean.

Compared to the main Hawaiian Islands, the Leeward Islands are poorly known geologically. They are much older than the main islands; the ages of five of the islands are known and range from about 7 to 27 million years (Table 1).

VEGETATION

The vegetation of the Leeward Islands is composed chiefly of typical strand species and the naturalized alien plants that can tolerate strand conditions. Cultivated ornamental plants are maintained on the three inhabited islands, and some also persist around abandoned buildings. On Nihoa, the highest island, several genera usually considered to be elements of mid-elevation, diverse mesic forests can be found. Thus, hu'ahu'ak  (*Rumex albescens*), *Schiedea verticillata*, and perhaps *Pritchardia remota* and 'akoko (*Chamaesyce celastroides*) may be remnants of an earlier vegetation before the island eroded to its present state. Several of the strand species, such as p polo (*Solanum nelsonii*), ' naunau (*Lepidium bidentatum* var. *o-waihiense*), and 'ohai (*Sesbania tomentosa*), which are rare on the main Hawaiian Islands, are still common on several of the Leeward Islands. This may be due to the greater disturbance of strand areas on the main Hawaiian islands.

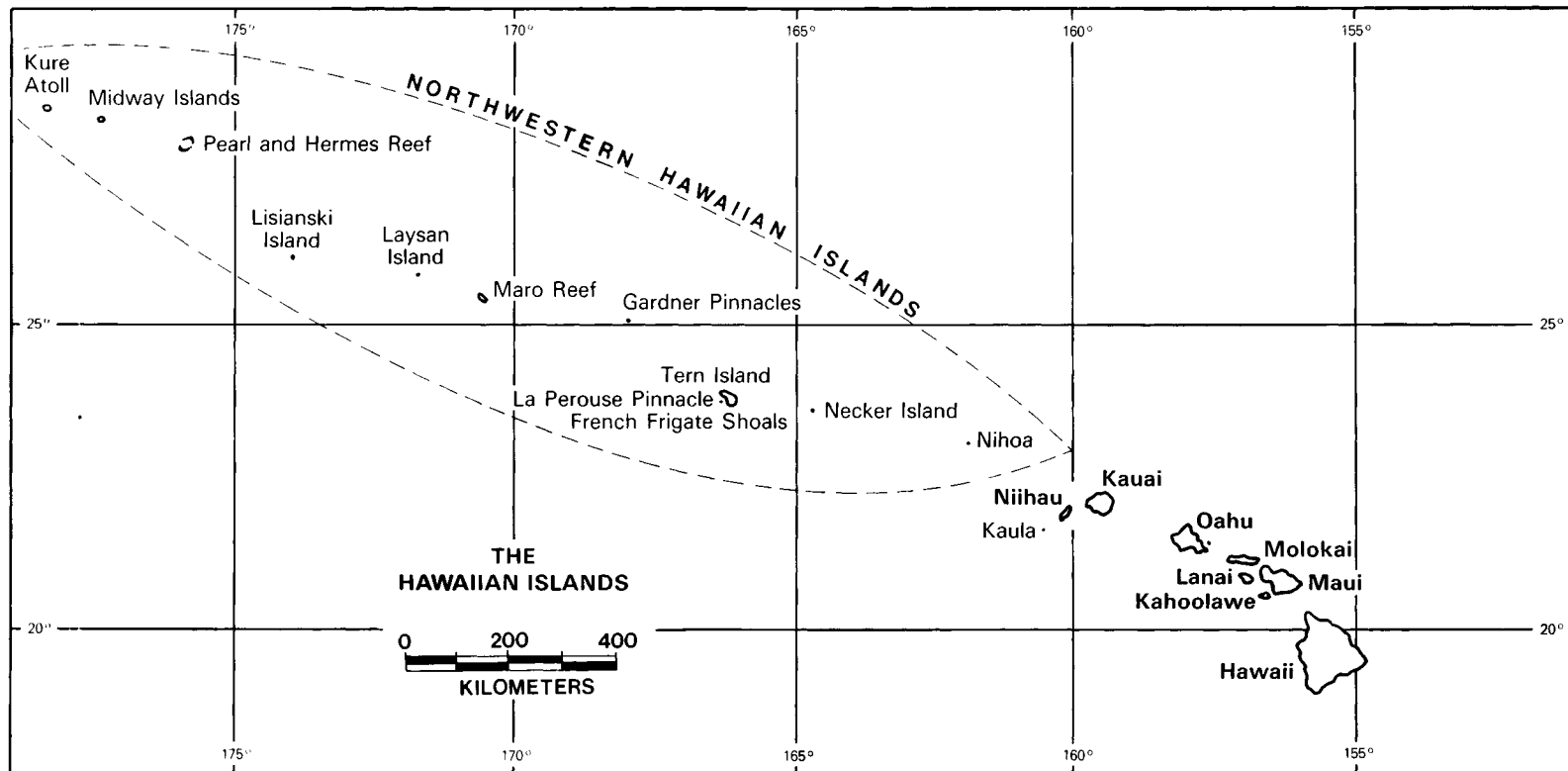


Figure 1. The Hawaiian Archipelago.

Table 1. Area, elevation, and age of the Leeward Hawaiian Islands.

Island Group	Area ^a (acres)	(hectares)	Maximum elevation ^a feet (meters)	Age (in millions of years by Potassium-Argon)
Nihoa Island	191	(77)	910 (277)	7.0 + 0.3 ^c
Necker Island	58	(24)	277 (84)	10.0 + 0.4 ^c
French Frigate Shoals (13 islets)	56	(23)	135 (41) ^b	11.7 ^{b,c}
Gardner Pinnacles	3	(1)	190 (58)	--
Laysan Island	981	(397)	35 (11)	--
Lisianski Island	432	(175)	20 (6)	--
Pearl and Hermes Atoll (7 islets)	78	(32)	10 (3)	20.1 + 0.5 ^d
Midway Atoll (4 islets)	1,280	(518)	12 (4)	27.0 + 0.6 ^e
Kure Atoll (2 islets)	237	(96)	20 (6)	--
Northwestern Hawaiian Islands (Total)	3,316	(1,343)		

^afrom Armstrong 1983.^bLa Perouse Pinnacles only.^cDalrymple *et al.* 1974; unreliable due to sampling problems.^dClague *et al.* 1975; probably too young.^eDalrymple *et al.* 1977; probably too young.

Table 2. Summary of status information for plant taxa on Leeward Islands.

Island Group	E	I	X	Status ^a				Total Taxa
				C	S	P	?	
Nihoa Island	3	17	5	-	-	-	-	25
Necker Island	-	5	1	-	1	7	-	14
French Frigate Shoals	-	12	27	22	2	5	-	68
Gardner Pinnacles	-	1	-	-	2	-	-	3
Laysan Island	6	26	12	2	6	18	1	71
Lisianski Island	-	15	3	2	2	2	1	25
Pearl and Hermes Atoll	1	15	9	3	1	2	-	31
Midway Atoll	3	26	101	124	-	-	1	255
Kure Atoll	3	16	41	15	-	-	-	75
Totals ^b	8	42	114	132	8	11	2	317

^aE = endemic; I = indigenous; X = naturalized alien species; C = cultivated alien species;

S = seeds that arrived via natural dispersal; P = intentionally introduced propagules;

? = unknown.

^bIn calculating the totals, each species was counted only once, although it may have occurred on more than one island.

Of the 317 taxa of vascular plants recorded from the Leeward Islands, 8 (2.5%) are endemic and 42 (13.2%) are indigenous to these islands (although the indigenous species may be endemic to the Hawaiian Archipelago), while 114 (36.0%) are naturalized alien species and 132 (41.6%) are cultivated plants. The remaining 21 (6.6%) represent the seeds, cuttings, and seedlings deliberately introduced to the islands, or the seeds that floated to the islands but did not become established. The flora is summarized on an island by island basis in the Appendix and in Table 2 (page 192). A history of major disturbances on each of the Leeward Island groups is given in Table 3.

Plants have been introduced by two means: deliberate or unintentional introductions by humans, and introductions that did not involve the intervention of humans. Naturalized species and cultivated plants fall into the first category and native species into the last. For the purpose of this paper, alien species that moved from island to island by natural means (wind, ocean currents, or birds) are still considered alien species. Examples of different categories of naturalized alien species, based upon their means of introduction and their impacts, are given below.

CASE HISTORIES

Intentional Introduction of an Alien Plant: Ironwood

Casuarinaceae is a distinctive family of a single genus of shrubs and trees native primarily to Australia. A few species occur on Pacific Basin islands from Java to New Caledonia and in Asia as far north as Burma. The earliest documented record of the family in Hawai'i is a collection of ironwood (*Casuarina equisetifolia*) made by Heller on O'ahu in 1895 (Heller 1955: herbarium specimen, B.P. Bishop Museum). The species probably was introduced in 1882 by P. Isenberg, who planted trees at Kilohana Crater, Kaua'i. In 1890, A.S. Cleghorn, the father of Princess Ka'iulani, planted an avenue of ironwood trees on his estate in Waikiki. This is the avenue of ironwoods still standing in Kapi'olani Park and probably was the source of Heller's collection.

Ironwood has several qualities that help it compete under adverse conditions (Apfelbaum *et al.* 1983). It is capable of fixing atmospheric nitrogen and therefore is able to colonize nutrient-poor soils, especially those lacking nitrogen. The root system takes up most of the nutrients from the soil, which, along with the thick mulch of fallen branchlets that accumulates under the trees, prevents nearly all other plants from growing near it (Neal 1965). Ironwoods can reproduce both sexually and asexually, and the last, by root suckers, appears to be more prominent in Hawai'i. The leaves are reduced to whorls of minute scales with stomata (minute openings) located in longitudinal grooves where they are protected by minute cilia, reducing transpiration, an important adaptation for dry conditions. Moreover, ironwood is a facultative halophyte (salt lover). These qualities make ironwood a desirable, hardy ornamental and shade tree on the inhabited Leeward Islands. These same qualities make this species a potential management problem.

Table 3. History of major disturbances in the Leeward Hawaiian Islands.

ISLAND GROUP	EVENT	YEAR
Nihoa Island ^a	* Prehistoric habitation; house foundations, terraces, shelters, and religious sites.	----
	* Fire apparently destroyed much vegetation.	1885
	* HIRAN ⁺ projects probably introduced <i>Cenchrus echinatus</i> and <i>Paspalum</i> sp. (since disappeared), and <i>Portulaca oleracea</i> (replacing, perhaps via hybridization, native <i>P. lutea</i>).	1961
Necker Island ^b	* Religious sites and terraces indicate much impact by prehistoric Hawaiians.	----
	* Some evidence of unofficial bombing.	1940s
French Frigate Shoals ^c	* Shipwreck crew of 27 on island about one month.	1867
	* Vegetation partly destroyed during military exercise on East Island.	1932-1940
	* Permanent military station on East Island.	1942-1945
	* Tern Island enlarged by dredging, naval base built, all vegetation destroyed.	1942-1946
	* LORAN ⁺ station on East Island.	1942-1952
	* East Island inundated by a tidal wave.	1946
	* LORAN Station on Tern Island.	1952-1979
	* Tern Island inundated during heavy seas, much vegetation damaged.	1969
	* U.S. Fish & Wildlife Service refuge.	1979 to present
Gardner Pinnacles ^d	* None known.	

ISLAND GROUP	EVENT	YEAR
Laysan Island ^e	<ul style="list-style-type: none"> * Guano mining. * Various invasions by bird poachers. * Introduced rabbits virtually denuded the island. * Various plants reintroduced. * HIRAN operation may have accidentally introduced <i>Cenchrus echinatus</i> and <i>Conyza bonariensis</i>. 	1890-1910 ? -1915 1903-1923 1923-1966 1961-1962
Lisianski Island ^f	<ul style="list-style-type: none"> * Crews from 3 shipwrecks on island for up to 5 months. * Bird poachers (at least 5 groups, largest of 77 people, shacks built). * Rabbits destroyed all vegetation, then starved to death. 	1844-1872 1904-1910 after 1904-1915/16
Pearl and Hermes Atoll ^g	<ul style="list-style-type: none"> * Crews of 2 shipwrecks lived on island for 2 months. * Rabbits damaged vegetation. * Hawaiian Sea Products Co. erected buildings and harvested oyster shell. * Temporary naval base on SE Island. * Abandoned Sea Products buildings bombed and strafed; landing party burned them during a war exercise. * Navy constructed a 15 ft steel tower on SE Island. 	1822 before 1916-1928 1929 - 1931 1930s 1942 1961
Midway Atoll	<ul style="list-style-type: none"> * Shipwrecked crew lived on islands for 14 months until rescued.^h * Commercial Pacific Cable Co. installation built. About 9,000 tons of soil imported from Honolulu; 	1888-1889

Table 3, continued.

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ISLAND GROUP	EVENT	YEAR
	Windbreaks and sand-binding plants, vegetables, and ornamentals planted. ^h	1903-?
	* Pan American Airways built an airport, hotel, power plant, warehouses, and other buildings; planted over 200 species of ornamentals. ^{h,i}	1935-1941?
	* Military activities, especially during WWII, completely changed the ecology of the island. ⁱ	1941 to present
Kure Atoll^j	* Crew of shipwreck on island.	1837-1838
	* Crew of shipwreck on island (killed and ate ca 7000 seabirds, 60 seals, and 1 dog).	1842-1843
	* Crew of shipwreck on island ca 9 weeks before rescued.	1870-1871
	* Emergency building and water tanks built, tree seeds sown (none grew).	1886
	* Navy built radar reflector.	1955
	* LORAN station and runway built and maintained by Coast Guard.	1960 to present

^aClapp *et al.* 1977.^bClapp and Kridler 1977.^cAmerson 1971.^dClapp 1972.^eEly and Clapp 1973.^fClapp and Wirtz 1975.^gAmerson *et al.* 1974.^hBryan 1978.ⁱNeff and DuMont 1955.^jWoodward 1972.⁺HIRAN: High-precision short-range navigation; LORAN: Long-range navigation.

Ironwood has been introduced to seven of the Leeward Islands: Necker Island, French Frigate Shoals, Laysan and Lisianski Islands, and Pearl and Hermes, Midway, and Kure Atolls. Seeds were sown on Tern, Necker, and Laysan Islands by C.S. Judd in 1923 during the Tanager Expedition (Christophersen and Caum 1931); if any of these seeds germinated they did not survive. Ironwood trees were planted on Pearl and Hermes by naval personnel in 1963 to make this low island more visible from a distance. The seedlings subsequently were removed in 1964 by the U.S. Fish and Wildlife Service, as it violates Service policies to introduce alien plants on the Refuge. Ironwood trees were introduced to Laysan at least three times (Ely and Clapp 1973). G.P. Wilder planted a box of ironwood seedlings on Laysan in September 1905 and additional trees in 1930, and Judd sowed seed in 1923 (Christophersen and Caum 1931). Although several of the trees grew, only one is presently alive; it is believed to be one of the 1905 plantings. Coast Guard personnel planted trees around their installations on Tern Island and Kure in the mid 1950s. The original plantings are still alive, but only those on Tern Island have reproduced and become sparingly naturalized. Trees were planted on Lisianski in 1931 (Clapp and Wirtz 1975). Of the original plantings, only about four or five are still alive.

Ironwood has become abundant enough only on Midway to cause a management problem. In 1903, the Commercial Pacific Cable Company took possession of Sand Island, Midway Atoll, and erected permanent concrete buildings. Over the ensuing years, more than 9,000 tons of top soil was brought from Honolulu, vegetable gardens were established, and ornamental trees, shrubs, and flowers were planted. The island changed from a barren sand waste to an oasis around the company installations (Bryan 1978). In 1907, Daniel Morrison, then Assistant Superintendent of the cable station, planted hundreds of ironwood trees to give protection against the wind and sun (Bryan 1978). Descendants of those trees now dominate the island's ecosystem and have impacted the use of the island by both wildlife and humans. Changes in bird populations have occurred with ironwood establishment, favoring birds associated with forested areas and selecting against the species of open habitats. Although black noddies (*Anous minutus melanogenys*) and white terns (*Gygis alba rothschildi*) benefit from the increase in their preferred nesting habitat, other species, such as the black-footed albatross (*Diomedea nigripes*), which nests on the ground in open areas, suffer habitat loss. Also, several of the larger seabird species need open areas because they must run in order to become airborne. Native vegetation also has been impacted by ironwood trees. For example, the beach naupaka (*Scaevola sericea*) is an important sand stabilizer on these islands. Since beach naupaka cannot tolerate heavy shade, the gradual encroachment and replacement of the naupaka by ironwood has not only changed the vegetation components of the island but has rendered the shoreline more susceptible to erosion.

The Federal Aviation Administration requires that the vegetation along the sides and ends of runways be kept below certain heights for safety. The runway aprons were paved with "soil cement," an asphalt that was sprayed on the ground to prevent the encroachment of the ironwoods and reduce maintenance. According to L. Pinter (pers. comm.), however, seeds

became lodged in seams and cracks in the soil cement and germinated, their roots threatening to break up the aprons. Graders were used to remove the unwanted vegetation but broke through the soil cement; the ironwoods then invaded the area heavily. Tagged trees, measured at 6-month intervals by the Navy, grew as much as 40 ft (12 m) in 18 months. When the trees were cut down, they regrew from the stumps and roots. Herbicides were not used, although the species is very susceptible to them, because the runoff of the landing strips is the main source of water for the installation. It has been necessary to keep the runway area cleared mechanically, using manual labor to remove the seedlings. Backhoes, chain saws, and heavier equipment are used around the buildings, antenna fields, and other areas. Additionally, the older trees often are infested with ground termites (*Coptotermes formosanus*), which eat out the core of the plant. These trees break easily or lose large limbs during storms, damaging power lines and buildings. Ironwood control is, indeed, a major problem on Midway, but oddly, not on any of the other Leeward Islands.

Accidentally Introduced Alien Plants: *Heliotropium procumbens* and Golden Crown-beard

The heliotrope *Heliotropium procumbens* is a low, mat-forming, perennial herb. It superficially resembles, and shares the same habitat as, the indigenous nena (*Heliotropium curassavicum*) but can easily be distinguished from the latter by its nonsucculent, densely pubescent leaves. *Heliotropium procumbens* is native from the southern United States south to Central and South America and east to the West Indies. It also is found on Guam, where it is considered native (Stone 1970; Fosberg *et al.* 1979).

For about three centuries, Spanish galleons regularly laid over on Guam to load fresh supplies, drop off goods, and unload passengers during the annual Acapulco to Manila trip. Because the Guam populations of this heliotrope most closely resemble those of Mexico (Fosberg, pers. comm.), and because *Heliotropium procumbens* is otherwise native only in America, it seems likely that it represents an early, accidental introduction into Guam from Mexico.

H. procumbens was first discovered in 1975 in Hawai'i, at the Campbell Industrial Park at Barbers Point, O'ahu (Herbst and Ishikawa 5466: herbarium specimen, B.P. Bishop Museum), where it may have been brought accidentally by one of the frequent military flights between Hawai'i and Guam. On O'ahu, it was next seen at construction sites or other areas having a direct connection to Barbers Point. For example, it now grows at the Sand Island gas storage tanks that store gasoline refined at Barbers Point (Herbst and Ishikawa 5643: herbarium specimen, B.P. Bishop Museum). This heliotrope also occurs at the ready-mix concrete plant on Sand Island (D.R. Herbst observation), which uses raw materials brought from Barbers Point. *Heliotropium procumbens* has been spread from the concrete plant to various construction sites on O'ahu, such as the Entomology building at the University of Hawaii at Mānoa, (D.R. Herbst observation) and a Mariner's Ridge housing development (Nagata 1286: herbarium specimen, B.P. Bishop Museum). In recent years, it has gradually migrated to other disturbed sites on O'ahu and, more recently, has been collected on Maui

(Hobdy 1042: herbarium specimen, B.P. Bishop Museum). *H. procumbens* was collected on Tern Island in 1978 and Midway Atoll in 1980. The Midway and Tern Island plants probably were accidentally introduced by military flights from Barbers Point (Herbst 1980).

Although *H. procumbens* is not presently considered a management problem, it does represent a foreign element in the Leeward Islands and potentially could replace native vegetation. No management plan is being considered at present.

Golden crown-beard (*Verbesina encelioides*) has become a management problem. It was first reported on Kure Atoll by H.F. Clay in October 1959, growing near the radar reflector on Green Island. Bermuda grass (*Cynodon dactylon*), ironwood, and sourbush (*Pluchea symphytifolia*) were growing with it. Clay surmised that seeds of these plants were brought on equipment from Midway Atoll in 1955 when the reflector was built (Clay 1961). Golden crown-beard and sweet alyssum (*Lobularia maritima*) have become widespread on Green Island and are undergoing population explosions (Corn *et al.* 1981). Golden crown-beard forms a thicket that limits the space for ground-nesting seabirds, and it has become necessary to mow the central plain of Green Island to restore nesting areas for the birds.

Three taxa of plants endemic to the Leeward Islands are believed to have become extinct within the last 20 or 25 years. These are kāmanomano (*Cenchrus agrimonoides* var. *laysanensis*), *Achyranthes atollensis*, and *Phyllostegia variabilis*. On Green Island, all three grew only in the central plain area. Competition from the golden crown-beard and sweet alyssum undoubtedly had a major role in their extinction on that island.

The Leeward Islands have had a long history of human disturbance, dating back on Nihoa and Necker to prehistoric times (Table 3). Other plants and animals, such as *Pritchardia* sp., sandalwood (*Santalum ellipticum*), Laysan rail (*Porzana palmeri*), and Laysan honeycreeper (*Himatione sanguinea freethii*), on Laysan have become extinct as a direct result.

Naturally Introduced Alien Species: *Nephrolepis multiflora* and Tree Heliotrope

Nephrolepis multiflora, a sword fern, is known from two of the Leeward Islands, Midway (Herbst, unpub. data) and Nihoa (Conant and Herbst 1983; Conant 1985). On Midway, the fern may have been intentionally introduced as an ornamental, or it may have been accidentally brought in with soil or other ornamental plants. Today, it persists in abandoned cultivated areas and appears to have been deliberately cultivated at one time.

The fern was first collected on Nihoa by S. Conant in 1981. A colony was found on the western ridge of Miller Valley, a good distance away from the usual landing sites, and Conant believed that the spores arrived by wind dispersion rather than by accidental or intentional human intervention. In 1983, Conant discovered two additional small colonies that probably were established after her 1981 sighting. In 1983 the original colony had been reduced in size due to an invasion of its habitat by *Eragrostis variabilis*, a native grass. The fern does not appear to

be aggressive enough to impact native vegetation, and no management plan is being considered for its control.

Tree heliotrope, *Tournefortia argentea*, naturalized on the main islands since the mid 1800s, is known from six of the Leeward Islands. The species was growing on Pearl and Hermes Atoll as early as 1923 (Amerson *et al.* 1974), where it probably was introduced as an ornamental. It likely was planted on Midway for the same purpose at an earlier date, but we have no record of its original introduction. The oldest trees on Tern Island are believed to have been planted in the mid 1950s by the Coast Guard when that agency was upgrading and landscaping the old naval facility on the island. In 1959, H. Clay found a single young tree growing on the windward shore of Green Island, Kure Atoll (Clay 1961). Two years later a single small tree was found growing on the northwestern beach of Laysan (Tsuda 1965). The fruits of tree heliotrope contain corky tissue and are well adapted for water dispersal; the Kure and Laysan plants probably were the results of natural dispersal by ocean currents.

Studies of mercury in Hawaiian seabird eggs indicated that Midway and Laysan are influenced by the eastward-flowing Kuroshio Extension and North Pacific Current, while the currents around the other sites sampled during the study were more affected by the westward-flowing California Current Extension and North Equatorial Current (Ohlendorf and Harrison 1968). If this is correct, it would seem most probable that Midway was the source of both the Kure and the Laysan introductions of this species.

MANAGEMENT NEEDS

Except for the examples cited above, little has been done to manage the alien plants in the Leeward Islands. This is partly due to the logistics involved, as the islands are remote and getting to them is expensive and time consuming. Moreover, it is difficult or impossible to land on most islands except during the few times of the year that the seas are calm. The main reason for inaction, however, is that there has been little need seen for managing alien plants, other than taking precautions that no new species are introduced. These precautions should include careful cleaning and inspection of all equipment and supplies used in temporary camps established to accommodate scientists studying the wildlife of the Islands.

Most of the naturalized species, except for those on the three islands inhabited by humans, appear to be in balance with the rest of the flora. Some even appear to be beneficial to some of the native birds because they provide additional nesting sites and food and nesting material. Sandbur (*Cenchrus echinatus*), for example, provides additional nesting sites for wedge-tailed shearwaters (*Puffinus pacificus chlororhynchus*) and other burrowing birds. The fibrous root system binds the loose sand, allowing the birds to construct nesting burrows beneath them, while the leaves and seeds are used for nesting material and food by the Laysan finch (*Telespyza cantans*). Tree heliotrope, ironwood, and the naturalized shrubs provide additional nesting sites for noddies and other birds that prefer to nest off the ground.

RECOMMENDATIONS

The vegetation dynamics in the Leeward Islands should be closely monitored to determine changes in composition and to detect new introductions of plants or animals that may impact the existing vegetation. Also, general vegetation maps of each island are needed. Vegetation mapping methods for the Leeward Islands, using aerial photography, have been developed. Detailed distributional maps of all alien species could be completed while ground-truthing the general vegetation maps for all Islands.

Most of our knowledge about the vegetation of the Leeward Islands is based upon casual observations made by ornithologists during the course of their primary research, or by botanists or other biologists during brief visits. The study of ironwood by Apfelbaum *et al.* (1983) on Midway, although limited, constitutes one of the few detailed studies of plants undertaken in the Leeward Islands. Permanent transects and photo stations and the collection of baseline data are necessary for the development of long-term management plans.

A well-illustrated, nontechnical manual of the plants of the Leeward Islands would aid in monitoring the vegetation. It could be used by non-botanists to detect new island introductions or populations as well as distributional changes of both native and alien plants and would be a valuable tool for individuals requiring plant identification as an aspect of their research (*e.g.*, the host plant of an insect or the nesting site of a bird). A complete species list of the plants of Midway Atoll does not yet exist, but when a floristic survey of that atoll is completed, sufficient information about the Leeward Island plants will be available to develop such a manual. The appendix provided here is intended as an interim aid.

It is equally important that the Islands be monitored for the introduction of alien animals, particularly rats (*Rattus* spp.). Shipwrecks provide the most likely means for introducing rats to the islands. Within recent years, fishing vessels have gone aground on Laysan Island and French Frigate Atoll, but fortunately no rats were aboard. Rats have been established on Midway Atoll since 1943 (Kramer 1971), where they have caused damage to both birds and vegetation, as they eat both the seeds and the vegetative parts of plants. Rat damage to beach naupaka is most conspicuous; they chew through the branches just below the tuft of leaves to get the nutrients and moisture in the stem's pith, and the remaining tissue cannot support the weight of the leaves, causing the branches to break.

Mosquitoes, which are naturalized on Midway (U.S. Fish and Wildlife Service, unpub. report), carry fowl pox, infecting young albatross chicks. During their inactive periods, mosquitoes rest in the shelter of the dense vegetation surrounding the nests. Mowing the nesting areas has greatly decreased the incidence of fowl pox in the albatross colony. The "Scaevola dieback" on Lisianski and Laysan Islands may have been caused by an introduced scale insect. The insect may have weakened the shrubs to the

point where they could not withstand the stress of a prolonged period of drought followed by a severe winter storm.

Finally, it is important to develop a management plan for the control of alien species, both plant and animal, impacting the vegetation and wildlife of the islands. The plan should include a means for monitoring and detecting new introductions and for determining population and distribution changes of existing naturalized organisms, and it should discuss the various methods of containing or removing the alien species.

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SIDA RAS

APPENDIX

Checklist of the Vascular Plants of the Leeward Hawaiian Islands

This list is based on the collections in the herbaria of the B.P. Bishop Museum and the University of Hawaii, literature citations, and personal collections and observations. It should be considered a preliminary report, as the identification of many of the specimens has not been verified. Each entry includes the scientific name, the common name, the distribution, and the status of the species within the Leeward Islands.

The symbols used for status are:

- E- endemic to the Leeward Islands; *i.e.*, occurring naturally nowhere else in the world, including the main Hawaiian Islands.
- I - indigenous; *i.e.*, native to the Leeward Islands but occurring naturally (without the aid of humans) elsewhere; however, the plant may be endemic to the Hawaiian archipelago.
- X- non-cultivated alien species; *i.e.*, plants of accidental or deliberate introduction that have become naturalized on the islands.
- C- cultivated species which have not become naturalized.
- S - seeds that arrived through natural dispersal means. These are most commonly found in the debris line.
- P - intentionally introduced propagules, as seeds or cuttings, that did not germinate or live.
- ? - status unknown.
 - an underlined symbol denotes a non-vouchered species reported in the literature as an observation.

In the case of multiple entries, only the symbol which best describes the present status of the species is used. For example, Tern Island, French Frigate Shoals, has both cultivated ironwood trees (C) and wild plants that have seeded from these planted specimens (X); only the "X" symbol is used in the list, as it gives the most dynamic statement of that plant's present status on that island.

Symbols for the island groups are: N = Nihoa; Ne = Necker; FF = French Frigate Shoals; GP = Gardner Pinnacles; La = Laysan Island; Li = Lisianski Island; PH = Pearl and Hermes Atoll; Mi = Midway Atoll; Ku = Kure Atoll.

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	

PTERIDOPHYTA

DAVALLIACEAE (Sword fern family)

Nephrolepis multiflora (Roxb.) Morton

sword fern

X

C

DICKSONIACEAE (Dicksonia family)

Cibotium sp.

Hawaiian tree fern

C

POLYPODIACEAE (Common fern family)

Phymatodes scolopendria (J. Burm.) Ching

laua'e

C

PSILOTACEAE (Psilotum family)

Psilotum nudum (L.) Griseb.

moa

?

GYMNOSPERMAE

ARAUCARIACEAE (Araucaria family)

Araucaria heterophylla (Salisb.) Franco

Norfolk Island pine

C

C

CUPRESSACEAE (Cypress family)

Cupressus sp.

C

CYCADACEAE (Cycas family)

Cycas circinalis L.

sago palm

C

Cycas revoluta Thunb.

sago palm

C

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku

MONOCOTYLEDONAE										
AGAVACEAE (Agave family)										
<i>Agave sisalana</i> Perrine	sisal									C
<i>Cordyline fruticosa</i> (L.) A. Chev.	ti									C
<i>Cordyline</i> sp.										C
<i>Dracaena</i> sp.										C
<i>Sansevieria</i> sp.	bowstring hemp									C
ALOEACEAE (Aloe family)										
<i>Aloe</i> sp.	aloe									C
ARACEAE (Taro family)										
<i>Alocasia cucullata</i> (Lour.) G. Don	Chinese taro									C
<i>Anthurium andraeanum</i> Lindl.	anthurium									C
<i>Caladium bicolor</i> (Aiton) Vent.	caladium									C
<i>Colocasia esculenta</i> (L.) Schott	taro									C
<i>Dieffenbachia</i> sp.	dumb cane									C
<i>Monstera deliciosa</i> Liebm.	monstera									C
<i>Philodendron</i> sp.	philodendron						C			C
<i>Rhaphidophora aurea</i> (Andre) Birdsey	taro vine									C
<i>Syngonium podophyllum</i> Schott	syngonium									C
<i>Xanthosoma</i> sp.	'ape									C
ARECACEAE (Palm family)										
<i>Cocos nucifera</i> L.	coconut					C	X	C	C	C
<i>Livistona australis</i> (R. Br.) Mart.	cabbage palm		P			P				

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
<i>Phoenix dactylifera</i> L.	date palm					<u>P</u>					
<i>Phoenix</i> sp.								<u>C</u>	<u>C</u>		
<i>Pritchardia martii</i> (Gaud.) H.A. Wendl.	loulu			<u>P</u>							
<i>Pritchardia pacifica</i> Seem. & H.A. Wendl.	vin		<u>P</u>	<u>P</u>		<u>P</u>		<u>P</u>			
<i>Pritchardia remota</i> (Kuntze) Becc.	loulu	E									
<i>Pritchardia</i> sp.			<u>P</u>			<u>?</u>			<u>C</u>		
<i>Roystonea</i> sp.									<u>C</u>		
CANNACEAE (Canna family)											
<i>Canna indica</i> L.	canna									<u>C</u>	
COMMELINACEAE (Spiderwort family)											
<i>Commelina diffusa</i> N.L. Burm.	honohono									X	
<i>Dichorisandra thyrsiflora</i> Mikan.	blue ginger									C	
<i>Tradescantia spathacea</i> Sw.	oyster plant									<u>C</u>	
<i>Tradescantia zebrina</i> Bosse	wandering Jew									C	
CYPERACEAE (Sedge family)											
<i>Cyperus alternifolius</i>											
subsp. <i>flabelliformis</i> (Rottb.) Kukenth.	umbrella plant									X	
<i>Cyperus laevigatus</i> L.	makaloa					I					
<i>Cyperus papyrus</i> L.	papyrus									<u>C</u>	
<i>Cyperus rotundus</i> L.	nutgrass			X					X	X	
<i>Fimbristylis cymosa</i>											
subsp. <i>spathacea</i> (Roth) T. Koyama	button sedge			I		I			I		
<i>Fimbristylis cymosa</i> subsp.											
subsp. <i>umbellato-capitata</i> (Hillebr.) T. Koyama	button sedge					I			I	I	

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
<i>Mariscus javanicus</i> (Houtt.) Merr. & Metcalfe	'ahu'awa								I		
<i>Mariscus pennatifolius</i> subsp. <i>bryanii</i> (Kukenth.) T. Koyama						E					
<i>Pycreus polystachyos</i> (Rottb.) P. Beauv. subsp. <i>polystachyos</i>									I		
LILIACEAE (Lily family)											
<i>Allium cepa</i> L.	onion					X		X	C		
<i>Allium fistulosum</i> L.	bunch onion			C							
<i>Asparagus setaceus</i> (Kunth) Jessop	asparagus fern								C		
<i>Chlorophytum capense</i> (L.) Voss	bracket plant			C							
<i>Crinum asiaticum</i> L.	spider lily								C	C	
<i>Hemerocallis</i> sp.	day lily								C		
<i>Hippeastrum</i> sp.									C		
<i>Pancratium littorale</i> Jacq.	spider lily								C		
MUSACEAE (Banana family)											
<i>Heliconia psittacorum</i> L. fil.									C		
<i>Musa</i> sp.	banana								C		
<i>Strelitzia reginae</i> Banks	bird of paradise								C		
ORCHIDACEAE (Orchid family)											
<i>Vanda</i> sp.									C		
Various orchids									C		
PANDANACEAE (Screwpine family)											
<i>Pandanus tectorius</i> S. Parkinson ex Z.	hala			C					C	C	

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku
POACEAE (Grass family)										
<i>Ammophila arenaria</i> (L.) Link	European beachgrass								X	
<i>Brachiaria mutica</i> (Forssk.) Stapf	paragrass								X	
<i>Bromus willdenowii</i> Kunth	prairie grass								X	
<i>Cenchrus agrimonoides</i> var. <i>laysanensis</i> F. Br.						E			E	E
<i>Cenchrus echinatus</i> L.	sandbur	X		X		X	X		X	X
<i>Chloris barbata</i> (L.) Sw.	swollen fingergrass								X	X
<i>Chloris virgata</i> Sw.	feather fingergrass									X
<i>Cymbopogon citratus</i> (Nees) Stapf	lemon grass			C						
<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass			X		X		X	X	X
<i>Digitaria ciliaris</i> (Retz.) Koeler	kūkaepua'a			X					X	X
<i>Digitaria insularis</i> (L.) Ekman	sourgrass								X	
<i>Eleusine indica</i> (L.) Gaertn.	goosegrass			X					X	X
<i>Eragrostis tenella</i> (L.) Roem. & Schult.	Japanese lovegrass								X	X
<i>Eragrostis variabilis</i> (Gaud.) Steud.	'emoloa	I				I	I	I	I	I
<i>Eragrostis paupera</i> Jedwabn.				I				I	I	I
<i>Eustachys petraea</i> Desf.				X					X	
<i>Hordeum leporinum</i> Link									X	
<i>Lepturus repens</i> (G. Forst.) R. Br. var. <i>repens</i>				I					I	
<i>Lepturus repens</i> var. <i>cinereus</i> (Burch.) Fosb.										I
<i>Lepturus repens</i> var. <i>occidentalis</i> Fosb.								I		
<i>Lepturus repens</i> var. <i>subulatus</i> Fosb.				I		I	I	I	I	
<i>Melinis minutiflora</i> P. Beauv.	molasses grass					P				
<i>Panicum torridum</i> Gaud.	kākonakona	I	I							
<i>Paspalum fimbriatum</i> Kunth	Columbia grass									X
<i>Paspalum urvillei</i> Steud.	vasey grass								X	
<i>Paspalum</i> sp.			X							X

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku
<i>Poa annua</i> L.	annual bluegrass								X	X
<i>Polypogon interruptus</i> Kunth	ditch polypogon								X	X
<i>Polypogon monspeliensis</i> (L.) Desf.	rabbitfoot grass								X	
<i>Rhynchelytrum repens</i> (Willd.) Hubb.	Natal redtop								X	
<i>Setaria verticillata</i> (L.) P. Beauv.	bristly foxtail	X		X				X	X	X
<i>Sporobolus africanus</i> (Poir.) Robyns&Tournay	African dropseed								X	
<i>Sporobolus indicus</i> (L.) R. Br.	West Indian dropseed								X	
<i>Sporobolus pyramidatus</i> (Lam) Hitchc.				X					X	X
<i>Sporobolus virginicus</i> (L.) Kunth	beach dropseed					I			I	
<i>Stenotaphrum secundatum</i> (Walter) Kuntze	buffalo grass								X	
<i>Vulpia myuros</i> (L.) Gmelin	foxtail fescue								X	
<i>Zea mays</i> L.	corn			C						
ZINGIBERACEAE (Ginger family)										
<i>Catimbum speciosum</i> (Wendl.) Holtum	shell ginger								C	
<i>Hedychium gardnerianum</i> Ker-Gawl.	kāhili ginger								C	
DICOTYLEDONAE										
ACANTHACEAE (Acanthus family)										
<i>Asystasia gangetica</i> (L.) T. Anderson	asystasia								X	
<i>Odontonema stictum</i> (Nees) Kuntze	odontonema								C	
<i>Ruellia brittoniana</i> E. Leonard									X	
AIZOACEAE (Carpetweed family)										
<i>Sesuvium portulacastrum</i> (L.) L.	‘ākulikuli		I			I	I	I		
<i>Tetragonia tetragonioides</i> (Pall.) Kuntze	New Zealand spinach	X								

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
AMARANTHACEAE (Amaranth family)											
<i>Achyranthes aspera</i> L. var. <i>aspera</i>						X					
<i>Achyranthes atollensis</i> St. John						E		E	E	E	
<i>Alternanthera tenella</i> Colla	joyweed								C		
<i>Amaranthus brownii</i> Christoph. & Caum		E									
<i>Amaranthus dubius</i> Mart.	pakai								X		
<i>Amaranthus hybridus</i> L.	green amaranth								X		
<i>Amaranthus spinosus</i> L.	spiny pigweed								X	X	
<i>Amaranthus viridis</i> L.	slender amaranth					X			X	X	
ANACARDIACEAE (Mango family)											
<i>Mangifera indica</i> L.	mango								C		
<i>Schinus terebinthifolius</i> Raddi	Christmas berry								X		
APIACEAE (Carrot family)											
<i>Ciclospermum leptophyllum</i> (Pers.) Sprague	fine-leaved celery								X	X	
APOCYNACEAE (Periwinkle family)											
<i>Allamanda cathartica</i> L.	allamanda								C		
<i>Carissa macrocarpa</i> (Eckl.) DC.	Natal plum								C		
<i>Cascabela thevetia</i> (L.) Lippold	be-still tree								C		
<i>Catharanthus roseus</i> (L.) G. Don	periwinkle								C		
<i>Ervatamia</i> sp.	crape jasmine								C		
<i>Nerium oleander</i> L.	oleander								C		
<i>Plumeria obtusa</i> L.	Singapore plumeria				C				C	C	
<i>Plumeria</i> sp.	plumeria								C		

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
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ARALIACEAE (Ginseng family)											
<i>Polyscias guilfoylei</i> (Bull) Bailey	panax									<u>C</u>	
<i>Schefflera actinophylla</i> (Endl.) Harms	octopus tree									<u>C</u>	
ASTERACEAE (Daisy family)											
<i>Arctium lappa</i> L.	gobo									C	
<i>Bidens alba</i> var. <i>radiata</i> (Schultz-Bip.) Melchert	Spanish needles									X	X
<i>Bidens pilosa</i> L.	Spanish needles									X	
<i>Conyza bonariensis</i> (L.) Cronq.	ilioha			X		X				X	X
<i>Emilia fosbergii</i> Nicolson	red pualele										X
<i>Gaillardia pulchella</i> Foug.	waikāhuli										X
<i>Gnaphalium purpureum</i> L.	cudweed									X	
<i>Gnaphalium sandwicense</i> Gaud. var. <i>sandwicense</i>	‘ena‘ena									I	I
<i>Helianthus annuus</i> var. <i>macrocarpus</i> (DC.) Cockerell	sunflower									<u>C</u>	C
<i>Lactuca sativa</i> L.	lettuce			<u>C</u>							
<i>Lipochaeta integrifolia</i> (Nutt.) A. Gray	nehe					I					I
<i>Pluchea x fosbergii</i> Cooperr. & Galang										X	
<i>Pluchea indica</i> (L.) Less.	Indian pluchea					X				X	
<i>Pluchea symphytifolia</i> (Mill.) Gillis	sour bush			X						X	X
<i>Sonchus oleraceus</i> L.	sow thistle							X		X	X
<i>Tridax procumbens</i> L.	coat buttons									X	
<i>Verbesina encelioides</i> (Cav.) Benth. & Hook.	golden crown-beard									X	X
<i>Wedelia trilobata</i> (L.) Hitchc.	wedelia									X	
<i>Xanthium strumarium</i> var. <i>canadense</i> (Mill.) Torr. & A. Gray	cocklebur									X	

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku
BIGNONIACEAE (Bignonia family)										
<i>Spathodea campanulata</i> P. Beauv.	African tulip tree								<u>C</u>	
<i>Tabebuia</i> sp.									<u>C</u>	
BORAGINACEAE (Heliotrope family)										
<i>Cordia sebestena</i> L.	kou-haole								C	
<i>Cordia subcordata</i> Lam.	kou					<u>P</u>				
<i>Heliotropium curassavicum</i> L.	nena	I		I		I				
<i>Heliotropium procumbens</i> var. <i>depressum</i> (Cham.) Fosb.				X					X	
<i>Tournefortia argentea</i> L. fil.	tree heliotrope			X		X	X	X	X	X
BRASSICACEAE (Mustard family)										
<i>Brassica campestris</i> L.	field mustard							X		
<i>Brassica nigra</i> (L.) W. Koch	black mustard								X	
<i>Capsella rubella</i> Reut.	shepherd's purse								X	
<i>Coronopus didymus</i> (L.) Sm.	swine cress			X				X	X	X
<i>Lepidium bidentatum</i> var. <i>o-waihiense</i> (Cham. & Schlecht.) Fosb.	'ānaunau					I		I	I	I
<i>Lepidium virginicum</i> L.	pepper grass								X	X
<i>Lobularia maritima</i> (L.) Desv.	sweet alyssum								X	X
<i>Raphanus sativus</i> L.	radish								<u>C</u>	
CACTACEAE (Cactus family)										
<i>Epiphyllum oxypetalum</i> (DC.) Haw.	gooseneck cactus								X	
<i>Hylocereus undatus</i> (Haw.) Britton & Rose	night blooming cereus								<u>C</u>	
CAPPARACEAE (Caper family)										
<i>Capparis sandwichiana</i> DC.	puapilo					I		I	I	

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
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CARICACEAE (Papaya family)											
<i>Carica papaya</i> L.	papaya								<u>C</u>		
CARYOPHYLLACEAE (Pink family)											
<i>Cerastium fontanum</i>											
var. <i>triviale</i> (Link) Jalas	common mouse ear								X		
<i>Schiedea verticillata</i> F. Br.		E									
<i>Spergularia marina</i> (L.) Griseb.	mimi'ilio			X					X	X	
<i>Stellaria media</i> (L.) Vill.	common chickweed								X	X	
CASUARINACEAE (Casuarina family)											
<i>Casuarina equisetifolia</i> L.	ironwood		<u>P</u>	X		C	C	C	X	C	
CHENOPODIACEAE (Goosefoot family)											
<i>Atriplex suberecta</i> Verd.	salt bush			X		<u>P</u>					
<i>Beta vulgaris</i> var. <i>cicla</i> L.	Swiss chard			<u>C</u>							
<i>Chenopodium murale</i> L.	nettle-leaved goosefoot			X					X	X	
<i>Chenopodium oahuense</i> (Meyen) Aellen	'āweoweo	I	I	I		I	I				
<i>Salicornia virginica</i> L.	samphire			X							
CLUSIACEAE (Mangosteen family)											
<i>Calophyllum inophyllum</i> L.	kamani			S		<u>P</u>			C		
<i>Clusia rosea</i> Jacq.	copey								<u>C</u>		
COMBRETACEAE (Indian almond family)											
<i>Conocarpus erectus</i> L.	buttonwood			C		<u>P</u>			<u>C</u>		
<i>Terminalia catappa</i> L.	false kamani			C		<u>P</u>			C	<u>C</u>	
<i>Terminalia myriocarpa</i> Heurck & Muell.-Arg.						<u>P</u>					

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku
CONVOLVULACEAE (Morning-glory family)										
<i>Convolvulus</i> sp.						<u>P</u>				
<i>Ipomoea batatas</i> (L.) Lam.	sweet potato								<u>C</u>	
<i>Ipomoea indica</i> f. <i>albiflora</i> Stone							I			
<i>Ipomoea indica</i> (J. Burm.) Merr. f. <i>indica</i>	koali'awahia	I				I	I		I	I
<i>Ipomoea pes-caprae</i> subsp. <i>brasiliensis</i> (L.) Ooststr.	beach morning glory	I		I		I	I		I	I
<i>Ipomoea</i> sp.							<u>S</u>		<u>C</u>	
<i>Ipomoea triloba</i> L.	little bell								X	
<i>Merremia tuberosa</i> (L.) Rendle	wood rose								<u>C</u>	
CRASSULACEAE (Stonecrop family)										
<i>Crassula</i> sp.									<u>C</u>	
<i>Kalanchoe daigremontiana</i> x <i>tubiflora</i>									<u>C</u>	
<i>Kalanchoe pinnata</i> (Lam.) Pers.	air plant								X	
<i>Kalanchoe tubiflora</i> (Harv.) Raym.-Hamet	chandelier plant								<u>C</u>	
CUCURBITACEAE (Gourd family)										
<i>Cucumis sativus</i> L.	cucumber			<u>C</u>						
<i>Cucurbita pepo</i> L.	squash, zucchini			<u>C</u>		<u>P</u>			<u>C</u>	
<i>Sicyos maximowiczii</i> Cogn.						I	I	I		I
<i>Sicyos pachycarpus</i> Hook. & Arnott		I				I				
<i>Sicyos semitonsus</i> St. John						E				
EUPHORBIACEAE (Spurge family)										
<i>Acalypha wilkesiana</i> Muell.-Arg.	beefsteak plant								C	
<i>Aleurites moluccana</i> (L.) Willd.	kukui		S	S		S	S	S		

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku
<i>Breynia disticha</i> var. <i>rosi-picta</i> Hort.	snow bush								<u>C</u>	
<i>Chamaesyce celastroides</i> (Boiss.) Croizat & Degener										
var. <i>celastroides</i>	‘akoko	I								
<i>Chamaesyce hirta</i> (L.) Millsp.	hairy spurge			X				X	X	
<i>Chamaesyce hypericifolia</i> (L.) Millsp.				X				X	X	
<i>Chamaesyce maculata</i> (L.) Small								X	X	
<i>Chamaesyce prostata</i> (Aiton) Small	small ground fig			X				X		
<i>Codiaeum variegatum</i>										
var. <i>pictum</i> (Lodd.) Muell.-Arg.	croton							<u>C</u>	<u>C</u>	
<i>Euphorbia cyathopora</i> Murray	wild poinsettia							X		
<i>Euphorbia heterophylla</i> L.								X		
<i>Euphorbia peplus</i> L.	petty spurge							X	X	
<i>Euphorbia pulcherrima</i> Klotz.	poinsettia							<u>C</u>		
<i>Pedilanthus tithymaloides</i> (L.) Poit.	slipper flower							<u>C</u>		
<i>Ricinus communis</i> L.	castor bean							X		
FABACEAE (Pea family)										
<i>Acacia farnesiana</i> (L.) Willd.	klu								X	
<i>Albizia lebbek</i> (L.) Benth.	siris tree								C	
<i>Caesalpinia bonduc</i> (L.) Roxb.	kākalaioa, kinikini					S				
<i>Canavalia ensiformis</i> (L.) DC.	jackbean					<u>P</u>				
<i>Cassia</i> sp.									<u>C</u>	
<i>Crotalaria incana</i> L.	fuzzy rattle-pod								X	
<i>Crotalaria pallida</i> Aiton	rattle-pod								X	
<i>Delonix regia</i> (Hook.) Raf.	royal poinciana								<u>C</u>	
<i>Desmanthus virgatus</i> (L.) Willd.	virgate mimosa								X	
<i>Desmodium sandwicense</i> E. Mey.	Spanish clover								X	

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
<i>Dioclea wilsonii</i> Standl.	sea bean					S					
<i>Entada scandens</i> (Rosb.) Benth.						S					
<i>Erythrina variegata</i> var. <i>orientalis</i> (L.) Merr.	tiger's claw								C		
<i>Erythrina</i> sp.										C	
<i>Glycine soja</i> (L.) Sieb. & Zucc.	soy bean								C		
<i>Haematoxylum campechianum</i> L.	logwood tree		P	P		P					
<i>Leucaena leucocephala</i> (Lam.) de Wit	koa haole			X		P			X		
<i>Medicago lupulina</i> L.	black medic								X		
<i>Medicago polymorpha</i> L.	bur clover									X	
<i>Medicago sativa</i> L.	alfalfa								X		
<i>Melilotus alba</i> Medik.	white sweet clover								X		
<i>Melilotus indica</i> (L.) All.	sweet clover								X		
<i>Mucuna gigantea</i> (Willd.) Medik.	kā'e'e					S					
<i>Mucuna urens</i> (L.) Medik.	sea bean					S					
<i>Mucuna</i> sp.					S						
<i>Phaseolus vulgaris</i> L.	green bean			C					C		
<i>Prosopis pallida</i> (Willd.) Kunth	kiawe								C		
<i>Samanea saman</i> (Jacq.) Merr.	monkeypod								C		
<i>Senna surattensis</i> (N. L. Burm.) H. Irwin & Barneby	kolomona									C	
<i>Sesbania tomentosa</i> Hook & Arnott	'ohai	I	I								
Seedling legume										?	
FRANKENIACEAE (Frankenia family)											
<i>Frankenia salina</i> (Molina) I.M. Johnst.					X						

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
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GENTIANACEAE (Gentian family)											
<i>Centaurium erythraea</i> Raf. subsp. <i>erythraea</i>	bitter herb								X		
GERANIACEAE (Geranium family)											
<i>Pelargonium hortorum</i> Bailey	fish geranium								C		
GOODENIACEAE (Goodenia family)											
<i>Scaevola sericea</i> Vahl	naupaka kahakai			I		I	I	I	I	I	
HYDROPHYLLACEAE (Water-leaf family)											
<i>Nama sandwicensis</i> A. Gray	Hawaiian nama					I	I				
LAMIACEAE (Mint family)											
<i>Phyllostegia variabilis</i> Bitter						E			E	E	
<i>Plectranthus scutellarioides</i> (L.) R. Br.	coleus								C		
<i>Stachys arvensis</i> L.	staggerweed								X		
LECYTHIDACEAE (Barringtonia family)											
<i>Barringtonia asiatica</i> (L.) Kurz	barringtonia			C		P	P				
MALPIGHIACEAE (Malphigia family)											
<i>Tristellateia australasiae</i> Rich.	bagnit								C		
MALVACEAE (Mallow family)											
<i>Abutilon grandifolium</i> (Willd.) Sweet	hairy abutilon								X		
<i>Hibiscus esculentus</i> L.	okra								C		

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
<i>Hibiscus rosa-sinensis</i> L.	red hibiscus								<u>C</u>		
<i>Hibiscus tiliaceus</i> L.	hau			C		<u>C</u>		<u>P</u>	<u>C</u>		
<i>Hibiscus</i> sp.									<u>C</u>	<u>C</u>	
<i>Malva parviflora</i> L.	cheese weed			X					X		
<i>Malvastrum coromandelianum</i> (L.) Garcke											
subsp. <i>coromandelianum</i>	false mallow							X	X		
<i>Malvaviscus arboreus</i> Cav.	turks cap								<u>C</u>		
<i>Sida fallax</i> Walp.	'ilima	I							I		
<i>Thespesia populnea</i> (L.) Correa	milo		<u>P</u>	<u>P</u>		<u>P</u>			<u>C</u>	<u>C</u>	
MORACEAE (Mulberry family)											
<i>Ficus benghalensis</i> L.	Indian banyan								<u>C</u>		
<i>Ficus elastica</i> Hornem.	Indian rubber tree								<u>C</u>		
<i>Ficus microcarpa</i> L. fil.	Chinese banyan								<u>C</u>		
<i>Ficus</i> sp.				C					<u>C</u>		
<i>Morus alba</i> L.	white mulberry								<u>C</u>		
MYRTACEAE (Myrtle family)											
<i>Eugenia uniflora</i> L.	Surinam cherry								<u>C</u>		
<i>Psidium guajava</i> L.	guava								<u>C</u>		
NYCTAGINACEAE (Four o'clock family)											
<i>Boerhavia herbstii</i> Fosb.							I	I			
<i>Boerhavia repens</i> L.	alena	I		I		I	I	I	I	I	
<i>Bougainvillea spectabilis</i> Willd.	bougainvillea								<u>C</u>		
<i>Mirabilis jalapa</i> L.	four-o'clock								X		
<i>Pisonia grandis</i> R. Br.							I				

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
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OLEACEAE (Olive family)											
<i>Jasminum sambac</i> (L.) Aiton	pikake								<u>C</u>		
<i>Noronhia emarginata</i> (Lam.) Stadm.	Madagascar olive								<u>C</u>	<u>C</u>	
ONAGRACEAE (Evening primrose family)											
<i>Oenothera laciniata</i> J. Hill									X	X	
OXALIDACEAE (Wood sorrel family)											
<i>Oxalis corniculata</i> L.	yellow wood sorrel								X	X	
<i>Oxalis corymbosa</i> DC.	pink wood sorrel								X		
PASSIFLORACEAE (Passion flower family)											
<i>Passiflora edulis</i> Sims	liliko'i								C		
PLANTAGINACEAE (Plantain family)											
<i>Plantago lanceolata</i> L.	English plantain				X				X		
<i>Plantago major</i> L.	common plantain								X		
PLUMBAGINACEAE (Leadwort family)											
<i>Plumbago auriculata</i> Lam.	plumbago								<u>C</u>		
POLYGONACEAE (Buckwheat family)											
<i>Coccoloba uvifera</i> (L.) L.	sea grape				C	<u>P</u>			C	<u>C</u>	
<i>Rumex albescens</i> Hillebr.		I									
PORTULACACEAE (Purslane family)											
<i>Portulaca lutea</i> G. Forster	'ihi	I	I	I	I	I	I	I	I		
<i>Portulaca oleracea</i> L.	common purslane	X		X		X		X	X	X	

Appendix, continued.

Appendix, continued.

Taxon	Common Name	Island Group									
		N	Ne	FF	GP	La	Li	PH	Mi	Ku	
<i>Portulaca villosa</i> Cham.		I									
<i>Portulacaria afra</i> Jacq.	jade tree			C					C		
PRIMULACEAE (Primrose family)											
<i>Anagallis arvensis</i> L.	scarlet pimpernel								X	X	
ROSACEAE (Rose family)											
<i>Rosa</i> sp.	rose								C		
RUBIACEAE (Coffee family)											
<i>Gardenia</i> sp.									C		
RUTACEAE (Citrus family)											
<i>Citrus</i> sp.									C		
<i>Murraya paniculata</i> (L.) Jack	mock orange								C		
SANTALACEAE (Sandalwood family)											
<i>Santalum ellipticum</i> Gaud.	'iliahialo'e					I					
SCROPHULARIACEAE (Figwort family)											
<i>Bacopa monnieri</i> (L.) Wettst.	'ae'ae								I		
SOLANACEAE (Nightshade family)											
<i>Capsicum annuum</i> L.	nioi								C		
<i>Lycopersicon esculentum</i> Mill.	tomato		P	C							
<i>Nicotiana glauca</i> R.C. Graham	tree tobacco					P					
<i>Nicotiana tabacum</i> L.	tobacco					X	X				

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku
<i>Solanum americanum</i> Mill.	pōpolo	I				I	I	I	I	I
<i>Solanum melongena</i> L.	eggplant			C						
<i>Solanum nelsonii</i> Dunal		I				I		I	I	I
<i>Solanum tuberosum</i> L.	potato					X				
STERCULIACEAE (Cocoa family)										
<i>Waltheria indica</i> L.	‘uhaloa								I	
TROPAEOLACEAE (Nasturtium family)										
<i>Tropaeolum majus</i> L.	nasturtium								X	
URTICACEAE (Nettle family)										
<i>Pilea microphylla</i> (L.) Liebm.	artillery plant								X	
VERBENACEAE (Verbena family)										
<i>Lantana camara</i> L.	lantana								X	
<i>Phyla nodiflora</i> (L.) Greene									X	
<i>Stachytarpheta dichotoma</i> (Ruiz & Pav.) Vahl	oi								X	
<i>Stachytarpheta jamaicensis</i> (L.) Vahl	ōwī								X	
<i>Verbena litoralis</i> Kunth	ha‘uōwī								X	
<i>Vitex trifolia</i> var. <i>subtrisecta</i> (Kuntze) Mold.										
f. <i>subtrisecta</i>	pōlinalina								C	
<i>Vitex trifolia</i> var. <i>subtrisecta</i>										
f. <i>variegata</i> Mold.	pōlinalina								C	
VIOLACEAE (Violet family)										
<i>Viola odorata</i> L.	violet								C	

Appendix, continued.

Taxon	Common Name	Island Group								
		N	Ne	FF	GP	La	Li	PH	Mi	Ku
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VITACEAE (Grape family)										
<i>Vitis</i> sp.	grape									C
ZYGOPHYLLACEAE (Tribulus family)										
<i>Tribulus cistoides</i> L.	nohu	I		I	<u>S</u>	I	I	I	I	I

Literature Cited

- Amerson, A.B., Jr. 1971. The natural history of French Frigate Shoals, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 150.
- Amerson, A.B., Jr., R.B. Clapp, and W.O. Wirtz II. 1974. The natural history of Pearl and Hermes Reef, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 174.
- Apfelbaum, S.I., J.P. Ludwig, and C.E. Ludwig. 1983. Ecological problems associated with disruption of dune vegetation dynamics by *Casuarina equisetifolia* L. at Sand Island, Midway Atoll. *Atoll Res. Bull.* 261.
- Armstrong, R.W., ed. 1983. *Atlas of Hawai'i*, 2nd ed. Honolulu: Univ. Hawaii Pr.
- Bryan, E.H., Jr. 1978. *The Northwestern Hawaiian Islands: an annotated bibliography*. Honolulu: U.S. Fish and Wildl. Serv.
- Christophersen, E., and E.L. Caum. 1931. *Vascular plants of the Leeward Islands, Hawaii*. B.P. Bishop Mus. Bull. 81. Honolulu: Bishop Mus. Pr.
- Clague, D., G.B. Dalrymple, and R. Moberly. 1975. Petrography and K-Ar ages of dredged volcanic rocks from the western Hawaiian Ridge and the southern Emperor Seamount Chain. *Bull. Geol. Soc. Amer.* 86: 991-998.
- Clapp, R.B. 1972. The natural history of Gardner Pinnacles, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 163.
- Clapp, R.B., and E. Kridler. 1977. The natural history of Necker Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 206.
- Clapp, R.B., E. Kridler, and R.R. Fleet. 1977. The natural history of Nihoa Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 207.
- Clapp, R.B., and W.O. Wirtz II. 1975. The natural history of Lisianski Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 186.
- Clay, H.F. 1961. Narrative report of botanical field work on Kure Island. *Atoll Res. Bull.* 78.
- Conant, S. 1985. Recent observations on the plants of Nihoa Island, Northwestern Hawaiian Islands. *Pac. Sci.* 39(2):135-149.
- Conant, S., and D.R. Herbst. 1983. A record of *Nephrolepis multiflora* from Nihoa Island, Northwestern Hawaiian Islands. *Newsletter, Haw. Bot. Soc.* 22:17-19.
- Corn, C.A., D.R. Herbst, and C.H. Lamoureux. 1981. Floristic changes on Green Island, Kure Atoll. In *Abstracts, XIII Internatl. Bot. Congr.*, coll. D.J. Carr, 110.
- Dalrymple, G.B., M.A. Lanphere, and E.D. Jackson. 1974. Contributions to the petrography and geochronology of volcanic rocks from the Leeward Hawaiian Islands. *Bull. Geol. Soc. Amer.* 85: 727-738.

- Dalrymple, G.B., D.A. Clague, and M.A. Lanphere. 1977. Revised age for Midway volcano, Hawaiian volcanic chain. *Earth Planetary Sci. Letters* 37:107-116.
- Ely, C.A., and R.B. Clapp. 1973. The natural history of Laysan Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 171.
- Fosberg, F.R, M.-H. Sachet, and R. Oliver. 1979. A geographical checklist of the Micronesian Dicotyledonae. *Micronesia* 15: 41-295.
- Herbst, D.R. 1980. Miscellaneous notes on the Hawaiian flora I. *Phytologia* 45(1):67-81.
- Kramer, R.J. 1971. *Hawaiian land mammals*. Tokyo: Charles E. Tuttle Co.
- Neal, M.C. 1965. *In Gardens of Hawaii*. B.P. Bishop Mus. Spec. Pub. 50. Honolulu: Bishop Mus. Pr.
- Neff, J.A., and P.A. DuMont. 1955. A partial list of the plants of the Midway Islands. *Atoll Res. Bull.* 45.
- Ohlendorf, H.M., and C.S. Harrison. 1968. Mercury, selenium, cadmium and organochlorides in eggs of three Hawaiian seabird species. *Environmental Pollution* (Ser. B) 11: 169-191.
- Stone, B.C. 1970. The flora of Guam. *Micronesia* 6:1-659.
- Tsuda, R.T. 1965. Marine algae from Laysan Island with additional notes on the vascular flora. *Atoll Res. Bull.* 110.
- Woodward, P.W. 1972. The natural history of Kure Atoll, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 164.