RECOVERY PLAN FOR
CAESALPINIA KAVAIENSIS, AND KOKIA DRYNARIOIDES

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U.S. Fish and Wildlife Service, Pacific Region

RECOVERY PLAN FOR CAESALPINIA KAVAIENSIS AND KOKIA DRYNARIOIDES

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THIS IS THE COMPLETED RECOVERY PLAN FOR CAESALPINIA KAVAIENSIS AND KOKIA DRYNARIOIDES. IT DELINEATES REASONABLE ACTIONS THAT ARE BELIEVED TO BE REQUIRED TO RECOVER AND/OR PROTECT THESE SPECIES. OBJECTIVES WILL BE ATTAINED AND ANY NECESSARY FUNDS MADE AVAILABLE SUBJECT TO BUDGETARY AND OTHER CONSTRAINTS AFFECTING THE PARTIES INVOLVED, AS WELL AS THE NEED TO ADDRESS OTHER PRIORITIES. THIS RECOVERY PLAN DOES NOT NECESSARILY REPRESENT OFFICIAL POSITIONS OF OR APPROVALS OF THE COOPERATING AGENCIES, AND IT DOES NOT NECESSARILY REPRESENT THE VIEWS OF ALL INDIVIDUALS WHO PLAYED A ROLE IN PREPARING THE PLAN. IT IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS, CHANGES IN SPECIES STATUS, AND COMPLETION OF TASKS DESCRIBED IN THE PLAN.

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* Appendix B, which contains site specific maps, is not included in the general distribution of this Plan due to the possibility that vandalization or unauthorized collection could be encouraged by the public release of this information. The U.S. Fish & Wildlife Service will consider requests for the maps on a case by case basis.

ACKNOWLEDGEMENTS

The Recovery Plan for Caesalpinia kavaiensis and Kokia drynarioides was prepared by Dr. Grant Gerrish, Division of Natural Sciences, University of Hawaii at Hilo. Modifications have been made by the U.S. Fish & Wildlife Service.

EXECUTIVE SUMMARY OF THE CAESALPINIA KAVAIENSIS AND KOKIA DRYNARIOIDES RECOVERY PLAN

Current Species Status: Kokia drynarioides is federally listed as endangered. Only four wild individuals are known from the North Kona district of Hawaii island. Caesalpinia kavaiensis is also federally listed as endangered. Its population consists of approximately 30 individuals in three subpopulations in North Kona, 11 individuals in three subpopulations on Oahu, one mature tree on Kauai and a single individual on Lanai. K. drynarioides is not reproducing in the wild, and only limited reproduction of C. kavaiensis is occurring.

Habitat Requirements and Limiting Factors: The major habitat of both species is the native dry forests of the North Kona District, island of Hawaii. They occur on rough a'a lava with a thin, highly drained soil layer between 60 and 900 meters (200 and 2,950 feet) elevation. Major threats to both species in this area are competition with seedlings of and increased fire danger caused by fountain grass (Pennisetum setaceum), and the grazing of introduced ungulates. C. kavaiensis also occurs in similar dry forest habitat on Oahu, Kauai and Lanai where it is threatened by competition from alien plants and the grazing and rooting of feral ungulates.

Recovery Objective: Downlisting to threatened status.

Recovery Criteria: These species may be downlisted when: (1) there are a minimum of 100 naturally reproducing individuals in each of 3 secure populations of each species in North Kona and; (2) when there are three Caesalpinia kavaiensis populations, each with a minimum of 100 naturally reproducing individuals, on each of Oahu, Lanai, Kauai and Maui.

Actions Needed:

1. Secure habitat of current populations and manage threats.
2. Conduct research on limiting factors.
3. Expand current populations.
4. Establish new populations.
5. Validate and revise recovery objectives.

Total Estimated Cost of Recovery ($1000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1993	26.5	32	43	0	0	101.5
1994	152.55	239	48	0	0	439.55
1995	391.05	239	54	5.75	0	689.8
1996	337.2	239	107	45.25	0	728.45
1997	95.2	239	133	22	7	496.2
1998	95.2	207	121	21	7	451.2
1999	95.2	142	121	21	7	386.2
2000	95.2	142	100	21	7	365.2
2001	95.2	142	44	0	7	288.2
2002	95.2	142	0	0	7	244.2
2003	95.2	142	0	0	7	244.2
2004	95.2	0	0	0	10.32	105.52
2005	95.2	0	0	0	10.32	105.52
2006	95.2	0	0	0	12.32	107.52
Total	1859.3	1905	766	136	70	4736.3

Date of Recovery: Downlisting to Threatened should initiate in 2006, if recovery criteria are met.

TABLE OF CONTENTS

LIST OF TABLES

* Appendix B is not included in the general distribution of this Plan due to the possibility that vandalization or unauthorized collection could be encouraged by the public release of this information. The U.S. Fish & Wildlife Service will consider requests for the maps on a case by case basis.

LIST OF FIGURES

RECOVERY PLAN FOR
CAESALPINIA KAVAIENSIS AND KOKIA DRYNARIOIDES

PART I. INTRODUCTION AND LITERATURE REVIEW

1. BRIEF OVERVIEW

Caesalpinia kavaiensis (Fabaceae) and Kokia drynarioides (Malvaceae) are trees endemic to the Hawaiian Islands (Figure 1). Most of the few remaining wild trees of both species are growing in severely degraded habitat in dry forests on the slopes of Hualalai volcano in the district of North Kona, Hawaii island (Figure 2). The number of surviving trees has been reduced over the past two centuries by the browsing of domestic cattle and feral ungulates. Such browsing has prevented the growth and establishment of young trees. Currently, wildfire threatens final extirpation of the North Kona populations. Fountain grass (Pennisetum setaceum), an alien plant, now covers the once-barren lava substrate fueling wildfires where previously none burned, and competing with native tree seedlings for light and water.

Citing the dwindling numbers of survivors and the complete absence of regeneration in the face of these environmental problems, the U.S. Fish and Wildlife Service (USFWS) listed Kokia drynarioides and Caesalpinia kavaiensis as endangered species in 1984 (USFWS 1984) and 1986 (USFWS 1986), respectively. Critical habitat was designated for K. drynarioides at the time of listing.

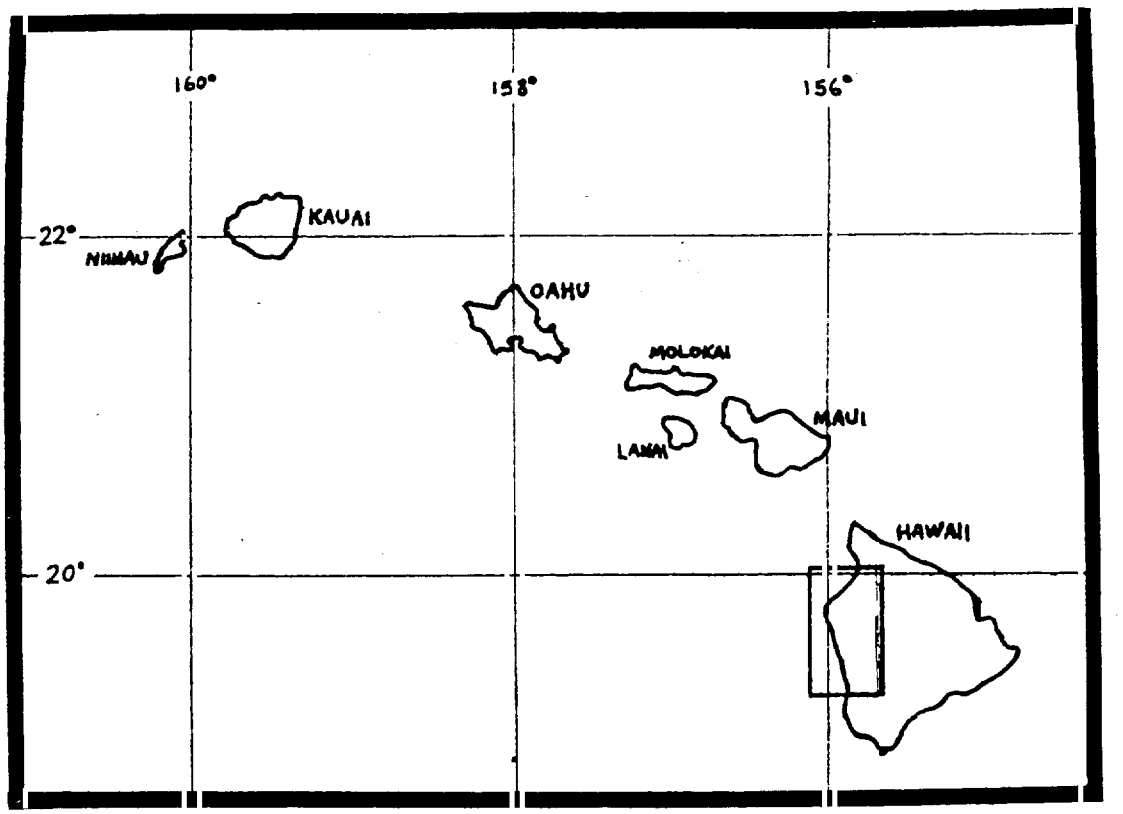

Figure 1. The Hawaiian Islands and the study area of North Kona and environs on the island of Hawaii (outlined).

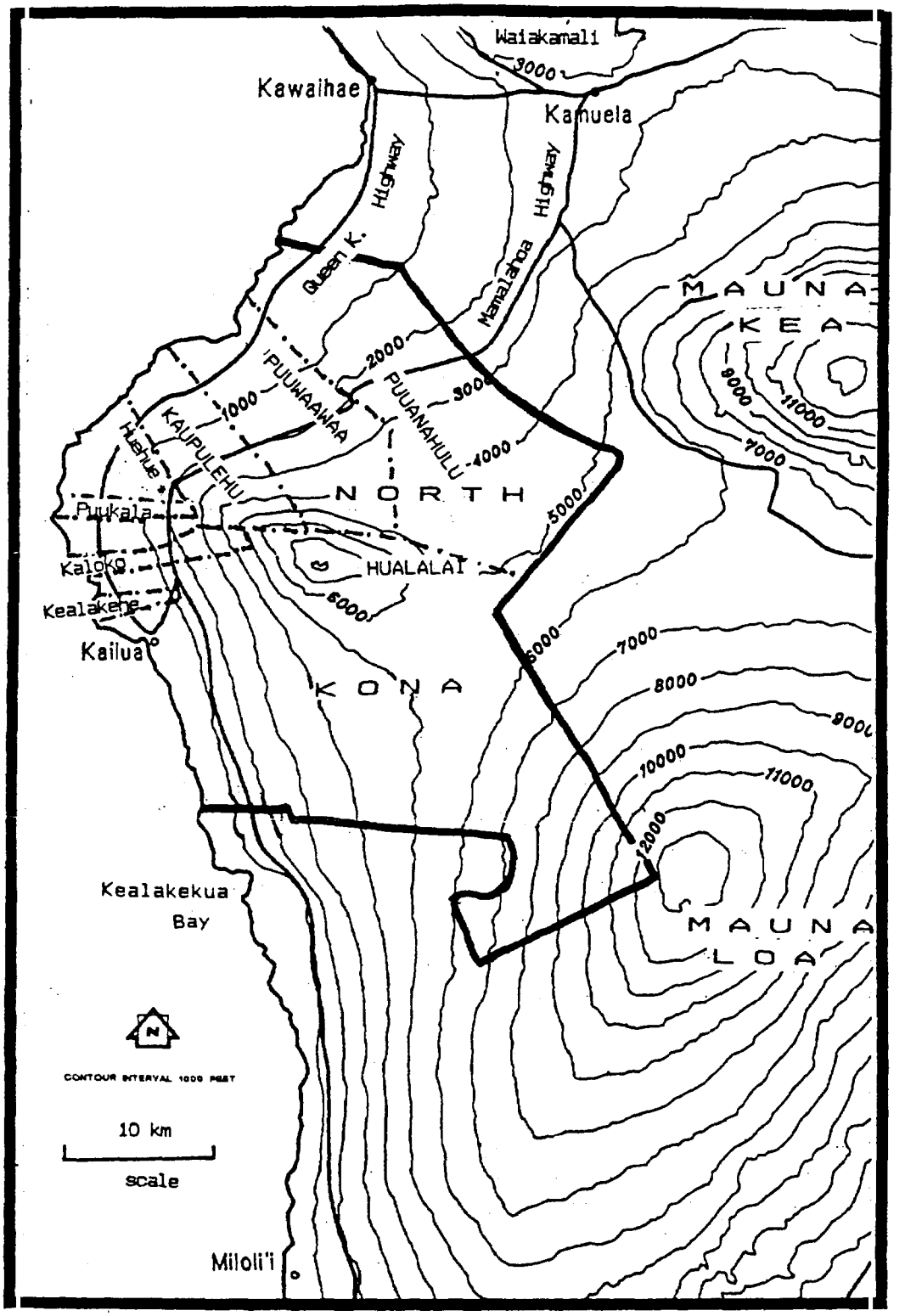

Figure 2. The North Kona and environs study area on the island of Hawaii.

2. TAXONOMY

(1) Taxonomy of Caesalpinia kavaiensis

This species was first collected on Kauai and described by Mann in 1867 as Caesalpinia kavaiensis Mann (Wagner et al. 1990). Hillebrand (1888), with additional specimens from Oahu and Maui available, moved the species into the Indo-Malesian genus, Mezoneuron (Lamoureux 1982). Caesalpinia kavaiensis was listed as endangered under the name Mezoneuron kavaiensis (Herbst 1986), the name by which it had been widely known until the publication in 1990 of a new Hawaiian flora (Wagner et al. 1990). Mezoneuron kavaiensis is a synonym, referring to the totality of the taxon Caesalpinia kavaiensis. The change of the name back to Caesalpinia kavaiensis does not indicate any ambiguity of identification of this Hawaiian species, as it is distinctly different from other Caesalpinia in Hawaii. The name change follows the opinion of Hattink (1974) that all members of the genus Mezoneuron properly belong within Caesalpinia.

The most widely used common name for Caesalpinia kavaiensis is the Hawaiian, *uhiuhi*. On Maui it is also known as *kea*. Wagner et al. (1990) and Lamoureux (1982) also list *kalamona* as a native name, but Rock (1913) says that this is the common name for an introduced Cassia species, not Caesalpinia kavaiensis.

An isotype specimen is in the Bernice P. Bishop Museum in Honolulu. A collection in the Cornell University herbarium, Ithaca, New York, may be designated as the lectotype.

Caesalpinia kavaiensis is in the Fabaceae or "legume" family of the flowering plants, and is placed in the subfamily Caesalpinioidae. Subspecies or other infra-specific designations have never been described for the various populations of Caesalpinia kavaiensis, however, Degener (1946) does comment that the trees from Hawaii have larger flowers and a slightly different pod than the collection from Kauai and they may be distinct.

(2) Taxonomy of Kokia drynarioides

The genus name, Kokia, is derived from the Hawaiian name *kokio*. Other common names are *hau*, *heleula* and Hawaiian tree cotton. Kokia drynarioides is in the Malvaceae or mallow family of the flowering plants.

Kokia drynarioides was first collected near Kealakekua Bay (Figure 2), on the island of Hawaii by the naturalist, David Nelson, during Cook's third voyage. The collection was described and named by Seemann as Gossypium drynarioides. Hillebrand (1888) misapplied this name to collections of Kokia cookei from Molokai. When Rock rediscovered the taxon collected by Nelson on the island of Hawaii, he sent collections to Lewton. Lewton subsequently removed it from the genus Gossypium and created the new genus Kokia for this collection and the two other species from Molokai and Oahu. Rock's Hawaii specimen was named Kokia rockii. It was left to Degener in 1934 to point out that the Hawaii taxon had originally borne the specific epithet, "drynarioides," and that the combination Kokia drynarioides should be used for the Hawaii species, not the Molokai species (Lamoureux 1981). Kokia drynarioides is the name under which this species was listed by USFWS as endangered (Herbst 1984).

Synonyms listed by Wagner et al. (1990) are Gossypium drynarioides, Hibiscus drynarioides and Kokia rockii. The type specimen is David Nelson's collection in the British Museum in London.

3. SPECIES DESCRIPTION

(1) Description of Caesalpinia kavaiensis

Caesalpinia kavaiensis is a medium-sized tree up to 10 meters (35 feet) tall with rough, dark bark and a spreading crown. The leaves are twice compound, made up of 1 to 5 pinnae with 4 to 8 pairs of leaflets. Each leaflet is about 4 centimeters (1.5 inches) in length. The flowers are borne in terminal racemes and are pink to red in color. The pink seed pods are short

(9 to 13 centimeters or 3.5 to 5.1 inches) and broad (4.5 to 6 centimeters or 1.8 to 2.4 inches) and winged on one side. These pink pods, the bright flowers and bright green lacy foliage combine to make this an attractive tree (Rock 1913 and Wagner et al. 1990).

The wood of Caesalpinia kavaiensis is highly valued for its color, grain and density. The heartwood is very dark brown, almost black, and close-grained. The wood would be readily used by craftsmen if it were available. Among other uses, the Hawaiians took advantage of the wood's high density to make a fishing implement that sinks rather than floats (Rock 1913).

(2) Description of Kokia drynarioides

Kokia drynarioides is a small tree from 4 to 10 meters (13 to 35 feet) tall and with a trunk up to 20 centimeters (8 inches) in diameter. The star-shaped leaves are large (7 to 28 centimeters long or 2.75 to 11 inches) with 7 to 9 palmate lobes, and are pale, glossy green, often with distinct red veins. The large and showy flowers are borne singly in leaf axils. Three large bracts below the flower are persistent. The petals are red, 10 to 15 centimeters (4 to 6 inches) long and up to 8 centimeters (3.1 inches) wide. The flowers are similar to Hibiscus flowers in that the stamens fuse to form a column around the style. The petals are somewhat twisted in the bud and the spiral pattern remains in the open flower. The fruit is a 5-lobed dry capsule about 2.5 centimeters (1 inches) long. (Lamoureux 1981).

The showy flowers and bracts and the attractive star-shaped leaves give Kokia drynarioides an appealing appearance. It is sometimes used as a garden and ornamental plant.

4. HISTORIC RANGE AND POPULATION STATUS

(1) Historical Range of Caesalpinia kavaiensis

Overview. Caesalpinia kavaiensis occurs or has occurred on dry leeward portions of five of the main Hawaiian Islands. The species was first discovered on Kauai by Horace Mann, Jr., around 1864. By 1888, Hillebrand had examined collections from Oahu and Maui as well as Kauai, and in 1909 Rock discovered Caesalpinia kavaiensis on Hawaii in North Kona. None of the writings of the early collectors contain much information about the abundance or ecological importance of this species in its natural communities. The relatively late discovery of this species on the various islands implies that it probably was never abundant in the past 200 years.

Recently, a single tree was discovered on Lanai, the first record from that island (Joel Lau, The Nature Conservancy of Hawaii, personal communication 1992).

(a) Historical Range of Caesalpinia kavaiensis on Hawaii

Rock described a population that he discovered in North Kona at 600 meters (2000 feet) elevation between Huehue and Puuwaawaa, where large trees were "not uncommon" (Rock 1919) (Figure 2). This is the same locale as that of the largest extant population of Caesalpinia kavaiensis. Writing in 1934, Degener (1946) reported that this population had dwindled and that he knew of only a dozen trees. This may well have been an under-estimate due to the rough terrain and inaccessibility of the habitat.

In the last two decades, Caesalpinia kavaiensis has been found at more North Kona locations than at any previous time. However, Caesalpinia kavaiensis has never been found growing naturally in any other district on Hawaii.

(b) Historical Range of Caesalpinia kavaiensis on Maui

One collection each from two widely separated occurrences on Maui are in the Bernice P. Bishop Museum herbarium. J. M. Lydgate made a collection from a location he called "West of Maui" (Figure 3). This may be the collection on which Degener (1946) bases a reference to the species' occurrence in the "dry fore hills of West Maui." Hillebrand collected Caesalpinia kavaiensis on southern East Maui near Ulupalakua (Figure 3). Writing in 1919, Rock reported that this species and all native vegetation had since disappeared from Ulupalakua. No subsequent collections from either of these sites were ever made. Rock (1919) reported that native informants said Caesalpinia kavaiensis grew at Kaupo, Hana District, East Maui, but no collections are known that document this occurrence (Figure 3). No trees have been found at any of these Maui locations in recent years (Lamoureux 1982).

(c) Historical Range of Caesalpinia kavaiensis on Oahu

Historically, populations of Caesalpinia kavaiensis were known from both mountain ranges on Oahu (Figure 4). The Waianae Mountains population is extant; the Wailupe population in the Koolau mountains is now extinct. In the Waianae mountains, Caesalpinia kavaiensis still grows in Makaleha Valley and at Puupane, two of the three locales known to Hillebrand (1888). Caesalpinia kavaiensis has not been seen at the third Waianae site, Makua Valley, since 1931 (Lamoureux 1982).

In 1870, Hillebrand (1888) collected this species in the Koolau Mountains in the ahupuaa of Wailupe (ahupuaa = land sections usually running from the uplands to the sea). Rock (1913) and Degener (1946) both mention this occurrence without further comment upon recent observation. It was never again collected at this site in southeastern Oahu where it was probably extirpated long ago.

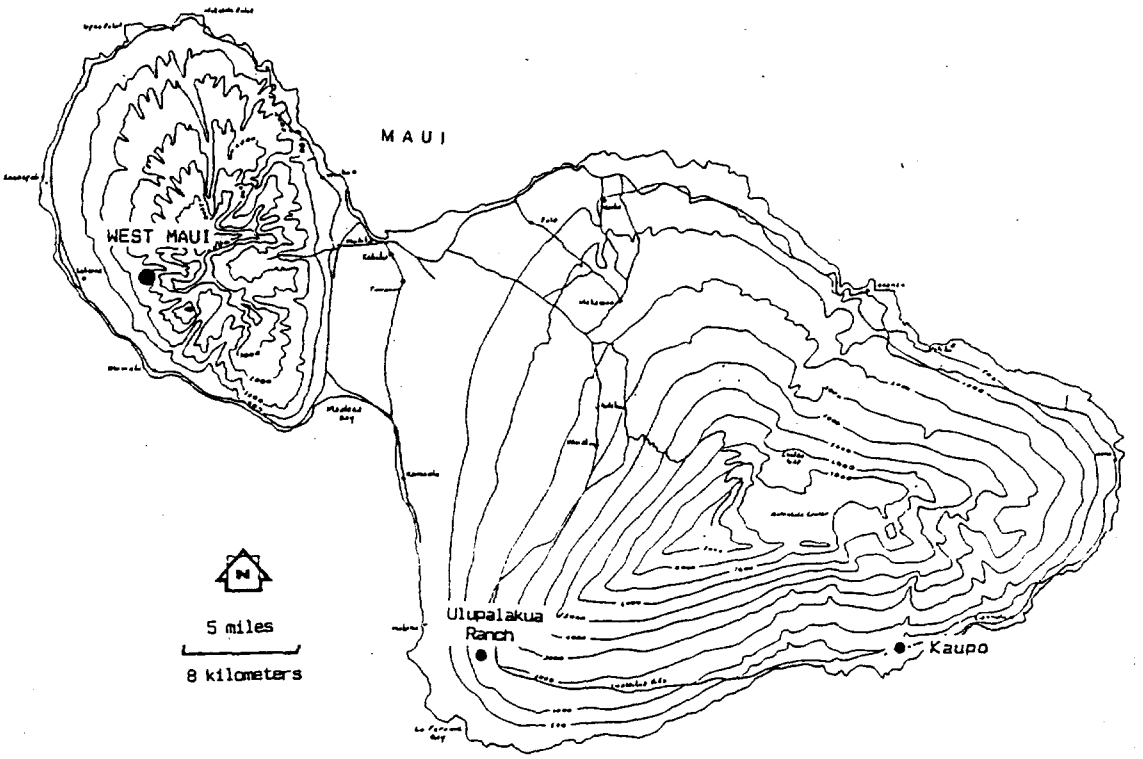

Figure 3. The island of Maui showing three possible former locations of Caesalpinia kavaiensis.

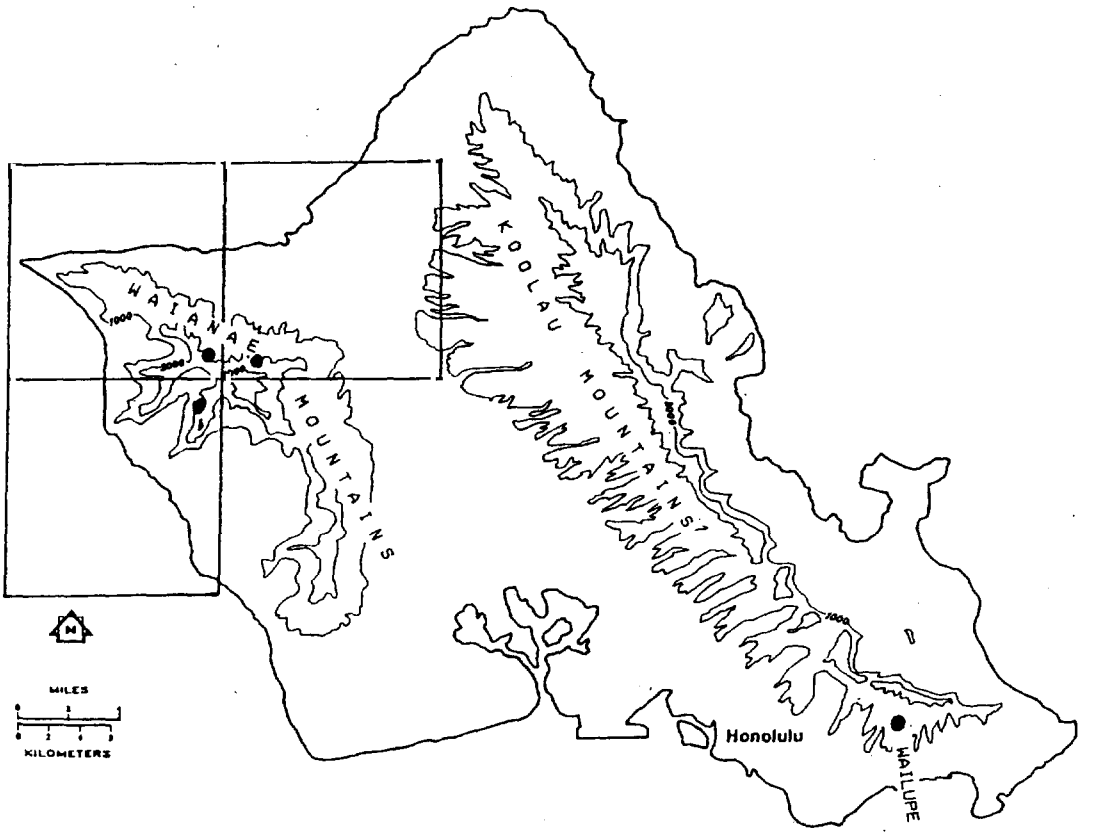

Figure 4. The island of Oahu showing one former (Wailupe) and three present Waianae Mountains sites of Caesalpinia kavaiensis.

(d) Historical Range of Caesalpinia kavaiensis on Kauai

This species first became known to science from a collection made in the 1860's from western Kauai (Figure 5). At that time it was probably fairly widespread in the dry forests of leeward Kauai, west of Waimea Canyon. Collections were made from three locales of this region: Kaawaloa, Puu-ka-Pele and Kaholuamanu (Lamoureux 1982). Rock (1919) could find scattered trees at only one of these sites, Puu-ka-Pele.

(2) Historical Range of Kokia drynarioides on Hawaii

Kokia drynarioides is endemic to the island of Hawaii. All collections and observations this century are from a very limited area in the ahupuaa of Puuwaawaa and Kaupulehu in North Kona (Figure 2). This population is in the same dry forest community on the slope of Hualalai Volcano as the major population of Caesalpinia kavaiensis described above.

The first collection of Kokia drynarioides was made by Nelson on Captain Cook's third voyage to the Hawaiian Islands. From the journals of that voyage, Degener (1986) and others deduce that the collection must have been made near Kealakekua Bay, about 32 kilometers (20 miles) south of the critical habitat (Figure 2). The species was never again collected in that vicinity. Degener also reports conversations with a native of Milolii, Kau, about the ethnobotanic use of Kokia drynarioides and suggests that the species may once have grown there. The species has never been collected in the District of Kau.

Rock (1919) described this species as "exceedingly rare" but still in its "prime" and in no danger of extinction if protected from cattle. Based on a 1975 census of 15 living, mature trees, Lamoureux (1981) estimated that no more than 20 trees likely survived in the wild.

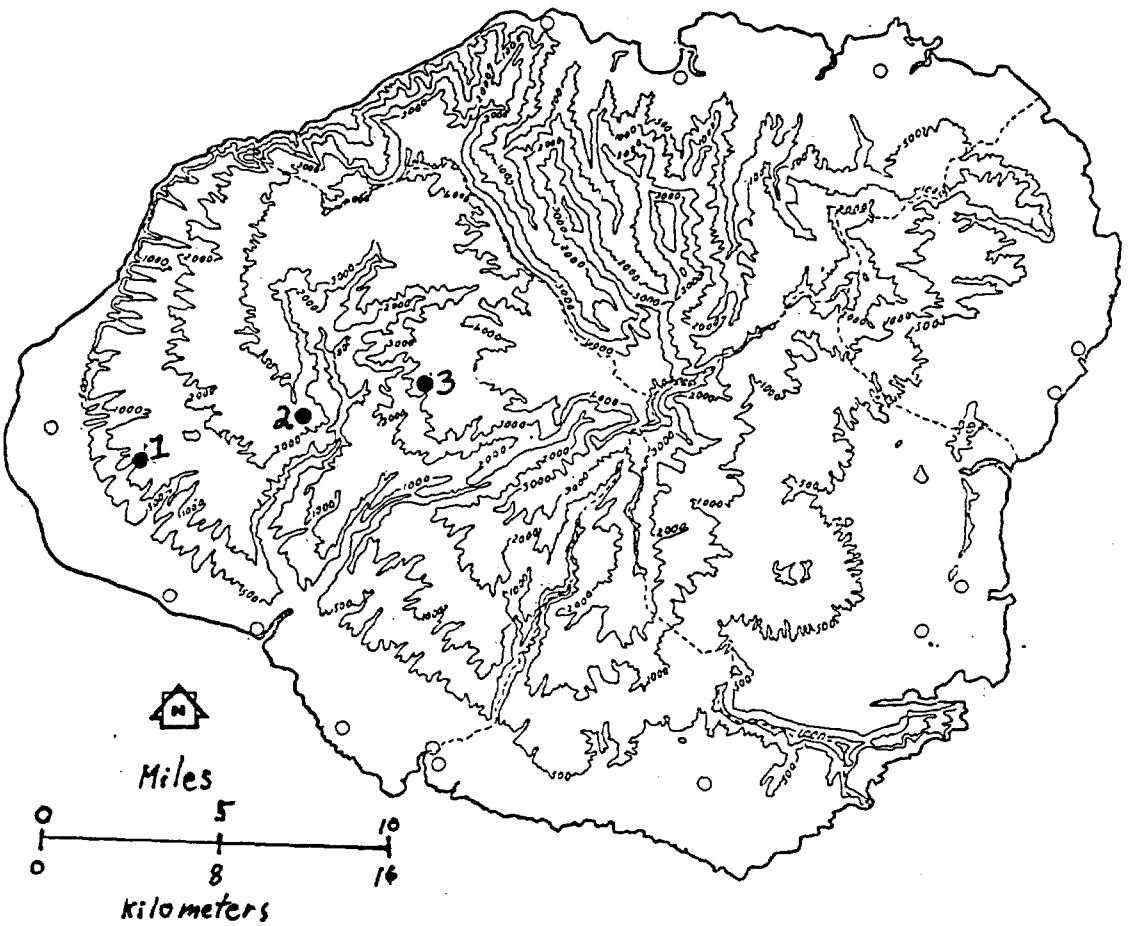

Figure 5. The island of Kauai showing three historical locations (black dots) of Caesalpinia kavaiensis where the species is no longer known to occur. 1 = Kaawaloa, 2 = Puu Ka Pele, 3 = Kaholumanu.

5. CURRENT RANGE AND POPULATION STATUS

Maps or descriptions of the exact locations of known individuals will not be included in this Plan due to the possibility that vandalization or unauthorized collection could be encouraged by the public release of this information. The U.S. Fish and Wildlife Service will consider requests for Appendix B, which contains site specific information, on a case-by-case basis.

(1) Caesalpinia kavaiensis

Overview. Populations or individual trees still survive on Hawaii, Oahu, Kauai and Lanai. This species is believed to be extinct on Maui. On Oahu, one of the two formerly known populations is extinct, and on Kauai only a single tree is known. On Lanai, only one tree has ever been found. Fewer than 80 mature trees are known to survive in the wild. Only the Makaleha, Oahu colony appears to be successfully recruiting new individuals into the breeding population without active management (Lamoureux 1982; Steve Perlman, National Tropical Botanical Garden, personal communication 1991).

(a) Current and Recent Range of Caesalpinia kavaiensis on Hawaii

All occurrences of Caesalpinia kavaiensis are within the District of North Kona on the leeward (west and northwest) slope of Hualalai. The known range extends from the ahupuaa of Puuanahulu, in the north to Kealakehe in the south (Figure 2 and Appendix B). Data are provided by the Hawaii Heritage Program Database (The Nature Conservancy of Hawaii), the 1989 (Takeuchi 1990) and early 1992 (J. Lau, personal communication 1992) surveys of State lands of Puuwaawaa, Jon Giffin (Division of Forestry and Wildlife (DOFAW), personal communication 1992), and from Michael Tomich (personal communication 1992) a consultant for PIA Sports Property, Inc., a lessee of Kamehameha Schools/Bishop Estate lands in Kaupulehu. It is

probable that there are other living Caesalpinia kavaiensis at unknown locations.

Trees occur as widely scattered small clusters or individuals, or in one of two small subpopulations. The best known of the two subpopulations, contained about 48 trees in 1989 in a kipuka (a kipuka is a remnant area of older land surrounded by a recent lava flow) of the Kaupulehu flow. All of these trees were below the Mamalahoa Highway between about 430 meters (1400 feet) and 600 meters (2000 feet). This site is within the critical habitat of Kokia drynarioides. By combining and collating the observations by Takeuchi (1990) and J. Lau (personal communication 1992), an estimate of 19 trees was reached for the state-owned portion of the kipuka. It should be noted that both the 1989 and 1992 surveys were designed as vegetation surveys and were not conducted with the goal to locate every specimen of Caesalpinia kavaiensis. An estimate of 29 trees on the privately owned portion of the kipuka was reached by combining and collating the mapped observations by PIA, Inc. (M. Tomich, personal communications, 1992) with 1992 survey observations (J. Lau, personal communications, 1992). The majority of this kipuka was burned in a wildfire in May, 1993, and Loyal Mehrhoff (USFWS, personal communication 1993) estimates that 80% of the Kokia drynarioides and Caesalpinia kavaiensis growing there were killed.

Takeuchi (1990) found no Caesalpinia kavaiensis trees above the Mamalahoa Highway. The entire Halepiula 3, Waimea Paddock of Puuwaawaa Ranch, which is above (south of) the highway, was among the areas proposed as critical habitat for this species (Lamoureux 1982). Takeuchi (1990) concluded that Caesalpinia kavaiensis was extirpated from this part of its recent range by wildfire in 1986.

The second sizeable subpopulation of 21 mature Caesalpinia kavaiensis was discovered in 1989 in the ahupuaa of Kealakehe in North Kona. This site is about 11 kilometers (7 miles) south of the Kokia drynarioides critical habitat

in Puuwaawaa. All or most of the trees are growing on land owned by the state of Hawaii. (Belt Collins 1990).

Approximately ten Caesalpinia kavaiensis trees are known between Kealakehe and the boundary kipuka. A single tree was recorded in 1981 at 90 meters (300 feet) elevation in the ahupuaa of Kaloko (Figure 2). Two trees were observed at 185 meters (600 feet) elevation in the ahupuaa of Puukala in 1986 (Figure 2) (M. Tomich, personal communication 1992). A cluster of 4 trees is at 500 meters (1600 feet) elevation in Kaupulehu near the Kaupulehu lava flow (M. Tomich, personal communication 1992). Another single tree occurs at 625 meters (2040 feet) elevation in Kaupulehu. Hawaii Heritage Program records a 1983 single-tree observation in this vicinity at 615 meters (2000 feet) elevation.

Approximately 11 other trees have recently been observed northeast of the kipuka. One tree is at 550 meters (1800 feet) elevation (Takeuchi 1990). Another single tree was observed at 430 meters (1400 feet) elevation (Takeuchi 1990). Two separate sightings of Caesalpinia kavaiensis trees along the jeep road from Mamalahoa Highway to Kiholo Bay have been recorded. Near the eastern boundary of the ahupuaa of Puuwaawaa, a cluster of six or seven trees occur between 300 and 330 meters (1000 and 1100 feet) (J. Giffin, personal communication 1992). The northernmost occurrence of Caesalpinia kavaiensis is in the ahupuaa of Puuanahulu, within a kipuka in the 1859 lava flow (J. Giffin, personal communication 1992).

The highest elevation sighting of Caesalpinia kavaiensis was recorded in 1966 near Puuanahulu. The elevation given with the herbarium collection is 900 meters (2950 feet) (Hawaii Heritage Program). However, the site description indicates that this tree was probably nearer 650 meters (2400 feet).

Lamoureux (1982) found no saplings or seedlings in the North Kona population, nor are there any other reports of successful natural regeneration on Hawaii. Takeuchi (1990) remarked that seedlings were occasionally found, but concluded that these were ephemeral and that natural regeneration and

recruitment of this species was not occurring in Puuwaawaa. He also reported that all the trees seen were mature or senescent and that the population appeared to be dying. Similarly, the mature Caesalpinia kavaiensis in Kealakehe, North Kona, were observed in 1989 to be flowering and had many seed pods, but an intensive search found no seedlings or saplings (Belt Collins 1990).

(b) Current Range of Caesalpinia kavaiensis on Oahu

A total of eleven living mature trees are known from three locations in the Waianae mountains (Figure 4 and Appendix B). The following data are believed to be the most up-to-date available. A few other trees may exist elsewhere at inaccessible sites in the Waianae Mountains (Lamoureux 1982).

Two mature trees are in the Waianae Kai Forest Reserve at an elevation of 585 meters (1900 feet) (John Obata, Hawaii Botanical Society, personal communication 1992; J. Lau, personal communication 1992). No seedlings or saplings are reported at this site.

Two mature trees survive at Puupane (Carolyn Corn, DOFAW, personal communication 1993). Five mature trees and five seedlings were reported at this site in 1981 (Hawaii Heritage Program Data Base, The Nature Conservancy of Hawaii, citing S. Perlman). This site is at 520-585 meters (1700-1900 feet) elevation in Kaimuhole Gulch (Hawaii Heritage Program Data Base, The Nature Conservancy of Hawaii), and is within the Mount Kaala Natural Area Reserve.

The largest remaining population in the Waianae mountains is in Makaleha Valley. Eight mature trees and three saplings were confirmed in 1992 (J. Obata, personal communication 1992) and four adults and 3 saplings were seen there in 1993 (C. Corn, personal communication 1993). In 1987, several more mature trees and many saplings were reported at this site. It is at 340 to 520 meters (1100-1700 feet) elevation (Hawaii Heritage Program Data Base, The Nature Conservancy of Hawaii).

(c) Current Range of Caesalpinia kavaiensis on Kauai

Lamoureux (1982) reported one living Caesalpinia kavaiensis tree in the Koaie Valley near Waimea Canyon (Appendix B) that appeared to be old and somewhat decadent. The tree has since fallen over and died (Hawaii Heritage Program Data Base, The Nature Conservancy of Hawaii.) Viable seeds may still be in the soil.

Another fallen but still living tree was discovered in 1987 in the Poomau Branch of Waimea Canyon near 460 meters (1500 feet) elevation (S. Perlman, personal communication 1992). This tree and a sapling and seedling reported nearby have since died. A mature, fruiting tree and several young individuals were observed in 1988 on nearby privately owned land (John Fay, USFWS, personal communication 1994; and Fay 1988). Currently, access to this area is not allowed, but the owner has an ongoing native plant conservation program, and seed from this individual is stored in the NTBG collection (Loyal Mehrhoff, USFWS, personal communication 1993).

(d) Current Range of Caesalpinia kavaiensis on Lanai

In 1990 a single mature, fruiting Caesalpinia kavaiensis tree was found in Kaoha ahupuaa on windward Lanai. The tree is on the edge of Puhielelu Ridge at 480 meters (1580 feet) elevation (Figure 6). The vegetation of this isolated location is dominated by other native tree species, including Dodonaea, Diospyros and Canthium. The tree appears to be naturally established even though no others are known from this island. (J. Lau, personal communication 1992).

(2) Kokia drynarioides

The only known wild population of Kokia drynarioides is dispersed in the designated critical habitat in the ahupuaa of Kaupulehu and Puuwaawaa in North Kona on the island of Hawaii (Figure 2 and Appendix B). A 1975 census found 12 living, mature trees, reports of 2 or 3 other living trees, 4 or

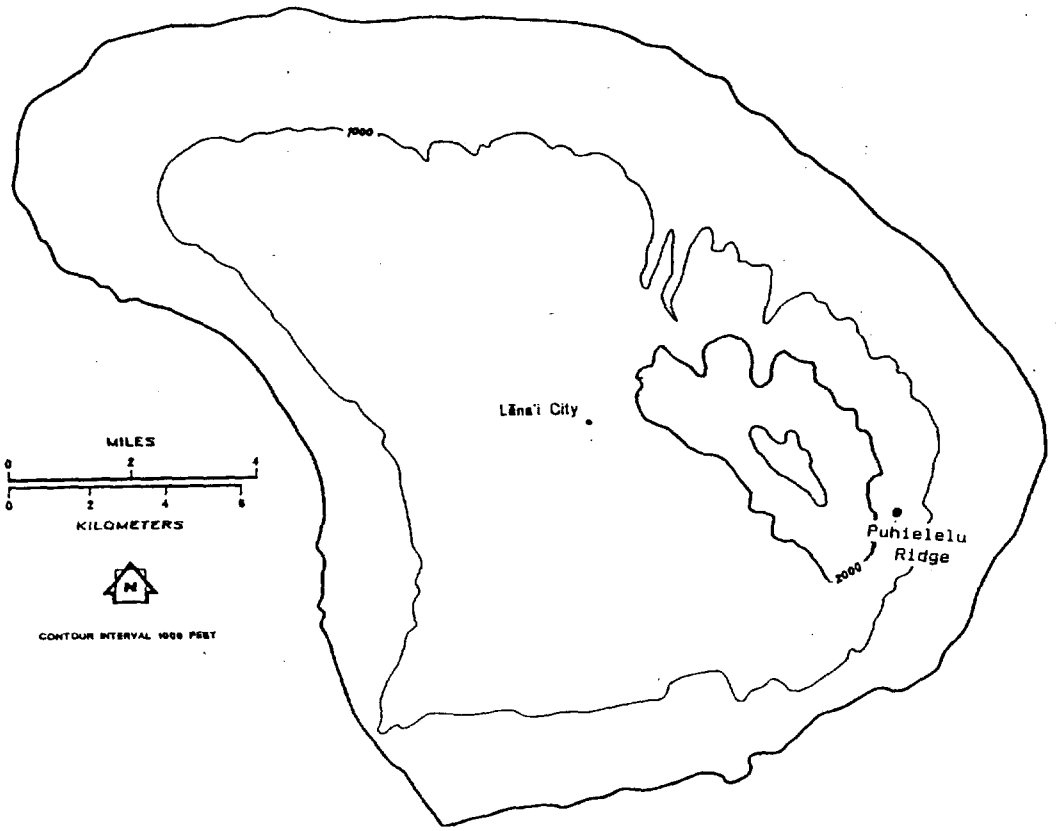

Figure 6. Location of one Caesalpinia kavaiensis tree (black dot) on Puhielelu Ridge, Lanai.

5 dead ones and no seedlings or saplings (Lamoureux 1981). Lamoureux (1981) estimatedthat there were probably no more than 20 living trees in the wild. Since wildfire burned through the critical habitat in 1986, 1988 and 1993, only 4 wild Kokia drynarioides trees are known.

Three Kokia drynarioides were found in 1989 by Takeuchi (1990) and by The Nature Conservancy in 1992 (J. Lau, Personal Communications, 1992) in the Halepiula 3, Waimea Paddock portion (Puuwaawaa Portion) of the critical habitat. In 1992, the condition of these three trees was described as "two slender, partially dead; one bushy, 5 meters (16 feet) tall, healthy" (J. Lau, personal communication 1992).

One other Kokia drynarioides tree is within the ahupuaa of Puuwaawaa, within the boundary kipuka portion of the critical habitat. It is about 2 meters (6 feet) tall, bent and of poor vigor (Takeuchi 1990, J. Lau, personal communication 1992). This tree was probably killed in the May 1993 wildfire is this area (L. Mehrhoff, personal communication 1993).

Three Kokia drynarioides trees are known from the ahupuaa of Kaupulehu. Two are in the boundary kipuka, near the firebreak access road (M. Tomich, personal communication 1992) and were probably killed in the 1993 fire (L. Mehrhoff, personal communication 1993). The other tree is in the Kaupulehu portion of the critical habitat.

6. LIFE HISTORY

(1) Life History of Caesalpinia kavaiensis

(a) Reproductive Biology of Caesalpinia kavaiensis

Some isolated trees produce viable seed, showing that the species is capable of self-pollination, e.g. the single living wild tree on Kauai. Some wild trees and some cultivated trees regularly produce a good quantity of

viable seeds. Seeds germinate in nature and can be germinated in nurseries. However, some isolated trees that flower apparently do not produce viable seed. The tree growing in the Botany Department Courtyard, University of Hawaii at Manoa, has been found to produce normal pollen, but has never set seed. It is not known what kinds of barriers to self-pollination, if any, may be responsible for this failure (Lamoureux 1982).

Neither natural nor adventive pollinators are described in available literature. Lamoureux (1982) interprets the flower as insect-pollinated. The broad, winged pod suggests that the seeds are dispersed by a combination of gravity and wind. Seeds may also be dispersed by ingestion by birds (Lamoureux 1982) or introduced mammals.

Sprouts sometimes form at the base of the stump but no other vegetative reproduction is known (Lamoureux 1982). Attempts to root cuttings have been unsuccessful (Woolliams 1978).

(b) Life Cycle of Caesalpinia kavaiensis

The life cycle of Caesalpinia kavaiensis has not been described in the literature. Growth rates, age at reproductive maturity and life span are almost entirely unknown. The extreme density of the wood suggests a slow growth rate in the adult stage.

Eight nursery grown seedlings less than one year old were planted in a Puuwaawaa exclosure in 1989. Two of these flowered and set fruit in 1991 and 1992. Seed collected appeared normal in every way. Viability was not tested. It was noted that many young pods blew off the trees before maturing. (S. Bergfeld, personal communication 1992)

(c) Phenology of Caesalpinia kavaiensis

Herbarium specimens collected throughout the year have flowers, fruit and new leaves, indicating no marked seasonality. Growth and flower and leaf

production may decline during drought periods (Lamoureux 1982). Little else is known.

(2) Life History of Kokia drynarioides

(a) Reproductive Biology of Kokia drynarioides

The reproductive biology of wild plants is completely unknown. The natural pollination and seed dispersal mechanisms are not known (Lamoureux 1981). Individual, isolated trees do produce viable seed, so self-fertilization is possible with this species. There is some evidence of vegetative reproduction, as three damaged individuals re-sprouted when the trunks were cut.

(b) Life Cycle of Kokia drynarioides

Vegetative growth rates, age at reproductive maturity and lifespans are not reported in the literature. A comment by Young and Popenoe (1916) indicates that a cultivated seedling of Kokia cookei began flowering at about age 4 years.

(c) Phenology of Kokia drynarioides

Herbarium collections show that Kokia drynarioides may flower at any time of the year. During dry periods, the trees may lose many leaves (Lamoureux 1981).

7. HABITAT DESCRIPTION

(1) Description of Habitat of Caesalpinia kavaiensis and Kokia drynarioides on Hawaii

(a) Physical Characteristics.

The major habitat of these two species is the northwest and west slopes of Mount Hualalai in the District of North Kona. Historically, Caesalpinia

kavaiensis has occurred between about 60 meters (200 feet) and approximately 900 meters (3000 feet) elevation. Kokia drynarioides has historically grown between 460 meters (1500 feet) and 900 meters (3000 feet) elevation. The general slope is 5° to 10°. The substrate is mostly rough a'a lava covered by a thin and discontinuous layer of organic soil (Sato et al. 1973, Lamoureux 1981). The steep slope and rugged volcanic features of the landscape impede passage on the ground.

The rainfall in this area is about 75 to 100 centimeters (30 to 40 inches) a year, with no pronounced wet and dry seasons (Blumenstock and Price 1961). Air temperature also fluctuates little during the year, with mean monthly temperatures varying between 14° and 18° Celcius (58° and 64° Fahrenheit) (Lamoureux 1982). The moderate rainfall and high insolation in combination with the shallow, excessively drained soil provides a dry habitat where moisture is probably frequently limiting.

(b) Vegetation of Habitat.

Because of their very low numbers today, Caesalpinia kavaiensis and Kokia drynarioides are very minor components of the dry forest communities where they occur, and there is not much evidence of their former densities and ecological importance in these communities.

The Kaupulehu and Puuwaawaa habitat of Kokia drynarioides and Caesalpinia kavaiensis is Lama/Kauila Forest (Diospyros/Colubrina oppositifolia), a subtype of the Lowland Dry Forest (Gagne and Cuddihy 1990). The canopy of this open forest is 5 to 6 meters (16.4 - 19.7 feet) high and is made up of a diversity of native tree species with native shrubs below, and includes several other rare plant species (Table 1). Formerly, the ground between the woody plants was mostly bare. Today, the ground layer is filled with the alien Lantana camara and, especially, fountain grass (Pennisetum setaceum). Few native grasses or forbs are found.

The trees of Caesalpinia kavaiensis that persist at lower elevations in Kiholo may be within another Lowland Forest Subtype, the Wiliwili (Erythrina) Forest. The habitat of the subpopulation of Caesalpinia kavaiensis in Kealakehe is described as Open Mixed Shrubland on a'a lava. Other communities that may once have been habitat for Caesalpinia kavaiensis include Lowland Dry Shrublands and Coastal Dry Forests. The southern end of the range, near Kailua, may include Lowland Mesic communities (Gagne and Cuddihy 1990).

All of these formerly diverse native tree and shrub communities have been heavily impacted by human activity, especially browsing by domestic and feral ungulates, alien plant invasions, and fire (Gagne and Cuddihy 1990). The degraded condition of the habitat and potential habitat for Caesalpinia kavaiensis and Kokia drynarioides above 500 meters (1650 feet) is indicated by the results of the USFWS Hawaii Forest Birds Survey (Jacobi and Scott 1985). The survey mapped a total of 5,933 hectares of Dry Mixed Native Tree Forest above 500 meters (1650 feet) elevation in North Kona and neighboring South Kohala. 21.4% of the dry mixed native forest area was categorized as tree layer dominated by native plants, but alien plants dominated the lower layer (mostly fountain grass in this case). The remaining 78.6% was classified as dominated by alien plants with remnant populations of native plants.

(2) Habitat for Caesalpinia kavaiensis on Oahu, Kauai and Lanai

The habitats on other islands are similar to that described above on Hawaii in that they have relatively low rainfall and are on rough, steep substrates with stony soils (Lamoureux 1982).

On Oahu, Caesalpinia kavaiensis is listed as a component in the Waianae mountains of the Aulu (Sapindus) Forest community of the Lowland Dry Forest Subtype. This is a drought-resistant community dominated by 15 meters (50 feet) tall Sapindus trees with a sparse understory, including some other rare native plant species (Table 1) (Gagne and Cuddihy 1990). The

specific Waianae sites are in mixed forests of Lama and Kauila with alien Lantana camara, Psidium sp., Christmasberry (Schinus terebinthifolius) and Toona ciliata (Hawaii Heritage Program). Toona is a particular problem, as its tall, dense canopy heavily shades the Caesalpinia trees.

The Caesalpinia kavaiensis trees known on Kauai, Lanai and formerly known on Maui have been in degraded open forests of mixed native trees, including some rare species (Table 1) with infestations of numerous alien plant species, including Lantana camara (Lamoureux 1982, Hawaii Heritage Program).

Table 1. List of rare plant species associated with Caesalpinia kavaiensis and Kokia drynarioides.

Scientific name	Status
Nothocestrum breviflorum[1]	Proposed Endangered
Isodendrion pyrifolium[1]	Proposed Endangered
Colubrina oppositifolia[1]	Proposed Endangered
Abutilon sandwicensis[2]	Endangered

Proposed Endangered = has been formally proposed for listing as an endangered species.

1 - Recovery of these species will be addressed in the Big Island Plant Cluster Recovery Plan

2 - Recovery of this species will be addressed in the Waianae Plant Cluster Recovery Plan

8. REASONS FOR DECLINE AND CURRENT THREATS

Overview

These species were listed as endangered because of a combination of diminished range and greatly diminished numbers in their wild populations (Herbst 1984, 1986). There is also very little successful recruitment of new

plants into the breeding population and the population structures are dominated by mature and aging plants (Lamoureux 1981, 1982). The historical reasons for the decline of these two species are essentially the same major threats imperiling them today, i.e. grazing or browsing of domestic and feral ungulates, alien plant invasion, insect infestations, drought and fire hazard enhanced by alien plant invasion.

(1) Habitat Degradation

(a) Grazing and Browsing by Ungulates

Rock (1913), Degener (1946) and others recognized that the rapid disappearance from North Kona of Caesalpinia kavaiensis and Kokia drynarioides was mostly due to forest destruction and community disintegration as a result of cattle ranching in the dry forest. Nearly all of the habitat on the island of Hawaii is or has until recently been managed for commercial cattle production. Seedlings and saplings of both species are highly palatable to cattle. Feral goats and sheep also live in this habitat. On Oahu, Maui and Kauai, feral goats have unrestricted access to the Caesalpinia kavaiensis habitat (Lamoureux 1982) and the Lanai individual may also be subject to browsing by Axis deer (Axis axis) and Mouflon sheep (Ovis musimon). It is unlikely that either species can recover while subjected to such grazing.

(b) Fountain Grass Invasion and Enhanced Fire Danger

Today the most devastating factor within the dry forest habitat of these two species on the island of Hawaii is the invasion by fountain grass that has occurred during this century, resulting in its complete domination of the groundcover in the dry forest habitat of North Kona. Fountain grass has two major negative impacts on the community: the promotion of fire and usurpation of native plant habitat. Fountain grass is a fire-adapted bunch grass that enhances fuel-loading and promotes fire (Tunison in press). Unlike most

other alien grasses, fountain grass can invade barren lava flows that were not formerly subject to wildfire. Major fires burned through Puuwaawaa Ranch in 1986 and 1988. Trees of both species, as well as other native dry forest species, were completely eliminated from the burned areas in these fires. Wildfire also burned a major portion of the boundary kipuka section of the Kokia drynarioides critical habitat in May, 1993, killing an estimated 80% of the Kokia drynarioides and Caesalpinia kavaiensis found there (L. Mehrhoff, personal communication 1993).

The establishment of a closed layer of fountain grass completely alters the structure of the vegetation at these formerly bare-lava sites. The competitive interactions of fountain grass with native tree seedlings have not been scientifically studied, but it is believed that the fountain grass has an adverse effect on seedlings of Caesalpinia kavaiensis and Kokia drynarioides as well as other native woody plants in these communities (Lamoureux 1981, 1982). Upon the removal of fountain grass from protected exclosures on Bishop Estate land, numerous Kokia drynarioides seedlings have been observed next to a fallen adult tree (Steve Bergfeld, Division of Forestry and Wildlife, personal communication 1991), and five Caesalpinia kavaiensis seedlings survive where fountain grass was removed from under an adult tree inside a DOFAW exclosure.

Control strategies for fountain grass have been assessed by the National Park Service at Hawaii Volcanoes National Park (Tunison et al. 1989, Tunison in press). Mechanical (hand-pulling) means have been used to eradicate satellite populations on the edge of the major infestations to prevent further spread. This strategy follows recommendations for cost-effective control of plant pests (Moody and Mack 1988). Some experimental work has been done by the Park Service using a preemergence herbicide to prevent reestablishment from the seed bank. Some success is reported but results have not yet been released (J. Timothy Tunison, Hawaii Volcanoes National Park, personal communication 1991). Prospects for biological control of fountain grass are

generally considered poor, because no pathogens or predators specific to this species are known (Gardner and Davis 1982). A 1992 survey by the Hawaii Department of Agriculture (DOA) found no organisms of potential value for control in the species native range (Lyle Wong, DOA, personal communication 1993). There is also some reluctance to introduce pathogens or predators that may damage economic grass crops (Markin and Yoshioka in press).

(c) Other Alien Plants

Many other alien plants are naturalized in the North Kona habitat. Two that are widespread and disruptive are lantana (Lantana camara) and silk oak (Grevillea robusta). Two cultivated plants that have become established locally on the cinder cone of Puuwaawaa itself are the custard apple (Annona cherimola) and Pittosporum viridiflorum (Takeuchi 1990). Takeuchi cautions that if fountain grass is controlled in the future, these or other alien plants may increase in cover and become serious pests. The subpopulation at Puupane, Oahu, is being shaded and crowded by Australian red cedar (Toona ciliata) (J. Obata, personal communication 1992) and both the Makaleha and Puupane populations are surrounded by stands of Christmasberry and Strawberry guava (Psidium cattleianum). The Makaleha population is also bordered on one side by Lantana camera.

(2) Land Ownership/Land Use Classification

The critical habitat of Kokia drynarioides and the surrounding areas of Kaupulehu and Puuwaawaa ahupuaa that contain several Caesalpinia kavaiensis trees do not have protective state or county zoning. All or nearly all of the land has a State Land Use Classification (LUC) of Agriculture, and much of it is actively managed for commercial ranching. This lack of protective zoning is somewhat alleviated by the Hawaii endangered species law which gives jurisdiction to the Department of Forestry and Wildlife (DOFAW) to manage endangered plant populations.

(3) Insect Damage

The alien black coffee twig borer (Xylosandrus compactus) attacks and may kill Caesalpinia kavaiensis seedlings (Lamoureux 1982). Xylosandrus attacks on outplanted seedlings in North Kona have been observed but no deaths have been attributed to them (S. Bergfeld personal communication 1991). Damage from Xylosandrus may be far more serious on Oahu. Based on observations over a 20 year period, J. Obata (personal communication 1992) attributes the marked decline of this previously "widespread" species on Oahu to a combination of the twig borer and drought. DOFAW staff report (C. Corn, personal communication 1993) that ants farming aphids are one of the biggest threat to the survival of outplanted C. kavaiensis seedlings in North Kona.

No insect predators of Kokia drynarioides are reported (Lamoureux 1981), but Xylosandrus is known to kill other species, apparently through the introduction of a fungus (L. Wong, personal communication 1993), and may be a threat to Kokia drynarioides.

(4) Seed Predation.

Predation of seeds of both species by introduced rats, mice and unspecified game birds and invertebrates is well known. Rats eat the seeds of both species while they are still on the tree (Lamoureux 1981, 1982). The large, hard, bean-like seeds of Caesalpinia kavaiensis have been found in rat burrows (Lamoureux 1982) as have the seed coats of Kokia drynarioides (Derral Herbst, U.S. Fish and Wildlife Service, personal communication 1992). The importance of seed predation has not been scientifically assessed.

(5) Genetic Problems

Since the numbers of individuals of both of these two species are very low, it is possible that each species' viability may be reduced due to problems

with in-breeding and the depleted gene pool. At this time, it appears that both species produce viable seeds that grow normally when protected.

If Kokia drynarioides are grown in botanical gardens near other Kokia species from other islands, it is possible that cross-pollination leading to hybridization may take place. Such mixing of the gene pools should be avoided by keeping careful records of provenance. It is unlikely that Caesalpinia kavaiensis will inadvertently hybridize with any available species.

(6) Destruction by Volcanic Eruption

The North Kona populations of these two species occur in a relatively restricted area on the side of a dormant volcano that last erupted about 1800 AD. A future eruption could threaten these wild populations.

(7) Illegal Harvests of Caesalpinia kavaiensis

The dark, dense wood of Caesalpinia kavaiensis is prized by a few knowledgeable craftsmen (Lamoureux 1982). The few remaining wild trees are considered at some risk to illegal harvesting (Herbst 1986).

(8) Drought

The North Kona area has experienced drought conditions for several years, and if these two species reproduce only in widely spaced times of favorable climactic conditions, the prolonged drought could be a factor in their recent decline. It is also possible that the drought conditions have exacerbated the insect infestation problems because dry vegetation is more susceptible to such invasion (C. Corn, personal communication 1993).

(9) Instability of Substrate

Because of past habitat destruction, current Caesalpinia kavaiensis populations on Oahu are now limited to steep, inaccessible terrain which is subject to frequent rock slides which damage the trees. Feral goats in these

areas add to the landslide problem by dislodging rock and soil, and by browsing on stabilizing ground cover (C. Corn, personal communication 1993).

9. CONSERVATION EFFORTS

(1) Protection as Endangered Species

Kokia drynarioides was listed as an endangered species in 1984 by the U.S. Fish and Wildlife Service with critical habitat in the Puuwaawaa and Kaupulehu ahupuaa (USFWS 1984). Caesalpinia kavaiensis was listed as endangered in 1986 (USFWS 1986). Although Lamoureux (1982) had recommended designating the critical habitat of Kokia drynarioides as the critical habitat for Caesalpinia kavaiensis, no critical habitat was designated for fear that publication of the location of this species might lead to illegal harvesting.

The critical habitat of Kokia drynarioides is on State and private land. The critical habitat contains all known wild Kokia drynarioides and is made up of three separate sections identified in this report as the Puuwaawaa portion, Kaupulehu portion and the boundary kipuka.

Federal listing of these two species as endangered triggered listing by the state of Hawaii, resulting in significant benefits. The State's endangered species law (HRS 195D, Conservation of Aquatic Life, Wildlife and Land Plants) has more stringent prohibitions on taking or damaging these species in their natural habitat and places these species in the State's threatened and endangered plant management program. Under this program, the state (DOFAW) has made use of federal funds for fencing, fire control, weed removal and outplanting of both species (C. Corn, personal communication 1991).

(2) Habitat Management in Puuwaawaa by the State of Hawaii.

The habitat within Puuwaawaa ahupuaa is owned by the state of Hawaii. It is zoned as agricultural land and managed under the jurisdiction of the Division of Land Management of the Department of Land and Natural Resources. Most of the best habitat for these two species is within the Puuwaawaa Ranch which is leased to a private operator. The best forest habitat within this lease was proposed as a State Natural Area Reserve prior to the fires of 1986, 1988 and 1993. Most of the State land below the Mamalahoa Highway where the majority of Caesalpinia kavaiensis are found (Puuwaawaa makai lands) has been withdrawn from the ranching lease. This land will probably be managed in the future as a State Game Management Area (S. Bergfeld, personal communication 1992). A new county landfill is also proposed for the Puuwaawaa makai lands.

DOFAW actively manages part of the habitat of the remaining wild trees. The sites under management are on the State-owned lands of Puuwaawaa. Management goals include reduction of the threats of fire and damage by mammalian herbivores, habitat improvement to encourage natural regeneration, and outplanting nursery-raised trees.

The management strategy is centered on fenced exclosures. The exclosures are designed to be large enough to permit expansion of the subpopulation by natural regeneration and outplanting. Fire breaks and fire roads outside the exclosures have been cleared to protect and give access to the exclosures. The fences protect the trees from browsing by domestic cattle and feral ungulates. Within the exclosures, fountain grass is periodically removed to reduce the fuel near the endangered trees. Fountain grass removal also increases the probability of natural regeneration and seedling establishment by reducing the competition for water and light. Some trapping of rats has been carried out to reduce seed predation (S. Bergfeld, personal communication 1991).

Wild and cultivated trees of both species produce viable seed which can be readily germinated. Seeds are occasionally collected by DOFAW and grown in their Hilo nursery. Seedlings have been planted into the fenced exclosures. Seedling establishment is aided by some watering and weed removal. Survival of outplanted seedlings of Kokia drynarioides is high. Caesalpinia kavaiensis seedlings also do well but have been attacked by boring beetles. All attacked seedlings and saplings have survived (S. Bergfeld personal communication 1991). Seed collections, plantings, and survivorship are not documented. Limited resources and personnel prevent the frequent monitoring and tending of out-planted seedlings (S. Bergfeld, personal communication 1991).

One fenced plant sanctuary (approved by the Board of Land and Natural Resources) and five additional exclosures in Puuwaawaa currently protect individuals of one or both of these species. The sanctuary, "Puuwaawaa I sanctuary," is located northeast of the northeast corner of the Puuwaawaa portion of the Kokia drynarioides critical habitat. Nursery stock of Kokia drynarioides has also been planted into the Acacia koaia Plant Sanctuary at Waiakamali (Figure 2), outside the historical range of the species. A second sanctuary, Puuwaawaa II, had seven outplanted Kokia drynarioides individuals which were severely damaged when cattle broke in in early 1993. After being cut back, three have re-sprouted.

None of these exclosures contain naturally occurring Kokia drynarioides, i.e. all Kokia drynarioides within exclosures are out-planted nursery-raised stock (Table 2). One exclosure at Puuwaawaa contains one naturally occurring Caesalpinia kavaiensis; the Caesalpinia kavaiensis in all other exclosures are out-planted nursery stock. None of the few remaining wild Kokia drynarioides are within DOFAW exclosures.

The colony of 21 or more mature Caesalpinia kavaiensis recently found in Kealakehe is on land owned by the Department of Land and Natural Resources, State of Hawaii. This parcel is the proposed site of a housing development sponsored by the Housing Finance and Development Corporation, a State agency (Belt Collins 1990). A mitigation plan to protect Caesalpinia kavaiensis has been proposed to DLNR by Paul Weissich and Associates, Inc. of Kaneohe, Hawaii (Wayne Takeuchi, Division of Forestry and Wildlife, personal communication 1992).

The proposal concentrates on protective actions during the construction phase and calls for a master plan to manage Caesalpinia kavaiensis and other natural resources on the site following the construction phase. The proposal specifies protective fencing, fire prevention and other activities.

(4) Habitat Management in Kaupulehu by Private Landowner/Lessee.

The habitat within Kaupulehu ahupuaa is owned by the Kamehameha Schools/Bernice Pauahi Bishop Estate. The land below the Mamalahoa Highway is leased to PIA Sports Properties, Inc. Most of the area is undeveloped and unused. PIA has taken some steps to protect and manage the endangered species on the leased lands. The Kaupulehu land above the Mamalahoa Highway is leased to Hualalai Ranch which practices commercial ranching and other agricultural pursuits.

PIA Sports Properties, Inc., has established a fenced exclosure of 230 meters^2 (2500 feet^2) to protect one Caesalpinia kavaiensis and one Kokia drynarioides tree. Seedlings of both species were reported in September 1991, but the mature Kokia drynarioides had died. Recent drought conditions are threatening survival of the seedlings of both species (Heather Cole, PIA Sports Properties, Inc., personal communication 1991). A jeep road through the Kaupulehu side of the boundary kipuka is maintained to provide access and to serve as a firebreak within the habitat.

Table 2. DOFAW plant sanctuaries with wild or artificially established nursery stock of Caesalpinia kavaiensis or Kokia drynarioides as of 1992 (S. Bergfeld, personal communication 1993).

Puuwaawaa I Sanctuary	10 Planted Kokia drynarioides
Koaia Plant Sanctuary	2 Planted Kokia drynarioides
Puuwaawaa II Sanctuary	3 Planted Kokia drynarioides (re-sprouting) 4 Planted Caesalpinia kavaiensis
Puuwaawaa III Exclosure	16 Planted Kokia drynarioides 10 Planted Caesalpinia kavaiensis
Uhiuhi Exclosure	5 Wild Caesalpinia kavaiensis 3 Planted Caesalpinia kavaiensis

A 2.4 hectare (5.8 acre) exclosure on Hualalai ranch is known as the Kaupulehu Forest Reserve, Section B (not a state forest reserve). This exclosure contains no living Caesalpinia kavaiensis at this time, but one (possibly two) Kokia drynarioides were observed there in 1991. This exclosure, privately-owned by Bishop Estate, was formerly managed by the National Tropical Botanical Garden (NTBG), Lawai, Kauai, but NTBG has no active management program at this time (S. Perlman, personal communication 1991). The status of endangered plants elsewhere on this lease is not known. Reconnaissance surveys of Hualalai Ranch have found no Caesalpinia kavaiensis or Kokia drynarioides (M. Tomich, personal communication 1992).

(5) Habitat Management on Kauai by Private Landowners.

Since 1986, a private landowner has managed a 100 acre preserve on his land for the conservation of native plant species. After clearing of the dominant, non-native vegetation from this area, the native vegetation began to recover and individuals of several extremely rare species, including Caesalpinia kavaiensis, were able to grow from long dormant seeds which remained in the soil (Fay 1988). On a visit to the property in the late 1980's, John Fay, who was then working for the Pacific Tropical Botanical Garden, observed a mature C. kavaiensis individual as well as several seedlings and saplings which were thriving in the preserve thanks to the landowner's efforts (John Fay, USFWS, personal communication 1994). Any individuals of this species which have survived thanks to the landowner's hard work and dedication are probably the last on Kauai.

(6) Conservation Status of Caesalpinia kavaiensis on Kauai, Oahu and Lanai

Caesalpinia kavaiensis grows on Oahu and Kauai on State-owned forest reserves zoned conservation districts. The tree at Puupane, Oahu, is within the Mount Kaala Natural Area Reserve. No specific management programs are carried out for the trees on any of these islands (DOFAW personnel, Personal Communications, 1991). None of these trees are protected by exclosure fences.

(7) Germ Plasm Reserves

Both of these species are readily grown from seed in cultivation (Lamoureux 1981, 1982; Diane Ragone, National Tropical Botanical Garden, personal communication, 1991), and adult trees are known from several arboreta, botanical gardens and public parks within the state (Lamoureux 1981, 1982). It is well known that both species are grown in private gardens; however, number and condition of these are not known. Both species are

being grown at the DOFAW base yard nursery in Hilo. Seedlings of Kokia drynarioides were also grown in the Maui District baseyard nursery and then outplanted at three locations on Molokai in 1986 for testing of site suitability for the even rarer Kokia cookei. Seedlings have also been used as root-stock for graftings of Kokia cookei.

NTBG on Kauai maintains a seed bank for Caesalpinia kavaiensis and is growing seedlings in a nursery. NTBG has entered into a cooperative agreement with DOFAW and has a permit to collect seeds and propagate endangered species. NTBG participates with the Center for Plant Conservation, St. Louis, Missouri, and maintains Caesalpinia kavaiensis as part of the national collection of endangered plants. NTBG made multiple seed collections of Caesalpinia kavaiensis in 1990, 1991 and 1993 from Hawaii, Kauai, and Oahu and some seed is in storage at NTBG. Currently, they also have a small number of seedlings in the nursery and a few dozen have been planted on their grounds.

NTBG has two live specimens of Kokia drynarioides in their collection, and about 30 seeds in storage.

10. POPULATION VIABILITY ANALYSIS

(1) Introduction to Population Viability Analysis

Population Viability Analysis (PVA) is a structured and comprehensive approach to estimating the probability of extinction of a population of a given size and, perhaps more importantly, to investigate the interactions of the factors affecting survival of the population (Shaffer 1990). There is no single PVA methodology. Two kinds of PVA are mentioned here. The first uses demographic data to construct a numerical model that predicts the growth rate (negative or positive) of a population (Menges 1990). The second models the environmental dynamics that control availability of suitable habitat (Murphy et al. 1990).

(2) Demographic Models for Kona Dry Forest Species

A demography-based PVA requires detailed life history information, especially knowledge of the rates at which the organisms graduate from one life-stage to the next, e.g. from seed to germinant to established seedling to sapling to fruiting adult. A matrix of these rates or probabilities can be used in a deterministic Markov Chain model or a probabilistic Monte Carlo-type model to project a growth rate for the population.

At this time, a formal demography-based PVA is inappropriate for the endangered Kona dry forest species for two conspicuous reasons: detailed demographic data are not available and the prognosis for the natural recovery of these populations is obvious. Observations over the last ten or more years of the wild North Kona populations of these two species have found no seedling establishment and no recruitment of reproductive trees. These observations set the probability of population growth and longterm survival to zero. They also point out that the key to recovery is reclaiming the habitat by removal of fountain grass, alien herbivores, seed predators and all other factors that prevent natural regeneration.

Reproduction studies should include the objective of determining if these species might be "episodic reproducers" in which seedling establishment is dependent upon widely spaced favorable periods of higher than normal rainfall. Such a finding would greatly affect the estimates of the negative impact of such external threats as fountain grass competition and herbivory and the overall understanding of the species' demography.

(3) An Environmental Model for Risk Analysis of Kona Dry Forest Habitat

A PVA model that identifies suitable habitat and the appearance and disappearance of habitat patches (due to fires, volcanism, changes in land use, etc.) for these species would be useful. This kind of PVA is useful for species that can thrive as long as suitable habitat is available. The working assumptions that both of these dry forest species are reproductively and

biologically viable but endangered due to habitat loss and habitat degradation emphasize that it is the dynamics of the habitat segments rather than the demographics that are critical.

Until the threats of fountain grass, fire, ungulate damage and development are alleviated, management of the wild populations of these species will essentially consist of preventing their extinctions. An environmental PVA might be useful in estimating the probability of loss to development, fire, lava flows and other large-scale activities that could destroy the existing trees. An environmental PVA might be useful at the present time and again after fountain grass and the threat of fire are brought under control.

An environmental model of the dry forest habitat would at least:

1) identify areas that have the suitable physical characters to be habitat for these species;

2) consider planned development and land use within the ranges of these species;

3) consider the frequency and size of possible fires;

4) consider the frequency and size of lava flows from Mt. Hualalai and how they might reduce the habitat.

The model would predict the likelihood that all the existing populations could be extirpated in a relatively short time period before new populations could be established.

PART II. RECOVERY

1. RECOVERY OBJECTIVES

This recovery plan has two operational objectives: 1) prevent the imminent destruction of the few remaining wild trees of these species; and 2) remove the environmental factors that prevent their natural regeneration and dispersal. The first can probably be achieved by building exclosure fences and preventing fire from burning the trees. The second objective is dependent upon development of effective region-wide control methods, such as biological control, for fountain grass and other alien plants, feral ungulate control and insect control. Unfortunately, there is no concerted research and development program for fountain grass control at this time and control of the other factors is often difficult, expensive and controversial. This recovery plan is written with the assumption that research will provide region-wide control of fountain grass, but is written with an incremental approach that directs basic protection of existing trees and expansion of germplasm reserves that should be implemented at once.

Downlisting or delisting of these species is completely dependent upon restoration of naturally regenerating populations. Management and research activities will be directed towards reduction of the known environmental factors that threaten extinction and prevent natural regeneration.

Literature review leads to the conclusion that these two species are endangered because of identifiable external factors within their habitat that prevent seedling establishment and recruitment, predation by introduced ungulates and insects, and the threat of fire. The low number of individuals of these species could also be an obstacle to reproduction of viable plants and populations. From the present state of knowledge, it is concluded that if the external threats are significantly reduced throughout a large portion of dry forest habitat, these species would reproduce on their own, but given the

extremely small number of mature plants, they may not be able to reproduce fast enough to support viable populations on their own.

At the present, there is no scientific basis for setting minimum population sizes or minimum number of populations required for down-listing or delisting these species. The lack of such basic knowledge as life span and age at reproductive maturity make demographic modelling and projections impossible; therefore, recovery objectives dealing with minimum population size should be viewed as temporary estimates which will be updated and refined as more information becomes available.

These species should be considered for downlisting when:

1) It is observed and documented that the major threats listed in Part I are greatly reduced.
2) It is observed and documented that following the removal of threats, new trees are being recruited by natural regeneration at a rate adequate to replace individuals lost from the population and preserve long term genetic diversity.
3) Recovery proceeds for the time, approximately 13 years, needed to provide demographic data to be used in population viability analysis (PVA) to estimate minimum population numbers and densities for effective reproduction.
4) A thorough review of the environmental dynamics and human activities within the dry forest habitat is conducted to determine the minimum habitat area needed to give a high probability of survival of the species over the next 200 years.
5) Current habitat has been secured in perpetuity.
6) Any management practices necessary to maintain the protected habitats have been implemented.

7) The habitat is populated with the numbers and densities of these two species indicated by the results of research and the PVA (minimum of 100 naturally reproducing individuals in each of 3 populations of each species in North Kona and a minimum of 100 naturally reproducing Caesalpinia kavaiensis, in each of three populations, on each of Oahu, Lanai, Kauai and Maui).

2. STEP-DOWN NARRATIVE

1. Protect habitat of current populations and manage threats.

Current habitat of Caesalpinia kavaiensis and Kokia drynarioides should be protected through cooperative agreements with landowners, and threats to current populations should be controlled.

11. Protect and manage North Kona populations.

Several management areas adequate in size for long-term recovery should be designated based on the present location of critical biological resources and a realistic evaluation of future land use in North Kona.

111. Select management areas.

A scientific statement of the area needed to support self-sustaining populations of these species is not now possible, but since they are large, long-lived life forms in a dynamic and stressful environment, the management areas will be regional rather than local in scale. Management areas should be measured in hundreds of hectares at the minimum. Each management area may contain several management sites prioritized for intensive management and other candidate sites that will be used for reestablishing Caesalpinia kavaiensis and Kokia drynarioides when conditions and available resources permit. Management areas must be chosen taking into consideration the distribution of the biological resource, an analysis of habitat hazards, and the ability to obtain long-term security of the area.

Although knowledge of the occurrences of Caesalpinia kavaiensis and Kokia drynarioides is not complete, several sites can be recommended for high priority as management areas. Priority should be given to the area within the Halepiula 3, Waimea Paddock portion of the critical habitat with three Kokia drynarioides trees and the Caesalpinia kavaiensis population in Kealakehe. Because of its location within a proposed development, management of the Kealakehe population may require a modification of management as presented in this plan and/or adaptation of the proposals that have been submitted as a mitigation plan (See Section 9 of Introduction). The Kealakehe

population is important because of the number of Caesalpinia kavaiensis trees there, but more so because this site marks an extension of the range far south of the critical habitat. A third potential site on state land would include all or some of the trees on either side of the Puuwaawaa-Puuanahulu boundary. This site is also near the northern extreme of the range of Caesalpinia kavaiensis. Other sites that should be considered for inclusion in management areas are: all other sites with one or more Caesalpinia kavaiensis or Kokia drynarioides trees with other rare or endangered plants of other species; and sites dominated by native plant communities which are within the historical range of the subject species (Takeuchi 1990).

1111. Use distribution information in this report and future surveys to prioritize sites according to their value as endangered species habitat.

Priority should be given to areas that have wild Caesalpinia kavaiensis or Kokia drynarioides trees. This plan should be fully integrated with other endangered species recovery plans; therefore, priority can also be given to areas suitable for these species which contain other endangered or candidate species. Two other tree species of the dry forest community, Colubrina oppositifolia and Nothocestrum breviflorum, are proposed for listing as endangered, and other rare and unique plants occur in the region. Because of the goal of maintaining Caesalpinia kavaiensis and Kokia drynarioides in a natural ecosystem, communities which are suitable for these species and contain a high proportion of native to alien plants, or other characters that enhance their value as native plant habitat should be included in management areas whether or not they contain either of these species at the present time.

1112. Identify State or private lands that can be secured for management in perpetuity.

A review of public and private lands within the historical range of the species should be made to determine which can be made available as management areas and can be secured in perpetuity by means such as long-term cooperative agreements, zoning, conservation easements, etc.

1113. Determine extent of habitat required for recovery.

The risk of habitat destruction, especially by fire or volcanism, should be analyzed to help determine the extent and dispersion of management areas necessary to decrease the chance that a single disaster could damage the entire protected populations of Caesalpinia kavaiensis or Kokia drynarioides. Extent of past fires and lava flows should be analyzed. Planning should take advantage of natural firebreaks, such as lava flows, if any exist.

112. Protect the management areas.

Efforts should be made between adjacent landowners and managers to enter into long-term agreements for the protection of sites where Caesalpinia kavaiensis or Kokia drynarioides are known to exist or where they may be found in the future. Such protection may involve changes in land use, large-scale fencing, fire suppression and control, etc.

After the areas are protected, the first objective of site management is the prevention of the accidental loss of trees of these two species. This objective can be achieved largely by removing the threats of fire and browsing by establishing intensive management sites around all wild Kokia drynarioides and Caesalpinia kavaiensis trees. Intensively managed sites should be large enough to include areas for natural reproduction and the augmentation tasks (#3) described below.

1121. On State-owned lands, change State land use classifications of management areas to Conservation.

On State-owned lands, the land-use classification (LUC) of management areas should be changed to Conservation, Protected subzone, to maximize protection. This LUC will afford legal protection to the entire regional management area rather than protecting only the individual endangered plant or the local site as required by the State endangered species law.

1122. Protect State lands leased for ranching.

Agreements for the management of endangered species should be negotiated with the lessees (Hualalai and Puuwaawaa ranches) of these properties.

1123. Protect lands owned by Kamehameha Schools/Bishop Estate and lessee PIA Sports Properties.

High priority should be given to reaching agreement with Kamehameha Schools/Bishop Estate and its lessee, PIA Sports Properties, Inc., for the management of the Kaupulehu side of the boundary kipuka. At this time, PIA is working to protect these endangered plants (see Section 9, Part I of this plan). Recovery efforts should include assisting the landowner and/or lessee to continue to manage this site with the methods detailed below, in Section 3. A second potential management area within the Kamehameha Schools/Bishop Estate land of Kaupulehu would include the site of four Caesalpinia kavaiensis trees at 500 meters (1600 feet) elevation in Kaupulehu, and a third is the exclosure where Kokia drynarioides seedlings have recently sprouted.

113. Create and/or expand scientifically managed germplasm reserves including a seed bank and specimens in arboreta.

Both species should be protected against the catastrophic loss of the few remaining trees in the wild. It is believed that a sizable number of both species are grown in private and institutional gardens. However, it is not known how well these trees are faring or if reliable propagation is occurring. Therefore, an effort should be made to locate and asses all individuals growing in these private gardents. In addition, it is important to support a scientifically managed germplasm reserve, including a seed bank and specimens in arboreta. At this time, the National Tropical Botanical Garden (NTBG), Kauai, has a permit from the State of Hawaii to collect seeds and propagate endangered plants. Caesalpinia kavaiensis is among the plants that they maintain as part of the national collection of endangered plants sponsored by the Center for Plant Conservation. Such germplasm reserves for both species should be financially supported at NTBG and at least one other facility. This should

include material from all islands where the species occurs, and from as many individuals as possible. Careful records of the origin of all material must be kept.

114. Develop a fire response and suppression plan for both species.

Short-term survival as well as long-term recovery of the remaining wild populations of these species requires aggressive implementation of a fire control plan in the management areas. Wildfire should be stopped by continuing the current DOFAW North Kona fire control plan until a new plan is adopted. Under the current plan, DOFAW maintains firebreaks on both sides of the Belt Highway in Puuwaawaa and other firebreaks which also serve as access to the sites with endangered plants, and periodically remove the highly flammable fountain grass from near the trees. The adequacy of the current plan should be reviewed, updated if necessary, and extended to the population of Caesalpinia kavaiensis in Kealakehe and any other sites with these endangered species.

1141. Improve access to all management sites; file access maps with fire department.

All management sites must be accessible in case of fire. Roads may need to be built and/or upgraded to provide access. Also, easy to read maps that show access to the management sites and alternative routes must be provided to the fire department.

1142. Train several people as liaisons with the fire department to facilitate the response plan.

Personnel from the principal endangered plant protection agency (probably DOFAW) must be available as liaisons to the firefighters. More than one person must be well-trained in this role so that a liaison is always available. The liaison should be able to indicate where the management sites are and what resources are available, such as location of water reservoirs and equipment that might be available from other agencies.

1143. In cooperation with other state and federal land managing agencies, assemble best available technical information for fire prevention in fountain grass infested lands.

Contact should be established with other state and federal agencies that manage fountain grass infested lands to assemble best-available technical information for fire prevention.

1144. Implement updated fire control strategy in North Kona.

Information from tasks 1141 - 1143 should be used to implement an updated fire control plan in North Kona.

1145. Schedule maintenance.

A regular schedule of monitoring and maintenance of fire breaks and fuel-free areas should be set.

115. Implement a fountain grass control plan for North Kona.

The control of fountain grass is likely to be the most recalcitrant problem facing restoration of the dry forest ecosystem and recovery of its endangered species. Forming a dense, grassy ground cover in communities that formerly had a sparse ground cover on near-barren lava, fountain grass presents two formidable threats to endangered trees and the former native community: 1) it is a fire-adapted grass that promotes wildfire; and 2) it dominates the ground cover and appears to out-compete seedlings of native trees and other plants. Hawaii Volcanoes National Park, Resource Management Division, is managing a large area with a fountain grass problem. The most widely used control method is simply hand-pulling; however, a considerable amount of planning time has gone into determining the most cost-effective strategy for selecting where and when to apply control. The best currently available control methods for small management sites must be identified while research proceeds in developing effective regional control methods. Attention should be given, as the Park Service has, to determining a cost-effective strategy for applying mechanical control.

Using information from other land management agencies and from research, implement a coordinated fountain grass control program for the North Kona management sites.

116. Control ungulate damage.

Browsing by ungulates will be stopped by establishing and maintaining exclosure fences and removing any animals from the exclosures. Fences must be adequate to exclude domestic and feral livestock. Exclosures should be large enough to protect a functioning community unit with room for natural regeneration and augmentation of the endangered species and other native plants.

117. Continue control of alien plants in North Kona exclosures.

Control of alien plants including fountain grass, Lantana, Silk oak and Custard apple, should continue in the North Kona management areas.

118. Control rodents, game birds and insects, as necessary.

Rodents, game birds and invertebrates, including Xylosandrus, should be trapped or otherwise controlled based on research results.

119. Manage other environmental factors that limit natural regeneration.

Other limiting factors, such as recreational impacts from hikers, may need to be managed based on research results (Task # 29).

1110. Implement tagging and long term monitoring of North Kona individuals.

In order to keep accurate records of recovery progress, all individuals must be mapped, tagged and routinely monitored. Tagging and monitoring activities should be expanded to include new individuals and subpopulations as they are established.

12. Protect and manage Oahu populations.

The habitat of the three Waianae mountain populations of Caesalpinia drynarioides must be protected, and threats controlled.

121. Enter into a long term agreement with the State of Hawaii for management of Oahu forest reserve lands containing Caesalpinia kavaiensis.

An agreement for management of the Waianae Kai, Mount Kaala and Makaleha Valley Caesalpinia kavaiensis individuals should be negotiated with the State of Hawaii.

122. Create and/or expand germplasm reserves.

See narrative under task # 1131.

123. Evaluate need for a fire control program on Oahu.

The extent of fire threat to the Oahu populations should be evaluated and a fire control program developed if necessary.

124. Control ungulates on Oahu.

The Waianae Kai, Mount Kaala and Makaleha Valley Caesalpinia kavaiensis populations should be fenced. Fenced areas should be large enough to accommodate natural regeneration and augmentation of the populations. Fencing of the entire area should be considered in cost effective and warranted by other resources in the area.

125. Control alien plants on Oahu as needed.

Australian red cedar must be controlled and the individuals shading the Caesalpinia kavaiensis trees removed at Puupane. Removal work should be done by experienced people so as not to damage the endangered trees. Schinus and Psidium control is also needed in all areas, and other species may need control in the future.

126. Control rodents, game birds and insects, as necessary.

See narrative under task # 118.

127. Manage other limiting factors on Oahu.

See narrative under task # 119.

128. Implement tagging and long term monitoring of all Oahu individuals.

See narrative under task # 1110.

13. Protect and manage Lanai population.

The habitat of Caesalpinia kavaiensis on Lanai should be protected and threats controlled.

131. Protect Lanai habitat owned by Castle & Cooke.

Steps should be taken to ensure that Castle & Cooke is aware of the presence of Caesalpinia kavaiensis on their lands and every effort should be made by DOFAW and/or the USFWS to assist Castle & Cooke, as necessary, in developing and implementing long-term management plans for the protection and restoration of C. kavaiensis on these lands.

132. Create and/or expand germplasm reserves.

See narrative under task # 1131.

133. Evaluate need for a fire control program on Lanai.

The extent of fire threat to the Lanai population should be evaluated and a fire control program developed if necessary.

134. Control ungulates on Lanai.

The single Lanai individual should be included in a fenced area large enough to accommodate natural regeneration and augmentation. The steep terrain may make this task difficult.

135. Control alien plants on Lanai as needed.

Alien plants in the Lanai exclosure should be controlled, as needed.

136. Control rodents, game birds and insects, as needed.

See narrative under task # 118.

137. Manage other limiting factors on Lanai.

See narrative under task # 119.

138. Implement tagging and long term monitoring of Lanai individuals.

See narrative under task # 1110.

14. Protect and manage Kauai populations.

If Caesalpinia kavaiensis still occurs on private land on Kauai, the remaining habitat should be protected and threats to the individuals should be controlled.

141. Protect Kauai habitat.

The landowner's current program of rare plant conservation should be supported and assisted.

142. Create and/or expand germplasm reserves.

See narrative under task # 1131.

143. Evaluate need for a fire control program on Kauai.

The extent of fire threat to any remaining Kauai population should be evaluated and a fire control program developed if necessary.

144. Control ungulates on Kauai.

Any remaining individuals on Kauai should be included in a fenced area large enough to accommodate natural regeneration and augmentation.

145. Control alien plants on Kauai as needed.

Control of alien plants in the Kauai exclosure should be done as needed.

146. Control rodents, game birds and insects, as needed.

See narrative under task # 118.

147. Manage other limiting factors on Kauai.

See narrative under task # 119.

148. Implement tagging and long term monitoring of Kauai individuals.

See narrative under task # 1110.

15. Protect and manage habitat on Maui.

Although Caesalpinia kavaiensis is thought to be extinct on Maui, it existed there in the recent past, and unknown individuals may still be present. Searches for individuals as well as habitat suitable for reintroduction should be conducted, and suitable habitat should be protected and managed.

151. Search for unknown Caesalpinia kavaiensis individuals on Maui.

Systematic searches should be conducted in likely habitat on Maui, and the extent and quality of potential habitat should be recorded.

152. Protect Caesalpinia kavaiensis habitat on Maui.

Using the results of task # 151, suitable habitat for extant individuals and for reintroduction of C. kavaiensis on Maui should be protected through a cooperative agreement, lease, fee purchase, or other agreement with the landowner.

153. Manage Caesalpinia kavaiensis habitat on Maui.

Once the habitat has been protected, threats to any individual plants and habitat should be evaluated, and control of the threats should begin. Fencing and alien plant control will probably be necessary in preparation for reintroductions.

2. Conduct research on limiting factors.

Implementing the management plan will require further research to identify and characterize the environmental threats that are preventing natural regeneration of these two species and to develop management techniques. It is suggested that all dry forest endangered species research be coordinated and contracted through a single office in order to maximize information sharing among researchers and to avoid duplication of efforts.

21. Research pollination, seed set, germination and life cycle.

Observations indicate that in both species, only some isolated trees are able to produce viable seed (Lamoureux 1981) and the pollination mechanisms for self-pollination and outbreeding, germination requirements and life cycles are not known. Research on these subjects should be done.

22. Determine extent of inbreeding suppression and inter-relatedness of subpopulations.

Recovery of a viable, interbreeding population of each of these species may be inhibited by unknown reproductive failure due to inbreeding suppression. Research on genetic variablity and possible inbreeding in these species should be done.

23. Evaluate role of abiotic factors and competition with alien plants in survival and reproduction.

Studies of the ecology of the two subject species should be supported to determine the environmental resources including light, water availability, mineral nutrients, and soil requirements needed for natural regeneration and survival. These studies must also evaluate the importance of fountain grass and other alien plants as competitors for these resources. The probability that these two species previously successfully reproduced only during unusual episodes of favorable climatic conditions should also be evaluated in this context. Some of this research may be done with seedlings raised in authorized nurseries or botanical gardens, but, on the whole, seedling ecology studies must be field oriented.

This research could include observation of the effects of weeding, watering, fertilizing, etc. Care must be taken to insure that no research which may be harmful to the remaining wild individuals is undertaken.

24. Determine properties of seed bank in soil.

The number of dormant seeds in the soil should be determined for both species.

25. Research utilization of endangered plant flowers, fruit, seeds, or seedlings by alien rodents, birds, and invertebrates.

The importance of seed and seedling predation in curtailing natural regeneration must be evaluated. Rats, mice, and unspecified game birds, and invertebrates have all been named as predators of seeds of one or both of these species. Seedlings have also been reported to have been chewed by rodents. No records of mortality have been kept. Research must determine the quantity of seed produced and the fate of the seeds.

26. Investigate possible relationships between subject species and root symbionts when numbers allow.

The present dangerously low numbers of both species preclude root symbiot research at this time. However, when more numerous speciments are available, the existence and nature of mycorrhizal symbiosis should be determined, as should the associations of Caesalpinia kavaiensis with nitrogen-fixing Rhizobium. The presence of other root commensals, including alien pathogens, should also be investigated.

27. Research alien plant control methods.

Development of effective methods of control for Fountain grass, Christmas berry, Strawberry guava, Silk oak, Lantana and other alien plants must be aggressively pursued in cooperation with other state and federal agencies that manage infested lands.

271. Appraise feasibility and risk vs. benefits of biological control.

Although past evaluations for biological control have been pessimistic, efforts to find safe biological controls for fountain grass and other alien plants should be aggressively pursued.

272. Evaluate use of pre-emergence herbicide, including adverse impacts on native plant seed bank.

The Park Service has gotten some encouraging preliminary results from the experimental application of pre-emergence herbicide to cleared areas to prevent reestablishment from the seed bank. DOFAW has used Round-Up herbicide with some success to maintain firebreaks in Puuwaawaa. Pre-emergence herbicides should be further evaluated for alien plant control, including determination of any adverse impact on seeds of native plants in the soil seed bank.

273. Evaluate use of grazing by cattle for fountain grass control.

The effectiveness and the negative impacts of using cattle to suppress fountain grass outside the management areas should also be evaluated.

28. Research control methods for insects.

Research exploring methods of control for scale insects, aphid farming ants, Xylosandrus and other pest insects should be conducted.

29. Evaluate role of other factors limiting natural regeneration that may be indicated.

Any other environmental factor that may limit natural regeneration or survival of either of the two subject species should be investigated.

210. Synthesize findings from 21 - 29 to develop techniques to improve survivorship of seeds and seedlings.

Following the identification and evaluation of factors limiting recovery, management techniques must be developed to eliminate or reduce the adverse effects. All research leading to management techniques for the various limiting factors must be coordinated and mutually informed so that all work well together. Restoration management plans should be a synthesis of up-to-date research.

3. Increase numbers in existing populations.

It is hoped that by eliminating current threats, populations will be able to reproduce well enough on their own to reach numbers necessary for

downlisting. The increase in numbers of these two species should be enhanced by special care and treatment of seeds and seedlings within the management sites. When possible, the present practice of outplanting nursery-raised seedlings should be de-emphasized for two reasons: 1) increasing numbers by outplanting will not reduce the environmental factors that are responsible for endangerment; and 2) nursery-raised stock may carry insects or pathogens into the natural population. Recruitment from seeds collected on the site or from nearby trees should be promoted by management techniques developed through research. Techniques might include barriers to discourage seed predation, drip irrigation systems, placement of seeds in select microhabitats, and shelters or other features to reduce evapotranspiration. Augmentation through transplant of nursery raised stock may be necessary in areas where only a few or no mature individuals remain.

31. Determine populations to be increased.

The populations on Lanai and Kauai will need to be enhanced by transplantation of nursery-raised individuals. The need for such augmentation on Oahu and in North Kona will need to be evaluated.

32. Determine appropriate techniques for increasing numbers.

Augmentation through transplant of nursery raised seedlings of both species and increased reproduction through alien plant control have already been started in North Kona by DOFAW. These efforts should be continued in order to determine the optimum techniques for increasing numbers.

33. Develop an augmentation plan for North Kona, if necessary.

If adequate natural regeneration does not occur, detailed augmentation plans which address the specific genetic stock to be used and the precise location of all transplants should be developed.

331. Select genetic stock to be used in augmentation.

The results of task # 22 should be used to select the most appropriate genetic stock for use in augmentation.

332. Identify areas to augment.

Within management exclosures, specific areas within the historical range of the species must be identified as the precise anticipated locations of all transplants.

333. Propagate genetically suitable Caesalpinia kavaiensis plants.

Once the genetic stock has been selected, plants must be propagated in an appropriate facility. Special care must be taken to insure that seedlings to be outplanted are free of insects and pathogens. Enough seedlings for use in both augmentation and new population establishment (task # 4) should be propagated.

334. Propagate genetically suitable Kokia drynarioides plants.

See narrative under task # 333.

335. Transplant nursery-grown plants.

Once the transplant areas have been identified and the proper genetic stock propagated, transplantation can proceed. Transplanting should be done using the best information on techniques, time of year, etc. All plants which fail to survive transplantation will need to be replaced with genetically similar individuals.

34. Develop an augmentation plan for Oahu, if necessary.

If adequate natural regeneration does not occur, detailed augmentation plans which address the specific genetic stock (from Oahu, if available) to be used and the precise location of all transplants should be developed.

341. Select genetic stock to be used in augmentation.

See narrative under task # 331.

342. Identify areas to augment.

See narrative under task # 332.

343. Propagate genetically suitable Caesalpinia kavaiensis plants.

See narrative under task #333.

344. Transplant nursery-grown plants.

See narrative under task # 335.

35. Develop an augmentation plan for Lanai.

Detailed augmentation plans which address the specific genetic stock (from Lanai, if available) to be used and the precise location of all transplants should be developed.

351. Select genetic stock to be used in augmentation.

See narrative under task # 331.

352. Identify areas to augment.

See narrative under task # 332.

353. Propagate genetically suitable Caesalpinia kavaiensis plants.

See narrative under task #333.

354. Transplant nursery-grown plants.

See narrative under task # 335.

36. Develop an augmentation plan for Kauai.

Detailed augmentation plans which address the specific genetic stock (from Kauai, if available) to be used and the precise location of all transplants should be developed.

361. Select genetic stock to be used in augmentation.

See narrative under task # 331.

362. Identify areas to augment.

See narrative under task # 332.

363. Propagate genetically suitable Caesalpinia kavaiensis plants.

See narrative under task #333.

364. Transplant nursery-grown plants.

See narrative under task # 335.

4. Establish new populations.

In order to reach the delisting goals of 3 populations of each species on Hawaii island and 3 populations of Caesalpinia kavaiensis on Oahu, Lanai, Kauai and Maui, new populations of Caesalpinia kavaiensis will have to be established on Lanai, Kauai and Maui within the historical range of the species.

41. Establish new populations on Lanai.

Steps should be taken to establish two new populations of Caesalpinia kaviensis on Lanai within the historical range of the species.

411. Select new sites on Lanai.

High priority for new sites will be given to areas with the best quality remnant communities of native plants within the historical range of the species. In choosing between sites of equal biological value, consideration should be given to the logistics of managing the site and the goal of dispersing the sites.

412. Secure new sites on Lanai.

An agreement for management of the new sites will need to be negotiated with Castle & Cooke.

413. Select genetic stock to be used in reintroductions on Lanai.

Using information from task # 22, appropriate genetic stock should be chosen for reintroduction. Genetic stock from another island should only be used when material from the same island is not available.

414. Control ungulates at new sites on Lanai.

Areas large enough to support 100 reproducing individuals should be fenced.

415. Control fire as needed.

See narrative under task # 133.

416. Control alien plants as needed.

See narrative under task # 135.

417. Control seed predators as needed.

See narrative under task # 1163.

418. Establish seedlings in new sites.

See narrative under task # 335.

42. Establish new populations on Kauai.

Steps should be taken to establish two new Caesalpinia kavaiensis populations on Kauai within the historical range of the species.

421. Select new sites on Kauai.

See narative for task # 411.

422. Secure new sites on Kauai.

A agreement for management of the new sites will need to be negotiated with the landowner(s).

423. Select genetic stock to be used in reintroduction on Kauai.

See narrative under task # 413.

424. Control ungulates at new site on Kauai.

See narrative under task # 414.

425. Control fire as needed.

See narrative under task # 133.

426. Control alien plants as needed.

See narrative under task # 135.

427. Control seed predators as needed.

See narrative under task # 1163.

428. Establish seedlings in new sites.

See narrative under task # 335.

43. Establish new populations on Maui.

Steps should be taken to establish three new Caesalpinia kavaiensis populations on Maui, within the historical range of the species.

431. Select new sites on Maui.

See narative for task # 411.

432. Secure new sites on Maui.

A agreement for management of the new sites will need to be negotiated with the landowner(s).

433. Select genetic stock to be used in reintroduction on Maui.

See narrative under task # 413.

434. Control ungulates at new site on Maui.

See narrative under task # 414.

435. Control fire as needed.

See narrative under task # 133.

436. Control alien plants as needed.

See narrative under task # 135.

437. Control seed predators as needed.

See narrative under task # 1163.

438. Establish seedlings in new sites.

See narrative under task # 335.

5. Validate recovery objectives.

An important role for research is to verify the scientific validity of the stated recovery objectives in this plan.

51. Determine the number of populations needed to ensure survival over the next 200 years.

It will be important to know if the current objectives call for enough populations for these species to survive long term impacts such as hurricanes, volcanic eruptions, inbreeding suppression, fire and development.

52. Determine the number of individuals needed to ensure survival over the next 200 years.

It will be important to know if the current objectives call for enough individuals to sustain populations and to guard against inbreeding suppression.

53. Revise recovery objectives.

The recovery objectives should be revised as often as warranted by new information.

54. Determine if hypothesized human-induced changes in climate will affect populations.

Human-induced changes in global climate may also impact on local climates and thus plant distributions. How these global climate changes might affect the long-term survivability of existing Caesalpinia kavaiensis and Kokia drynarioides populations should be studied.

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PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated cost for the Caesalpinia kavaiensis and Kokia drynarioides recovery program, as set forth in this recovery plan. It is a guide for meeting the objectives discussed in Part II of this plan. This schedule indicates task priority, task numbers, task descriptions, duration of tasks, the agencies responsible for committing funds, and lastly, estimated costs. The agencies responsible for committing funds are not, necessarily, the entities that will actually carry out the tasks. When more than one agency is listed as the responsible party, an asterisk is used to identify the lead entity.

The actions identified in the implementation schedule, when accomplished, should protect habitat for these species, stabilize their existing populations and increase their population sizes and numbers. Monetary needs for all parties involved are identified to reach this point.

Priorities in Column 1 of the following implementation schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2 - An action that must be taken to prevent a significant decline in species population/ habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Key to Acronyms Used in Implementation Schedule

ES	-	Fish and Wildlife Service, Ecological Services, Honolulu, Hawaii
DLNR	-	Hawaii State Department of Land and Natural Resources
HUAL	-	Hualalai Ranch, Island of Hawaii
BISH	-	Kamehameha Schools/Bernice P. Bishop Estate
PIA	-	PIA Sports Properties, Inc.
HCFD	-	Hawaii County Fire Department
NBS	-	National Biological Survey
NPS	-	National Park Service
C&C	-	Castle & Cooke, Inc.

Key to Other Codes Used in Implementation Schedule:

C	-	Continuous task
O	-	Ongoing (already begun as of writing of plan)

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
Protect and manage Kona populations:											
1	1111	Prioritize management sites	1	* ES	0.5		0.5				
				DLNR	0.5		0.5				
1	1112	Identify lands that can be protected	1	ES	0.5		0.5				
				* DLNR	0.5		0.5				
1	1113	Determine extent of habitat required for recovery	2	* ES	2		1	1			
				DLNR	2		1	1			
1	1121	Change state land use class to Conservation, Protected subzone	2	ES	0.2		0.1	0.1			
				* DLNR	1		0.5	0.5			
1	1122	Protect habitat leased by the State	2	* ES	0.5		0.25	0.25			
				DLNR	0.5		0.25	0.25			
				HUAL	0.5		0.25	0.25			
1	1123	Protect lands owned and leased by Bishop Estate	2	* ES	0.5		0.25	0.25			
				DLNR	0.5		0.25	0.25			
				BISH	0.5		0.25	0.25			
				PIA	0.5		0.25	0.25			
1	113	Create/ expand germplasm reserves	2	ES	20	10	10				
				* DLNR	20	10	10				
1	1141	Improve access to sites and file maps with fire department	2	ES	1		0.5	0.5			
				* DLNR	1		0.5	0.5			
				HCFD	1		0.5	0.5			
1	1142	Train liaisons for fire management	2	ES	5		2.5	2.5			
				* DLNR	5		2.5	2.5			
				HCFD	5		2.5	2.5			
1	1143	Assemble best info. on fire management in fountain grass areas	2	* ES	1		0.5	0.5			
				DLNR	1		0.5	0.5			
				HCFD	1		0.5	0.5			
1	1144	Implement updated fire control plan in North Kona	1	ES	5			5			
				* DLNR	5			5			
				HCFD	5			5			

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
1	1145	Schedule maintenance of fire breaks	O	ES	7	0.5	0.5	0.5	0.5	0.5	Ongoing
				* DLNR	70	5	5	5	5	5	
				HCFD	14	1	1	1	1	1	
1	115	Implement a fountain grass control plan for N. Kona	C	ES	13		1	1	1	1	
				* DLNR	65		5	5	5	5	
1	116	Control ungulate damage in North Kona	C	* ES	170			60	60	5	
				DLNR	170			60	60	5	
1	117	Continue alien plant control in North Kona	C	ES	26		2	2	2	2	
				* DLNR	26		2	2	2	2	
1	118	Control rodents, game birds and insects as necessary	C	ES	13		1	1	1	1	
				* DLNR	65		5	5	5	5	
1	119	Manage other limiting factors in North Kona	C	ES	TBD		TBD				
				* DLNR	TBD		TBD				
1	1110	Tag and monitor all North Kona individuals	C	ES	13		1	1	1	1	
				* DLNR	26		2	2	2	2	
Protect and manage Oahu populations:											
1	121	Negotiate a long term agreement with State of Hawaii for Oahu habitat	2	* ES	0.5		0.25	0.25			
				DLNR	0.5		0.25	0.25			
1	122	Create and/or expand germplasm reserves	2	ES	5		2.5	2.5			
				* DLNR	5		2.5	2.5			
1	123	Evaluate need for fire control on Oahu	1	ES	0.5		0.5				
				* DLNR	0.5		0.5				
1	124	Control ungulates on Oahu	C	ES	70			30	30	1	
				* DLNR	70			30	30	1	
1	125	Control alien plants on Oahu	C	ES	25		5	5	5	1	
				* DLNR	25		5	5	5	1	
1	126	Control rodents, game birds and insects, as necessary	C	ES	260		20	20	20	20	
				* DLNR	260		20	20	20	20	
1	127	Manage other limiting factors on Oahu	C	ES	TBD		TBD				
				* DLNR	TBD		TBD				

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
1	128	Tag and monitor all Oahu individuals	C	ES	6.5		0.5	0.5	0.5	0.5	
				* DLNR	13		1	1	1	1	
Protect and manage Lanai population:											
1	131	Protect Lanai habitat owned by Castle & Cooke	2	* ES	0.5		0.25	0.25			
				DLNR	0.5		0.25	0.25			
				C&C	0.5		0.25	0.25			
1	132	Create and/or expand germplasm reserves	2	ES	5		2.5	2.5			
				* DLNR	5		2.5	2.5			
1	133	Evaluate need for fire control on Lanai	1	ES	0.5		0.5				
				* DLNR	0.5		0.5				
1	134	Control ungulates on Lanai	C	ES	30			10	10	1	
				* DLNR	30			10	10	1	
1	135	Control alien plants on Lanai	C	ES	6.5		0.5	0.5	0.5	0.5	
				* DLNR	6.5		0.5	0.5	0.5	0.5	
1	136	Control rodents, game birds, and insects, as necessary	C	ES	TBD		TBD				
				* DLNR	TBD		TBD				
1	137	Manage other limiting factors on Lanai	C	ES	TBD		TBD				
				* DLNR	TBD		TBD				
1	138	Tag and monitor all Lanai individuals	C	ES	1.3		0.1	0.1	0.1	0.1	
				* DLNR	6.5		0.5	0.5	0.5	0.5	
Protect and manage Kauai population:											
1	141	Protect privately owned habitat on Kauai	2	* ES	0.5		0.25	0.25			
				DLNR	0.5		0.25	0.25			
					0.5		0.25	0.25			
1	142	Create and/or expand germplasm reserves	2	ES	5		2.5	2.5			
				* DLNR	8		4	4			
1	143	Evaluate need for fire control on Kauai	1	ES	0.5		0.5				
				* DLNR	2		2				
1	144	Control ungulates on Kauai	C	ES	50			20	20	1	
				* DLNR	70			30	30	1	
1	145	Control alien plants on Kauai	C	ES	6.5		0.5	0.5	0.5	0.5	
				* DLNR	39		3	3	3	3	

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
1	146	Control rodents, game birds and insects, as necessary	C	ES	13		1	1	1	1	
				* DLNR	39		3	3	3	3	
1	147	Manage other limiting factors on Kauai	C	ES	TBD		TBD				
				* DLNR	TBD		TBD				
1	148	Tag and monitor all Kauai individuals	C	ES	1.3		0.1	0.1	0.1	0.1	
				* DLNR	13		1	1	1	1	
Protect and manage Maui habitat:											
1	151	Search for unknown individuals on Maui	2	* DLNR	5		2.5	2.5			
				ES	5		2.5	2.5			
1	152	Protect habitat on Maui	2	* ES	0.5		0.25	0.25			
				DLNR	0.5		0.25	0.25			
1	153	Manage habitat on Maui	C	* DLNR	TBD			TBD			
				ES	TBD			TBD			
		NEED 1 (Protect and manage current sites)			1859.3	26.5	152.55	391.05	337.2	95.2	
2	21	Research pollination, germination and life cycle	10	* NBS	280		28	28	28	28	
				DLNR	40		4	4	4	4	
2	22	Determine extent of inbreeding supression	5	* NBS	70		14	14	14	14	
				DLNR	10		2	2	2	2	
2	23	Evaluate role of abiotic limiting factors and alien plant competition	10	* NBS	280		28	28	28	28	
				DLNR	40		4	4	4	4	
2	24	Determine properties of seed bank	5	* NBS	70		14	14	14	14	
				DLNR	10		2	2	2	2	
2	25	Research utilization of seeds, seedlings, fruits and flowers	5	* NBS	140		28	28	28	28	
				DLNR	20		4	4	4	4	
2	26	Research ecology of root symbiots	10	* NBS	280		28	28	28	28	
				DLNR	40		4	4	4	4	
2	271	Appraise feasability of biological control	0	NBS	5	1	1	1	1	1	Ongoing
				DLNR	5	1	1	1	1	1	
				* NPS	70	14	14	14	14	14	

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
2	272	Evaluate use of herbicides for alien plant control	0	* NPS NBS DLNR	70 5 5	14 1 1	14 1 1	14 1 1	14 1 1	14 1 1	Ongoing
2	273	Evaluate use of cattle grazing for fountain grass control	5	NPS NBS * DLNR	5 5 35		1 1 7	1 1 7	1 1 7	1 1 7	
2	28	Research control methods for insects	10	* NBS DLNR	140 50		14 5	14 5	14 5	14 5	
2	29	Evaluate role of other limiting factors	10	* NBS DLNR	140 50		14 5	14 5	14 5	14 5	
2	210	Develop new techniques based on outcome of research	5	* ES DLNR	35 5						
		NEED 2 (Conduct research)			1905	32	239	239	239	239	
2	31	Determine populations to be increased	2	ES * DLNR	5 5		2.5 2.5	2.5 2.5			
2	32	Determine techniques for increasing numbers	0	ES * DLNR	15 15	5 5	5 5	5 5			Ongoing
Augment North Kona populations:											
2	331	Select genetic stock for augmentation	1	ES * DLNR	1 1			1 1			
2	332	Identify specific areas to augment	1	ES * DLNR	2 2			2 2			
2	333	Propagate genetically suitable C. kavaiensis plants	0	ES * DLNR	10 50	2 10	2 10	2 10	2 10	2 10	Ongoing
2	334	Propagate genetically suitable K. drynarioides plants	0	ES * DLNR	7 140	1 20	1 20	1 20	1 20	1 20	Ongoing
2	335	Transplant nursery grown plants	6	ES * DLNR	6 30				1 5	1 5	
Augment Oahu populations:											
2	341	Select genetic stock for augmentation	1	ES * DLNR	1 1				1 1		

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
2	342	Identify specific areas to augment	1	ES	1				1		
				* DLNR	1				1		
2	343	Propagate genetically suitable C. kavaiensis plants	5	ES	10				2	2	
				* DLNR	50				10	10	
2	344	Transplant nursery grown plants	5	ES	5					1	
				* DLNR	20					5	
Augment Lanai populations:											
2	351	Select genetic stock for augmentation	1	ES	1				1		
				* DLNR	1				1		
2	352	Identify specific areas to augment	1	ES	1				1		
				* DLNR	1				1		
2	353	Propagate genetically suitable C. kavaiensis plants	5	ES	10				2	2	
				* DLNR	100				20	20	
2	354	Transplant nursery grown plants	5	ES	5					1	
				* DLNR	75					15	
Augment Kauai populations:											
2	361	Select genetic stock for augmentation	1	ES	1				1		
				* DLNR	1				1		
2	362	Identify specific areas to augment	1	ES	1				1		
				* DLNR	1				1		
2	363	Propagate genetically suitable C. kavaiensis plants	5	ES	10				2	2	
				* DLNR	100				20	20	
2	364	Transplant nursery grown plants	5	ES	5					1	
				* DLNR	75					15	
		NEED 3 (Augment current populations)			766	43	48	54	107	133	
Establish new populations on Lanai:											
2	411	Select new sites on Lanai	1	ES	1			1			
				* DLNR	4			4			
2	412	Secure new sites through an agreement with Castle & Cooke	2	* ES	0.5			0.25	0.25		
				DLNR	0.5			0.25	0.25		
				C & C	0.5			0.25	0.25		

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
2	413	Select genetic stock for reintroduction	1	ES * DLNR	1 1				1 1		
2	414	Control ungulates at new sites	C	* ES DLNR	TBD TBD				TBD TBD		
2	415	Evaluate need for fire control at new sites	1	ES * DLNR	0.5 0.5				0.5 0.5		
2	416	Control alien plants as needed	C	ES * DLNR	TBD TBD				TBD TBD		
2	417	Control seed predators as needed	C	ES * DLNR	TBD TBD				TBD TBD		
2	418	Establish seedlings at new sites	5	ES * DLNR	5 25				1 5	1 5	
Establish new populations on Kauai:											
2	421	Select new sites on Kauai	1	ES * DLNR	1 4				1 4		
2	422	Secure new sites through an agreement with landowners	2	* ES DLNR	0.5 0.5				0.25 0.25	0.25 0.25	
2	423	Select genetic stock for reintroduction	1	ES * DLNR	1 1				1 1		
2	424	Control ungulates at new sites	C	* ES DLNR	TBD TBD				TBD TBD		
2	425	Evaluate need for fire control at new sites	1	ES * DLNR	0.5 0.5				0.5 0.5		
2	426	Control alien plants as needed	C	ES * DLNR	TBD TBD				TBD TBD		
2	427	Control seed predators as needed	C	ES * DLNR	TBD TBD				TBD TBD		
2	428	Establish seedlings at new sites	5	ES * DLNR	5 25				1 5	1 5	
Establish new populations on Maui:											

Recovery Plan Implementation Schedule for Kona Dryland Forest Plants

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
2	431	Select new sites on Maui	1	ES	1.5				1.5		
				* DLNR	5				5		
2	432	Secure new sites through an agreement with landowners	2	* ES	0.5				0.25	0.25	
				DLNR	0.5				0.25	0.25	
2	433	Select genetic stock for reintroduction	1	ES	1.5				1.5		
				* DLNR	1.5				1.5		
2	434	Control ungulates at new sites	C	* ES	TBD				TBD		
				DLNR	TBD				TBD		
2	435	Evaluate need for fire control at new sites	1	ES	1				1		
				* DLNR	1				1		
2	436	Control alien plants as needed	C	ES	TBD				TBD		
				* DLNR	TBD				TBD		
2	437	Control seed predators as needed	C	ES	TBD				TBD		
				* DLNR	TBD				TBD		
2	438	Establish seedlings at new sites	5	ES	7.5				1.5	1.5	
				* DLNR	37.5				7.5	7.5	
		NEED 4 (Establish new populations)			136	0	0	5.75	45.25	22	
3	51	Determine number of populations needed for 200 year survival	3	ES	0						
				DLNR	0						
				* FWS-RES	0						
3	52	Determine # of individuals needed for 200 year survival	3	ES	0						
				DLNR	0						
				* FWS-RES	0						
3	53	Revise recovery objectives	1	* ES	0						
				DLNR	0						
3	54	Determine effects of climate change	20	* NBS	50					5	
				ES	10					1	
				DLNR	10					1	
		NEED 5 (Validate recovery objectives)			70	0	0	0	0	7	
		TOTAL YEARLY COST			4736.3	101.5	439.55	689.8	728.45	496.2	

APPENDIX A - INDIVIDUALS CONTACTED DURING PLAN REVIEW

Chief, Fish and Wildlife Service
Division of Endangered Species
Mail Stop 452 ARLSQ
Arlington, VA

Chief, Fish and Wildlife Service
Office of Public Affairs
PA, 3447 MIB
Washington, D.C. 20240

Chief, Fish and Wildife Service
Division of Refuges
Mail Stop 670 ARLSQ
Arlington, VA

* Mr. Bruce McBryde
Fish and Wildlife Service, Region 8
Office of Research Support
RD-8/ORS, Mail Stop 725 ARLSQ
Arlington, VA

Environmental Protection Agency
Hazard Evaluation Division - EEB (TS769C)
401 M St., SW
Washington, D.C. 20460

* Dr. Loyal Mehrhoff
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Pacific Islands Office
P.O. Box 50167
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Ms. Linda Cuddihy
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Volcano, HI 96718

Mr. Patrick Dunn
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* Dr. Derral Herbst
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Mr. Robert Hobdy
Division of Forestry and Wildlife
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Hawaii Research Station
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Dr. Charles Lamoureaux
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Dr. Lloyd Loope
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Makawao, HI 96768

Dr. Clifford Morden
Dept. of Botany
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Mr. Steve Perlman
Hawaii Plant Conservation Center
National Tropical Botanical Garden
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