Recovery Plan for *Kokia Cookei*

June 1998

Kokia cookei (after Degener 1934)

RECOVERY PLAN FOR
Kokia cookei

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EXECUTIVE SUMMARY

Current Species Status: *Kokia cookei* is restricted to the island of Molokai and is federally listed as endangered. There are no naturally occurring populations. Currently, the species exists only at five sites: at a private residence, in managed outplantings at two sites, and in cultivation at two locations. The total number of individual plants is 23.

Habitat Requirements and Limiting Factors: The only known habitat for *Kokia cookei* was low-elevation dryland forest at approximately 200 meters (660 feet) elevation on the western end of the island of Molokai. The soil (mollisol) in this area is relatively young, well drained, and generally rich in plant nutrients. This area and all other low-elevation dryland habitats in Hawaii are highly degraded due to grazing by introduced herbivores, human disturbance, and weeds. All current populations are also threatened by a severely limited gene pool (all living individuals are cloned from a single plant) and a failure to produce viable seeds.

Recovery Objectives: To delist *Kokia cookei*. Downlisting and delisting criteria are provided.

Recovery Criteria: *Kokia cookei* may be downlisted to threatened status when natural regeneration from viable seeds is occurring at 5 managed outplanting sites; each with at least 100 reproductive individuals; and current and future threats to these populations are mitigated or eliminated. Delisting would require the establishment of at least three additional populations in managed outplanting sites and future reduction of threats to allow for unassisted reproduction and stable or increasing populations with a 10-year average of 100 reproductive plants in each of 8 populations.

Actions Needed:

1. Increase numbers of grafted plants.
2. Research and develop better propagation methods.
3. Establish additional populations.
4. Validate recovery objectives.

Estimated Cost of Recovery Actions ($1,000):

(some costs have yet to be determined)

Year	Need 1	Need 2	Need 3	Need 4	Total
1998	10	190	68	0	268
1999	10	190	68	0	268
2000	10	190	1,336	0	1,536
2001	10	190	393	0	593
2002	10	190	68	0	268
2003	10	150	60	0	220
2004	10	150	60	0	220
2005	10	150	60	0	220
2006	10	150	60	0	220
2007	10	150	60	4	224
2008	10	50	56	0	116
2009	10	50	56	0	116
2010	10	50	56	0	116
2011	10	50	56	0	116
2012	10	50	56	0	116
2013	10	50	56	0	116
2014	10	50	56	0	116
2015	10	50	56	0	116
2016	10	50	56	0	116
2017	10	50	56	4	120
2018	10	50	56	0	116
2019	10	50	56	0	116
2020	10	50	56	0	116
2021	10	50	56	0	116
2022	10	50	56	0	116
2023	10	50	56	0	116
2024	10	50	56	0	116
2025	10	50	56	0	116
2026	10	50	56	0	116
2027	10	50	56	4	120
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Total	300	2,700	3,353	12	6,365

Date of Recovery: Downlisting to Threatened could initiate in 2027, if recovery criteria are met.

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I. INTRODUCTION

BRIEF OVERVIEW

The endemic Hawaiian genus *Kokia* (Malvaceae) exhibits characteristics of both hibiscus (*Hibiscus* spp.) and cotton (*Gossypium* spp.) (Degener 1930, 1934). Known only from the island of Molokai (Figure 1), *Kokia cookei* has been described as the rarest plant in the world (Garnett 1991). When first discovered in the 1860s, only three trees of the species were found. By the twentieth century, only a single wild tree of *Kokia cookei* could be found. The species became extirpated from the wild in 1918. Seeds from the last tree produced only one individual that survived past 1933. This cultivated tree at a Kauluwai residence on Molokai bore abundant seed from the 1930s through the late 1950s and produced over 130 seedlings, which were outplanted on the islands of Hawaii, Molokai, and Oahu. None of these outplanted seedlings have survived. By the late 1950s, the single plant of the species at Kauluwai, Molokai, died and *Kokia cookei* was presumed to be extinct.

In 1970, a single plant of the species, a relict (surviving remnant) of previous cultivation, was discovered at the Molokai residence. In 1978, a fire killed this last naturally rooted plant of *Kokia cookei* (Woolliams 1979). After the fire, the only living material was a branch of this plant that had been grafted onto a rootstock of the related *Kokia kauaiensis* at Waimea Arboretum and Botanical Garden on Oahu. Thirty cloned plants of *Kokia cookei* have been produced by grafting to root stocks of the two related *Kokia* species, *Kokia kauaiensis* and *Kokia drynarioides*. Twenty-three of these remain, 15 of which occur on Molokai Ranch in 2 outplantings sponsored by the Division of Forestry and Wildlife (DOFAW), 7 exist in artificial cultivation facilities on Oahu and Maui, and one exists at a private residence on Hawaii. Viable seeds of the species were last obtained in 1974-1975 (Woolliams and Gerum 1992).

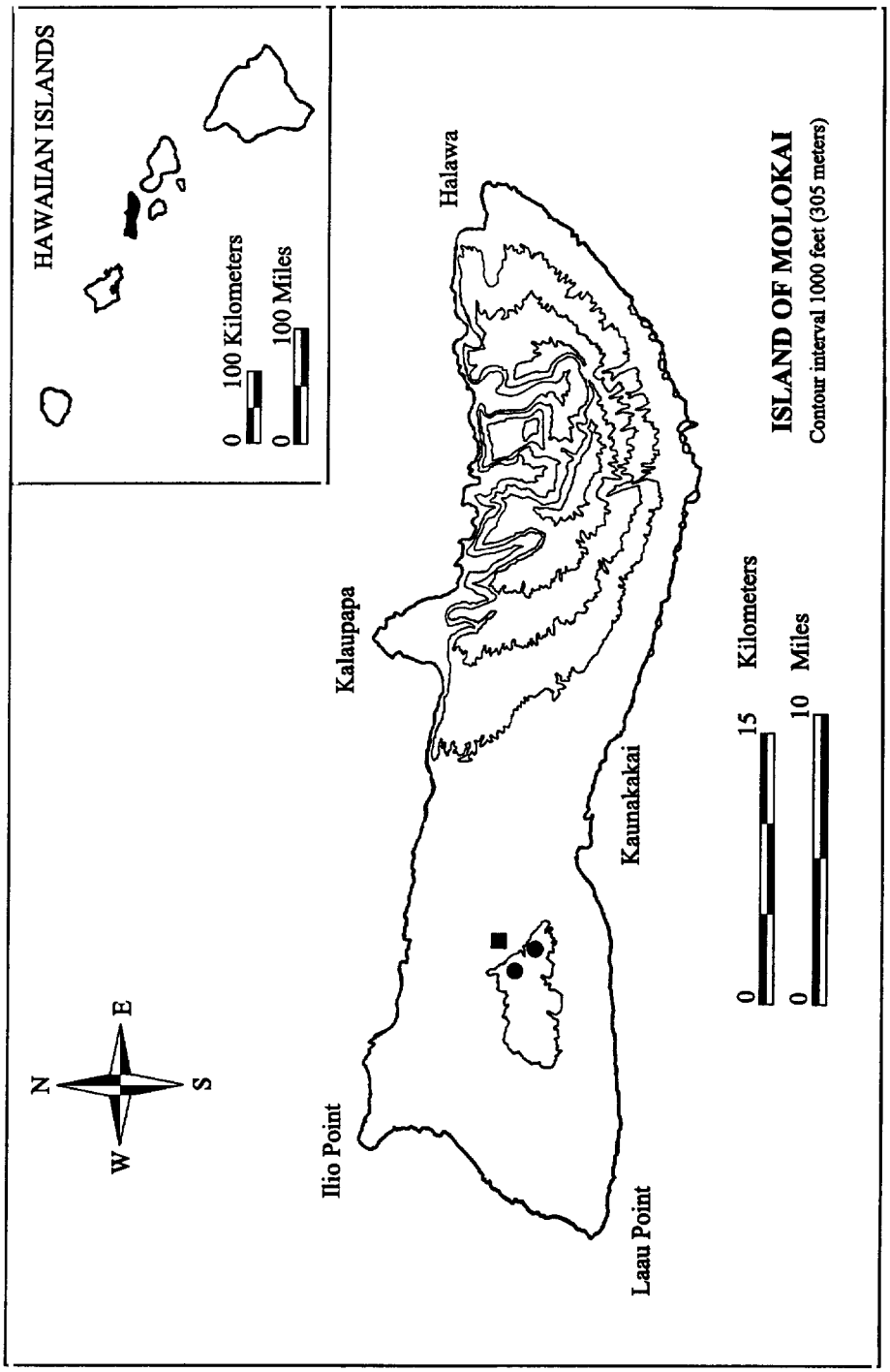

Figure 1. Historic (square) and current (circles; outplantings) locations of *Kokia cookei.*

Kokia cookei was proposed as an endangered species by the U.S. Fish and Wildlife Service (USFWS) on July 1, 1975 (USFWS 1975). The final rule listing this plant as an endangered species became effective on November 29, 1979 (USFWS 1979). Because *Kokia cookei* has been extirpated from its natural range, it was not considered prudent to designate critical habitat (USFWS 1979). This species has been assigned a recovery priority of 5 (See Appendix B for a description of the Recovery Priority System.)

TAXONOMY

The endemic Hawaiian genus *Kokia* (Malvaceae) consists of four species, each restricted to a single island: (1) *Kokia cookei* Degener, endangered (44 FR 62471), Molokai; (2) *Kokia drynarioides* (Seemann) Lewton, endangered (49 FR 47397), Hawaii; (3) *Kokia kauaiensis* (Rock) Degener and Duvel, endangered (61 FR 53088), Kauai; and (4) *Kokia lanceolata* Lewton, presumed extinct, Oahu (Wagner *et al.* 1990).

The first species of the genus to be collected was *Kokia drynarioides* in 1779 by David Nelson, the botanical collector of Captain James Cook's expedition on the island of Hawaii. This material was described by Seemann (1865) as a new species of cotton, *Gossypium drynarioides*. *Kokia cookei* was first collected in the 1860s by Mr. R. Meyer on the western end of the island of Molokai. Hillebrand (1888) considered the Molokai material as a form of *Gossypium drynarioides*. Lewton (1912) described the new genus *Kokia* and reported Molokai as the locality of *Kokia drynarioides*. Botanist Otto Degener (1934) described a new species, *Kokia cookei*, in honor of Mr. and Mrs. George P. Cooke, long time residents of Molokai, "who have materially aided in its preservation" (Degener 1934).

The derivation of the genus name *Kokia* is from the Hawaiian name *kokio* (Hillebrand 1888). Additional Hawaiian names for the genus include *koki`o* and *hau hele`ula* (Bates 1990). English common names for *Kokia cookei* are Molokai red cotton, Cooke kokio, and Hawaiian tree cotton (Degener 1934, Bates 1990, Rock 1919). Synonyms for *Kokia cookei* include *Gossypium drynarioides* Hillebrand and *Kokia drynarioides* (Seemann) Degener.

SPECIES DESCRIPTION

Kokia cookei is a small deciduous tree (Figure 2). The only wild individual of this century was about 3 meters (10 feet) in height (Rock 1919). The height has been described as "12-15 feet high" (3.7-4.6 meters) (Hillebrand 1888), "probably 3.5-4.5 meters" (11.5-15 feet) (Degener 1934), and "perhaps 3-5 m" (9.8-16.4 feet) (Bates 1990). The leaves are simple, five- to seven-lobed with an entire margin, 5-13 centimeters (1-5.2 inches) wide and clustered at branch ends. The large flowers occur singly in leaf axils near branch ends. Flowers are subtended by three sometimes persistent bracts that are 1.5 centimeters (0.6 inch) long. Flowers are showy with twisted and recurved orange-red petals clustered together around a staminal column about 6.5 centimeters (2.6 inches) long. The fruit is a five-lobed, dry, dehiscent (splitting open when ripe) capsule, globose and up to 3 centimeters (1.2 inches) in diameter, producing seeds 10-13 millimeters (0.4-0.5 inch) long, covered with a short dense pubescence.

LIFE HISTORY

Single, isolated trees of *Kokia cookei* can produce viable seeds. Botanist Joseph F. Rock collected seeds from the last wild tree of *Kokia cookei* on Molokai in 1910. From a plant grown from one of these seeds, many subsequent generations of plants were produced from seeds until the late 1970s (Woolliams and Gerum 1992).

Regarding pollination, unpublished research by Robert Hobdy and Drs. Herbert and Irene Baker demonstrated that *Kokia drynarioides* and *Kokia kauaiensis* are adapted to facilitate flower visitation and pollination by nectar-feeding birds. The bright red flowers of *Kokia* produce copious nectar with unusually high levels of amino acids, characteristics associated with bird-pollinated flowers (Robert Hobdy, Maui District DOFAW, personal communication 1995). The nectar of *Kokia cookei* was unavailable at the time of the study and was not assayed. The flowers of *Kokia cookei*, though somewhat smaller than the other two species, nevertheless contain copious nectar (R. Hobdy, personal communication 1995).

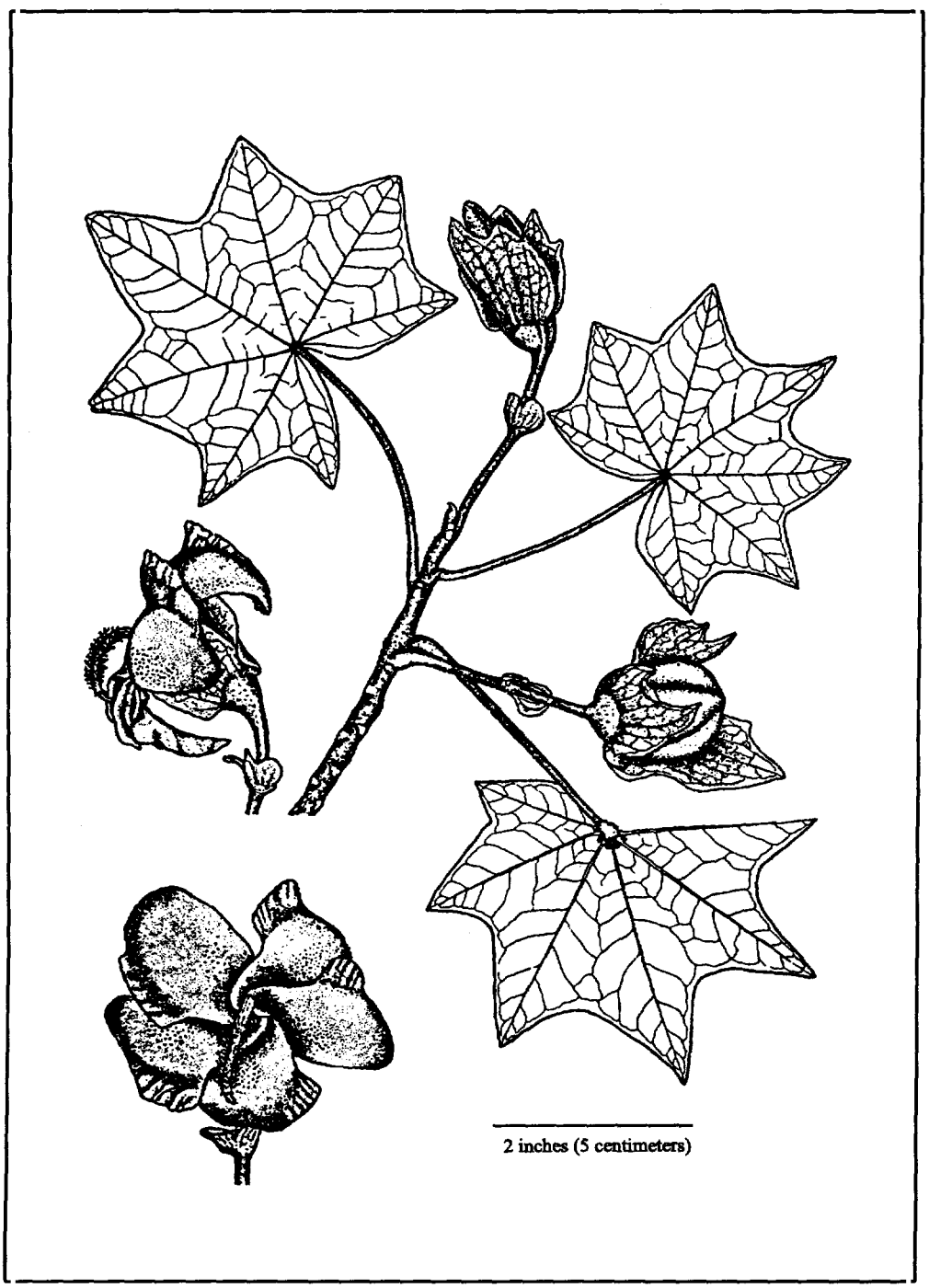

Figure 2. *Kokia cookei* (after Degener 1934)

Seasonally, large grafted individuals of *Kokia cookei* can produce hundreds of flowers. Flowering *Kokia cookei* trees may have been important food sources for native nectar-feeding honeyeater (Melphagidae) and honeycreeper (Fringillidae: Drepanidinae) birds. Fossil evidence indicates that these birds were once common in lowland areas before the arrival of humans (James and Olson 1991). After the arrival of humans, extirpation of native passerine birds from leeward Molokai may have greatly reduced outcrossing in *Kokia cookei* (USFWS 1979). Alien nectar-feeding birds such as Japanese white-eyes (*Zosterops japonica*) have not been observed visiting this tree (R. Hobdy and Richard Nakagawa, Maui District DOFAW, and Winston Morton, Waimea Arboretum and Botanical Garden, personal communications 1995). Honeybees (*Apis melifera*) do visit the flowers of *Kokia cookei* (R. Nakagawa and W. Morton, personal communication 1995).

Kokia cookei can be a fairly long-lived tree. One of the original seedlings produced from the last wild tree lived for over 39 years (1915 to sometime after 1954). In contrast, grafted trees of *Kokia cookei* often have shorter life spans.

Two cultivated grafted plants (approximately 4-5 years old) of *Kokia cookei* at Kahului, Maui, flowered prolifically in 1991, producing over 850 flowers and 88 seed pods, but no viable seeds (R. Nakagawa, personal communication 1995). Within a few months, both trees had died. Examination of the grafted rootstock revealed that although the *Kokia cookei* top section was relatively intact, the *Kokia drynarioides* rootstock had rotted (R. Nakagawa, personal communication 1995). Nakagawa believes that the death of the two plants was a result of depletion of resources after the heavy spring-summer flowering season. Since that time, he removes flower buds on the remaining *Kokia cookei* plants at the Division of Forestry and Wildlife's Kahului baseyard. By this procedure, Nakagawa hopes to prolong the life of stock plants for grafting and air layering (R. Nakagawa, personal communication 1995). At Waimea Arboretum and Botanical Garden, staff do not remove the flower buds of *Kokia cookei*. Only one of the larger plants flowers regularly at Waimea and immature seeds are collected for embryo culture at Lyon Arboretum (W. Morton, personal communication 1995).

Kokia cookei that have originated from seed flower as early as 4 years after germination (Degener 1934; Rock 1919; Young and Poepoe 1916). Rock (1919) stated that in cultivation at Kauluwai, Molokai, *Kokia cookei* flowered and fruited in the spring. Degener (1934) stated that this species flowers from "about February to June or July." At Kahului, Maui, *Kokia cookei* flowers from May through August (R. Nakagawa, personal communication 1995).

Degener (1934) remarked regarding *Kokia cookei*: "The flowers remain for several days fresh on the tree but soon wilt after picking unless their stems are plunged into boiling water. There is a faint hibiscus odor to the flowers. The tree bears seed pods and flowers at the same time."

The genus *Kokia* is deciduous (Bates 1990). However, in cultivation, *Kokia drynarioides* has some foliage year round (USFWS 1994). Even with regular watering, *Kokia cookei* lose most of their leaves by September (R. Nakagawa and W. Morton, personal communication 1995). For *Kokia cookei*, Degener (1934) stated that: "In the fall of the year, the leaves turn a reddish color, like those of the false *kamani* or maple, and fall off, leaving the brown dried seed pods. There is a temporary 'rest period' before the leaf buds appear - the dry pods still remaining on the tree more or less in a cured state until they at last fall off."

DISTRIBUTION AND POPULATION STATUS

Kokia cookei became extinct in the wild in 1918. Prior to extinction, *Kokia cookei* was found in the wild only in relictual dryland forest near Mahana, northeast of Puu Nana, western Molokai, County of Maui, at approximately 200 meters (660 feet) elevation (Degener 1934). In the 1860s three trees of *Kokia cookei* were discovered by Mr. R. Meyer on the "western end" of Molokai and "which could not be found again on a subsequent visit a few years later" (Hillebrand 1888). In April 1910, J. F. Rock discovered a single living tree and another dead one "in a lonely dry canyon at the extreme west end of Molokai back of Mahana" (Degener 1934).) This tree may have been one of the same three trees discovered by Meyer some 50 years previously (Degener 1934, Rock 1919). In June 1915, Rock and George P. Cooke visited the last tree of *Kokia cookei* in the wild at Mahana and found it in extremely poor condition with only "one or two branches still bearing foliage" (Degener 1934). They collected a "few seeds"

from the ground from which a number of seedlings eventually germinated. The full natural range of *Kokia cookei* cannot be determined due to the near complete loss of native, dryland forest on Molokai (USFWS 1979).

Presently, the species exists as 23 grafted plants in 5 different locations on the islands of Maui, Molokai, Oahu, and Hawaii (Table 1). Seven individuals are in artificial cultivation facilities on the islands of Maui and Oahu. One individual is located at a private residence on the island of Hawaii. The remaining 15 individuals are in small (930 square meters; 10,000 square feet or less) outplanting sites on Molokai Ranch lands, at Puu Nana, about 365 meters (1,200 feet) elevation. Puu Nana is within 2 kilometers (1.2 miles) of Mahana, the site where the original wild plants of *Kokia cookei* were discovered.

Table 1. Current locations of *Kokia cookei.*

Island	Location	Number of Plants	Information Source
Oahu	Waimea Arboretum and Botanical Garden Land ownership: private	4 plants	Woolliams
Molokai	State exclosure one Land ownership: private (Molokai Ranch)	4 plants	Manaba
Molokai	State exclosure two Land ownership: private (Molokai Ranch)	11 plants	Nakagawa
Maui	Division of Forestry and Wildlife, Kahului baseyard Land ownership: State of Hawaii	3 plants	Nakagawa
Hawaii	Private residence Land ownership: private (Erling Hedemann)	1 plant	Hedemann

HABITAT DESCRIPTION

The only historic habitat of *Kokia cookei* is dryland forest on the western (leeward) end of Molokai near Mahana, northeast of Puu Nana at approximately 200 meters (660 feet) elevation. Photographs taken of the last wild individual of *Kokia cookei* and its habitat in 1913 show an over-browsed, arid, pasture-like site of barren soil, large boulders, and scattered nonnative grasses (Rock 1913).

Rock (1919) described the relictual natural habitat of *Kokia cookei* on Molokai (where needed, current taxonomic names are in brackets): "The region in which this rare species grew is one of the weirdest and loneliest imaginable. The tree stood on a rocky bluff all by itself. Some distance from it there were the remnants of a forest, a few scattered trees of *Osmanthus sandwicensis* [*Nestegis sandwicensis*], *Nototrichium sandwicense*, *Xylosma Hillebrandii* [*Xylosma hawaiiense*], *Maba sandwicensis* [*Diospyros sandwicensis*], *Chrysophyllum polynesicum* [*Nesoluma polynesicum*] and the exceedingly rare vine *Breweria menziesii* [*Bonamia menziesii*], which clinged [sic] for support to an old decaying *Maba* [*Diospyros*] tree. All the trees were windswept, the crowns extending in oblong outline in one direction. On the ground lay scattered old trunks of once glorious trees, and among them a small dead tree of *Kokia drynarioides* [*Kokia cookei*] probably one of the original three trees discovered by R. Meyer..."

The former habitat of *Kokia cookei* appears most similar to modern dryland forest at Kanepuu, Lanai, and leeward Haleakala, Maui, at 300-600 meters (1,000-2,000 feet) elevation. In a recent classification of Hawaiian vegetation types (Gagne and Cuddihy 1990), the habitat of *Kokia cookei* (based on the field notes of J.F. Rock in 1919) appears closest to the *Olopua/Lama* (*Nestegis/Diospyros*) forest type know currently only from Kanepuu, Lanai. Associated native taxa are *Nestegis sandwicensis* (*olopua, pua*), *Nototrichium sandwicense* (*kului*), *Xylosma hawaiiense* (*maua*), *Diospyros sandwicensis* (*lama*), *Nesoluma polynesicum* (*keahi;* a species of concern), and *Bonamia menziesii*, an endangered liana endemic to Hawaii. A single individual of the endangered Hawaiian gardenia, *Gardenia brighamii* (*nanu, na`u*), now protected within an exclosure, is close to the original collection site of *Kokia cookei* (R. Hobdy, personal communication 1996). Associated weed species include *Lantana camara* (lantana), *Leucaena leucocephala* (*koa haole*), *Panicum maximum* (Guinea grass), *Prosopis pallida*

(*kiawe*), and *Schinus terebinthifolius* (Christmas berry) (Gagne and Cuddihy 1990, R. Hobdy, personal communication 1996).

Soil of the habitat of *Kokia cookei* on Molokai is a mollisol soil (Armstrong 1983). These are relatively young soils with good drainage that are generally rich in plant nutrients (Armstrong 1983). Rainfall of this leeward area is strongly seasonal with most of the approximately 50-63 centimeters (20-25 inches) of annual precipitation falling in a few winter storms generally followed by arid summers (Armstrong 1983, Wagner *et al.* 1990).

REASONS FOR DECLINE AND CURRENT THREATS

Historically, the reasons for the decline of *Kokia cookei* were:

Habitat Conversion

Dryland forests of the Hawaiian Islands have been greatly reduced and fragmented as a result of agricultural practices, the actions of introduced ungulates, invasion by nonnative plant species, and increased fire frequency (Gagne and Cuddihy 1990; Cuddihy and Stone 1990).

Effects of Introduced Grazing Mammals

Kokia cookei was directly impacted by browsing, bark stripping, and soil trampling by domestic and feral cattle, goats, and sheep (Rock 1913). In the early 1900s, Mahana, the only locality where *Kokia cookei* was known from the wild, was a central site for a sheep ranch run by Molokai Ranch. In 1908, the ranch had 17,000 sheep; by 1920, the ranch discontinued raising sheep (Pukui *et al.* 1974). Referring to *Kokia cookei*, Rock (1913) noted: "Several trees occurred on the west end of Molokai, at Mahana, all having now died, owing to ravages of cattle, sheep and goats, which eat off the bark and leaves."

Loss of Native Pollinators

Prior to the arrival of Polynesians around 400 A.D., nectar-feeding passerine birds were apparently common in lowland dryland forest areas of the Hawaiian Islands (James and Olson 1991). After the arrival of Polynesians, and followed by Europeans in the late 1700s, native nectar-feeding birds were extirpated from

dryland forests. *Kokia cookei* is apparently adapted to bird pollination. The loss of native nectar-feeding birds may have contributed to the decline of this species.

Seed Predation

No specific mention of seed predation by insect larvae has been noted on *Kokia cookei*. However, Hillebrand (1888) noted of the related *Kokia lanceolata*, " The ripe seeds are mostly spoiled by worms, for in consequence of the imperfect dehiscence of the capsule they are retained an undue length of time." Seed predation by insects occurs in the wild in the related species *Kokia kauaiensis* (Ken Wood, National Tropical Botanical Garden, personal communication 1995). Though including no specific mention for the genus *Kokia*, Swezey (1954) noted two species of moths (Lepidoptera: Tortricidae) as seed predators of other native Hawaiian species of Malvaceae.

The current threats to *Kokia cookei* are:

Low Number of Individuals and Populations

The low number of individuals and populations of *Kokia cookei* is the result of catastrophic habitat conversion and a recent history of failed propagation efforts.

Lack of Naturally Rooted Plants

A fire in 1978 at the Cooke's Kauluwai residence killed the last naturally rooted *Kokia cookei* plant. All *Kokia cookei* are now plants grafted onto rootstocks of related species. This technique, though successful in allowing for the continuing survival of the species, may have resulted in plants of reduced vigor and longevity compared to naturally rooted plants derived from seeds.

Lack of Viable Seed Production

The primary threat to the continuing survival of this species is the lack of viable seed production, which may be due to genetic problems associated with severe inbreeding and loss of genetic variability (USFWS 1979). All living plants of *Kokia cookei* are clones and genetic copies of a single individual. The lack of viable seeds may also be related to poor vigor of grafted plants of the species. The plant used in cloning had produced viable seeds (Woolliams and Gerum 1992).

CONSERVATION EFFORTS

Federal actions

Kokia cookei was added to the Federal list of endangered and threatened species in 1979 (USFWS 1979). The plant was listed as endangered, and designation of critical habitat was not deemed prudent at the time of listing because the plant had been extirpated from its natural range and existed only as a single individual in cultivation.

State of Hawaii actions

The State of Hawaii listed *Kokia cookei* as endangered in 1979 after the Federal listing and pursuant to Chapter 195D of the Hawaii Revised Statues. Active efforts by the State to propagate this species are described below under the sections on Propagation History and Outplanting.

Nongovernmental actions

Considerable effort to propagate *Kokia cookei* has been carried out by several private individuals and nongovernmental organizations. These actions are described below under the sections on Propagation History and Outplanting.

Propagation History

Five types of propagation have been attempted with *Kokia cookei*: seeds; cuttings; grafting; tissue culture (a method of sprouting roots and shoots from meristematic tissue by placing the tissue on a medium and applying a growth hormone); and air layering (a method of inducing root sprouting on branches by making small cuts on the branch, applying a root hormone, and wrapping in a moist, dark medium).

Seeds

The single first generation tree that grew at the Cooke's Kauluwai residence from 1915 to the late 1950s produced hundreds of viable seeds and about 130 second-generation seedlings. These seedlings were outplanted but none survived when checked in the 1970s (Woolliams *et al.* 1980a). Whether the failure of these plantings was due to ill-suited growing conditions or to lack of seedling vigor due to severe inbreeding depression is unknown.

Kokia cookei last produced viable seeds in 1974-1975 (Woolliams and Gerum 1992). Living *Kokia cookei* were grafted from the last individual known to have produced viable seeds (Woolliams and Gerum 1992). Though none of the seedlings grown from the seeds of this clone have survived, its ability to potentially produce viable seeds is encouraging. Seeds produced since the early 1970s when examined at maturity have deformed embryos or lack them entirely (Woolliams and Gerum 1992, Greg Koob, formerly of Lyon Arboretum, University of Hawaii, personal communication 1995). As a result, embryo culture techniques appear to be the only promising methods for producing seedlings of *Kokia cookei*. Plants in the west Molokai exclosures continue to produce nonviable seeds (R. Hobdy, personal communication 1997).

Chronology of *Kokia cookei* propagation by seed

June 1915: J.F. Rock and G.P. Cooke visited the last wild tree just prior to its death and collected "a few seeds" from the ground (Rock 1919, Woolliams 1979, Woolliams *et al.* 1980a). The seeds were sent to Molokai, Honolulu, and the Bureau of Plant Industry in Washington, D.C. (Rock 1919). Three seedlings were planted on Molokai: one at Mapulehu near Pukoo ("grew for several years before it died"), one at James Munro's house at Kaunakakai ("lived but a short time"), and one at Cooke's Kauluwai residence (Woolliams *et al.* 1980a). A fourth seedling was grown "at least to 1919" in the Bureau of Plant Industry gardens at Buena Vista, Florida (Degener 1934). The seedlings taken to Honolulu died "on account of the excessive rains during the winter of 1915-1916" (Rock 1919).

1918: The last wild tree of *Kokia cookei*, at Mahana, Molokai, was discovered to be dead by J.F. Rock (Degener 1934).

1919: Of the original seedlings derived from the last wild tree, only two were still living, both in cultivation on Molokai; one at Pukoo and the other at the Cooke's Kauluwai residence (Rock 1919).

1931: A *Kokia cookei* was reported alive at a residence at Hillside Avenue in Honolulu. The plant has not been reported since (Woolliams and Gerum 1992).

1933: The last surviving individual of the species at the Cooke's Kauluwai residence was reported to be a "healthy tree bearing a full crop of seeds each year". From these seeds ("sprouted between wet bags"), about 30 other trees were grown "out on the hill near by and are doing well and flowering" (Degener 1934, Woolliams *et al.* 1980a).

1934: Degener (1934) stated that the annual seed crop of *Kokia cookei* from the planted trees at Cooke's Kauluwai residence on Molokai was given by Cooke to Territorial Forester Charles S. Judd. From these seeds, about 50 *Kokia cookei* plants were outplanted at 610 meters (2,000 feet) elevation in the Waianae Mountains, Oahu, and 50 plants were outplanted at 305 meters (1,000 feet) elevation on Waahila Ridge in the Koolau Mountains, Oahu.

1954: Joseph Rock described the *Kokia cookei* tree at Cooke's Kauluwai residence as "very healthy" (Woolliams *et al.* 1980a).

Late 1950s: The lone cultivated plant of *Kokia cookei* at Cooke's Molokai residence died and the species was presumed extinct (Woolliams 1979).

1957: In a letter to George P. Cooke, J.F. Rock thanked him for seeds of *Kokia cookei* and noted plants of the species cultivated at the Board of Agriculture Nursery, Oahu; in the Manuka District near Kau; and at present day Hawaii Volcanoes National Park on the island of Hawaii (Woolliams and Gerum 1992).

1970: A single plant of *Kokia cookei,* apparently one of the cultivated plants at Kauluwai, Molokai, (or from a seed of one of these plants) was discovered alive at the Cooke residence at Kauluwai.

December 1970: Records at the Honolulu Botanical Garden indicate two living trees at the Cooke residence on Molokai (Woolliams and Gerum 1992).

1972-1973: Derral Herbst and Keith Woolliams collected seeds from the tree at the Cooke residence. After many attempts, eight seedlings were produced and planted at the Pacific Tropical Botanical Garden (now called the National Tropical

Botanical Garden, NTBG) at Lawai, Kauai (Woolliams 1979, Woolliams and Gerum 1992).

1974: Seeds were taken from the tree at Cooke's Molokai residence to Waimea Arboretum and Botanical Garden by Erling Hedemann of Waimea Arboretum and Botanical Garden and Noah Pekelo of the Maui District, Division of Forestry and Wildlife. Examination of the seeds revealed that the embryos were deformed or absent (Woolliams and Gerum 1992).

1975: By this time, all eight seedlings at the National Tropical Botanical Garden, Lawai, Kauai, had died (Woolliams and Gerum 1992).

February 1975: Seeds were gathered from the tree at Cooke's Molokai residence by Erling Hedemann and Keith Woolliams of Waimea Arboretum and Botanical Garden. The seeds failed to germinate (Woolliams and Gerum 1992).

September and October 1975: Molokai resident Joan Aidem hand-pollinated flowers of the single tree at the Cooke residence at Kauluwai. The resulting seeds were sent to Waimea Arboretum and Botanical Garden. Despite gibberellic acid treatment, the seeds failed to germinate (Woolliams and Gerum 1992).

December 1975: A check of botanical institutions worldwide revealed no living cultivated plants of *Kokia cookei* (Woolliams and Gerum 1992).

1978: A fire at Cooke's Kauluwai residence on Molokai killed the single remaining parent tree of *Kokia cookei* (Woolliams 1979).

1972-1979: Plantings of *Kokia cookei* reported by Rock in a 1957 letter to G.P. Cooke were field-checked. No plants remained alive at any of the three sites: Board of Agriculture Nursery on Oahu; Manuka District near Kau; or Hawaii Volcanoes National Park, island of Hawaii.

1980: A 0.3-meter- (1-foot-) tall seedling of *Kokia cookei* was reported growing at Kew Gardens in the United Kingdom from a seed gathered in 1974-1975, apparently from the cultivated tree at the Cooke residence on Molokai. The

seedling died "within a year or two" (Woolliams *et al.* 1980a; Woolliams 1982; Woolliams and Gerum 1992).

1993-1995: Seed harvested from outplanted *Kokia cookei* from the Division of Forestry and Wildlife's Molokai enclosures (see Outplanting on page 23) and planted at Kahului, Maui did not germinate (R. Nakagawa, personal communication 1995).

1993 to the present: Embryo culture was attempted by G. Koob at the University of Hawaii, Harold Lyon Arboretum, Honolulu in 1993, 1994 and 1995. Immature seeds are provided by Waimea Arboretum and Botanical Garden on Oahu. In embryo culture, the immature embryo is removed and matured in sterile growth medium (G. Koob, personal communication 1995). In 1993, two seedlings were produced from seven embryos; both subsequently died, possibly due to poor growing conditions. In 1994, all 12 immature embryos died. In the 1995 trials, 5 of 20 immature embryos initially grew but subsequently died. In 1996, all 12 immature embryos died (G. Koob, personal communication 1997). Koob (personal communication 1997) feels this technique could yield success in a single good year, but noted that the apparent quality of the embryonic material has declined each subsequent year.

Cuttings

Attempts at propagating *Kokia cookei* from cuttings have not been successful, although these attempts are ongoing at Waimea Arboretum and Botanical Garden (Keith Woolliams, personal communication 1997).

Chronology of propagation of *Kokia cookei* by cuttings

1974: Cuttings were taken from the tree at the Cooke Kauluwai residence on Molokai to Waimea Arboretum and Botanical Garden, Oahu, by E. Hedemann of Waimea Arboretum and Botanical Garden and N. Pekelo of the Maui District, Division of Forestry and Wildlife. These cuttings failed to root (Woolliams and Gerum 1992).

February 1975: Cuttings were taken from the tree at the Cooke residence on Molokai to Waimea Arboretum and Botanical Garden by E. Hedemann and K.

Woolliams of Waimea Arboretum and Botanical Garden. The cuttings failed to root (Woolliams and Gerum 1992).

November 1978: Cuttings were taken from a grafted plant at Waimea Arboretum and Botanical Garden. All failed to root (Woolliams and Gerum 1992).

October 1996: Cuttings were taken from a grafted plant at Waimea Arboretum and Botanical Garden. All failed to root (K. Woolliams, personal communication 1997).

Grafting

Grafting has been carried out at Waimea Arboretum and Botanical Garden on Oahu and at the Maui District, Division of Forestry and Wildlife baseyard at Kahului, Maui. At the Kahului baseyard, *Kokia cookei* branches are usually grafted onto rootstocks of the more available *Kokia drynarioides*, which is native to the dryland forests of the island of Hawaii. Grafted plants of *Kokia cookei* grow well and can become full-canopied small trees. However, when fertilized and irrigated in cultivation, *Kokia drynarioides* is a rapidly growing but relatively short-lived tree (K. Woolliams, personal communication 1995). *Kokia kauaiensis*, though of more limited availability than *Kokia drynarioides*, makes a better grafting rootstock as it is longer-lived (Woolliams and Gerum 1992, K. Woolliams and R. Nakagawa, personal communications 1995). The Division of Forestry and Wildlife's Kahului baseyard is planning to switch grafting rootstocks to *Kokia kauaiensis* in future efforts (R. Nakagawa, personal communication 1998). Grafting is an important technique in providing for the immediate survival of the species. Currently, grafting attempts continue at Waimea Arboretum and Botanical Garden, although with limited success. A lack of rootstock material from *Kokia kauaiensis* has recently slowed these activities (K. Woolliams, personal communication 1997).

Chronology of propagation of *Kokia cookei* by grafting

December 1975: Three side-grafts of *Kokia cookei* from Molokai were made onto *Kokia kauaiensis* rootstock at Waimea Arboretum and Botanical Garden, Oahu. All quickly failed (Woolliams and Gerum 1992).

September 1976: A single branch of *Kokia cookei* from Molokai was successfully side-grafted onto a rootstock of *Kokia kauaiensis* at Waimea Arboretum and Botanical Garden (Woolliams and Gerum 1992).

November 1976: The single graft at Waimea Arboretum and Botanical Garden was reported to be growing well. Using the same techniques as used in the successful September graft, several grafts were attempted on both *Kokia drynarioides* and *Kokia kauaiensis* rootstock. All of these attempts failed (Woolliams and Gerum 1992).

1978: The single grafted plant at Waimea Arboretum and Botanical Garden was reported to be growing vigorously (Woolliams and Gerum 1992).

June 7, 1979: The single grafted plant at Waimea Arboretum and Botanical Garden flowered for the first time (Woolliams 1979, Woolliams and Gerum 1992).

March 1981: Maui District Forester Wesley Wong and Division of Forestry and Wildlife staff develop a conservation plan for *Kokia cookei*. In three small (930 square meters; 10,000 square feet) fenced exclosures on Molokai, *Kokia drynarioides* would first be planted to determine the feasibility of the site for *Kokia* species. If the site proved feasible, the grafted *Kokia cookei* would be planted at these sites. Currently the Division of Forestry and Wildlife oversees 2 small (930 square meters; 10,000 square feet) exclosures on west Molokai that support 20 plants. These plants are growing slowly and a few have produced nonviable seeds (R. Hobdy, personal communication 1997). Propagation activities at the Kahului baseyard are down to three plants (R. Hobdy, personal communication 1997).

1982: Six grafted *Kokia cookei* were growing at Waimea Arboretum and Botanical Garden, one on *Kokia kauaiensis* rootstock and five on *Kokia drynarioides* rootstocks (Woolliams 1981, Woolliams *et al.* 1980b, Woolliams 1982).

1986: Erling Hedemann plants a grafted *Kokia cookei* on a *Kokia kauaiensis* rootstock at his home on Hawaii (Erling Hedemann, personal communication 1998).

November 1987: Staff from the Waimea Arboretum and Botanical Garden flew to Maui and grafted several *Kokia cookei* branch tips onto potted *Kokia drynarioides* at the Division of Forestry and Wildlife baseyard; all grafts failed. Grafts with older, non-tip branch pieces were successful (Garnett 1991, Woolliam and Gerum 1992). Older, non-tip grafts have proven unsuccessful at Waimea Arboretum and Botanical Garden (Woolliams and Gerum 1992).

Tissue Culture

Tissue culture has been attempted by the Institute of Breeding Research in Tokyo, by the Micropropagation Division of Kew Gardens in the United Kingdom, and by Ted Green of Kaaawa, Oahu. Though abundant callus tissue was produced, no cell differentiation took place. Eventually, all samples became contaminated and died (Woolliams 1983, Woolliams and Gerum 1992). No efforts at tissue culture are currently being conducted.

Chronology of propagation of *Kokia cookei* by tissue culture

December 1975: First attempt at tissue culture. Tip branches of a Molokai plant were sent to the Institute for Breeding Research in Tokyo. Though abundant callus tissue was produced, no cell differentiation occurred. Eventually, all samples became contaminated and died (Woolliams and Gerum 1992).

April 1978: Leaves from a grafted plant at Waimea Arboretum and Botanical Garden on Oahu were hand-carried to the Institute for Breeding Research in Tokyo. Though callus tissue was produced, all samples eventually became contaminated and died (Woolliams and Gerum 1992).

October 1979: Keith Woolliams of Waimea Arboretum and Botanical Garden sent branches of a grafted *Kokia cookei* to the Micropropagation Division at Kew Gardens, United Kingdom, and to Ted Green of Kaaawa, Oahu, for tissue culture work (Woolliams and Gerum 1992). Though abundant callus tissue was

produced, no cell differentiation took place. Eventually, all samples became contaminated and died (Woolliams 1983, Woolliams and Gerum 1992).

February 1980: K. Woolliams of Waimea Arboretum and Botanical Garden sent branches of a grafted *Kokia cookei* to Ted Green of Kaaawa, Oahu. Though abundant callus tissue was produced, no cell differentiation took place. Eventually, all samples became contaminated and died (Woolliams 1983, Woolliams and Gerum 1992).

January 1997: K. Woolliams of Waimea Arboretum and Botanical Garden finds that a commercially available root growth stimulant also aids in callous formation in grafted *Kokia cookei* (K. Woolliams, personal communication 1997).

Air Layering

Both *Kokia drynarioides* and *Kokia kauaiensis* can be successfully propagated by air layering. Though attempts to air layer *Kokia cookei* have thus far been unsuccessful, both Waimea Arboretum and Botanical Garden and Maui Division of Forestry and Wildlife are interested in continuing with this technique. Currently, experimentation with air layering of *Kokia cookei* is being carried out at Waimea Arboretum and Botanical Garden on Oahu (K. Woolliams, personal communication 1997), and has been attempted by the Division of Forestry and Wildlife's Kahului baseyard on Maui, but with negative results (R. Nakagawa, personal communication 1998).

Chronology of propagation of *Kokia cookei* by air layering

September and October 1975: Molokai resident Thomas Cooke placed air layers on the tree at Kauluwai (Woolliams and Gerum 1992).

1976: The air layers on the plant at the Cooke residence were removed and planted by T. Cooke but no roots formed (Woolliams and Gerum 1992).

November 1978: Air layers were made on a grafted plant at Waimea Arboretum and Botanical Garden. All failed (Woolliams and Gerum 1992).

February 1979: The last of the potted air-layered plants at Kauluwai, Molokai, died (Woolliams and Gerum 1992).

February 1997: An air layering was attempted at the Waimea Arboretum and Botanical Garden but was not successful. It was noted that the cut stems of *Kokia cookei* had spots of purple color that were apparently associated with the plant's vascular system. These spots do not occur on cut stems of the other two species of *Kokia* and may be related to the failure of these stems to take root (K. Woolliams, personal communication 1997).

Outplanting

An important part of the strategy for conservation of *Kokia cookei* has been the outplantings on west Molokai as an interagency effort of Maui District of the Division of Forestry and Wildlife, Molokai Ranch, Waimea Arboretum and Botanical Garden, and The Nature Conservancy of Hawaii. Currently, there are two outplantings at two locations, both of which are managed by the Division of Forestry and Wildlife. Both are located on privately owned Molokai Ranch lands, at Puu Nana, about 365 meters (1,200 feet) elevation. Puu Nana is within 2 kilometers (1.2 miles) of Mahana, where the original wild plants of *Kokia cookei* were discovered and last seen over 60 years ago. Currently, these outplantings contain over 65 percent (15 of 23 plants) of the total number of individuals of the species (Table 1).

On May 25, 1991, former Hawaii Governor John Waihee participated in the first outplanting of eight *Kokia cookei* plants (grafted onto *Kokia drynarioides* rootstock) into two small (930 square meters; 10,000 square feet) exclosures constructed by the Division of Forestry and Wildlife staff on Molokai Ranch lands (Garnett 1991, Woolliam and Gerum 1992). On March 16, 1992, 22 additional plants of *Kokia cookei* were outplanted in these same Molokai exclosures by Maui Division of Forestry and Wildlife, bringing the total to 30 outplanted grafted plants. Fifteen of these have survived as of early 1998 (R. Manaba, Maui Division of Forestry and Wildlife, personal communication 1998). After the Division of Forestry and Wildlife personnel established a drip irrigation system and reduced fertilization, the plants have appeared healthier. Many plants

flowered in 1995 and 1996 and occasionally set seeds (R. Hobdy, personal communication 1997). Three seed pods were produced in 1995 and 1996, but bore only nonviable seeds (R. Hobdy, personal communication 1997). Nonnative grasses are removed from around the *Kokia cookei* plantings in the Division of Forestry and Wildlife exclosure.

The third small (a few hundred square feet) outplanting site (sponsored by Molokai Ranch and The Nature Conservancy of Hawaii) originally had twelve *Kokia cookei* planted, but by early 1998 all of the plants had died (R. Manaba, personal communication 1998). Two plants flowered for the first time in the summer of 1995 but no seed pods were set (Sam Ford, Volunteer caretaker of Molokai Ranch/TNCH outplanting, personal communication 1995).

RECOVERY STRATEGY

Despite heroic efforts to save this species, *Kokia cookei* is not currently safe from the threat of extinction. The most immediate threat to the survival of *Kokia cookei* is the low number of individuals (23) in only 5 locations. Coupled with this is a lack of production of viable seed and the tendency towards short and unpredictable life spans of grafted plants. These factors increase the vulnerability of the species to extinction due to random naturally occurring events.

Generally speaking, directed propagation efforts should apply available technology toward efforts to propagate *Kokia cookei* using both sexual and asexual methods. Currently, an asexual method (grafting) serves the important, immediate goal of increasing the number of grafted plants. A continued effort in asexual reproduction is an essential interim objective to increase the number of individual plants and decrease the chances of extinction. Ultimately, the goal best suited to the natural recovery and removal of legal protection for the species is the production of viable seeds unassisted by man.

Three essential goals must be met to reduce the chances of random naturally occurring events causing the extinction of *Kokia cookei*:

Increase the number of individuals and natural populations

In addition to insulating *Kokia cookei* from extinction due to random naturally occurring events, an increase in the number of cloned plants will also provide material for directed research. Arrangements should be made to have cloned individuals of *Kokia cookei* planted in the State of Hawaii and elsewhere near centers of applied plant research.

Produce *Kokia cookei* plants that produce viable seeds

One of the most important goals of the recovery strategy for *Kokia cookei* is the production of viable seeds. Currently, the two most likely scenarios for the production of plants of *Kokia cookei* that produce viable seeds are embryo culture and an artificially controlled introgressive hybridization breeding program.

Embryo culture is a micropropagation technique that involves the extraction and culture of immature seed embryos (G. Koob, personal communication 1995). An artificially controlled introgressive hybridization breeding program would involve an initial hybridization of *Kokia cookei* with another *Kokia* species. The hybrid seedling would be grown until it flowered, then backcrossed with *Kokia cookei.* Repetition of this process, always backcrossing with *Kokia cookei*, could potentially result in a plant genetically and morphologically nearly identical to *Kokia cookei* but more vigorous and capable of reproduction by seed (Cliff Morden, Department of Botany, University of Hawaii at Manoa, and Charles Lamoureux, Lyon Arboretum, personal communications 1996).

Reestablish in native habitat that can sustain natural reproduction of the species

Another step for the recovery of *Kokia cookei* is the establishment of additional populations through outplanting. Outplanting will involve the construction of large exclosures, possible replanting of associated native dryland species, and management of threats (domestic and feral ungulates, selected nonnative plant species, and wildland fires). To ultimately recover the listed plant taxa in Hawaii, habitat must be protected and managed for natural expansion of the current populations, as well as reintroduction of these taxa into portions of former range. Habitats deemed essential for the recovery of listed species in Hawaii will be published by the U.S. Fish and Wildlife Service in the Recovery Plan for Multi-Island Plants. Maps showing these habitat areas may be used by land owners and

managers to identify priority areas for management and restoration and for wide-range planning purposes.

II. RECOVERY

RECOVERY OBJECTIVES

The objectives of this plan are to increase the numbers of *Kokia cookei* in stable, reproductively viable populations to the point that the species can be downlisted and eventually delisted. Priorities for actions and recommended time-frames are contained in the Implementation Schedule of this plan.

An endangered species is defined in section 3 of the Endangered Species Act as any species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

For the purposes of this plan, a population is defined as a discrete unit with sufficient distance between neighboring populations that the two are not affected by the same small-scale events (such as a landslide). Mature individuals are defined as those either known or believed to be capable of reproduction.

The strategy proposed for the continued survival and potential recovery of *Kokia cookei* involves three primary objectives: (1) reduction of risk of extinction due to random naturally occurring events; (2) production of reproductively viable plants through directed propagation and research efforts; and (3) the establishment of 8 outplantings and 5 arboretum collections of 75-100 reproductively viable individuals. Eight field populations on three islands (Molokai, Maui, and Lanai) were selected as the recovery goals because this plant has always been rare and an adequate number of individuals can be maintained in these field populations with additional support from five arboretum collections.

The first objective of the recovery of *Kokia cookei* should be to minimize the chances of its extinction due to random naturally occurring events by increasing and maintaining the number of cloned individuals to at least 1,000, distributed equally (80-100 individuals) in 8 field populations and in 5 cultivation collections.

This increase in plant numbers will also increase the availability of *Kokia cookei* material to scientific institutions for research on the genetics and reproductive biology of the species and for the development of specialized propagation methodology.

The long-term goal of propagation and research should be to produce plants that bear viable seed without assistance. Until viable seed production is achieved, survival of the species will continue to be tenuous. Naturally rooted plants of *Kokia cookei* originated from seeds are likely to be more vigorous and perhaps longer-lived than grafted plants. If even a single seedling of *Kokia cookei* could be raised to reproductive age, the impact on the long-term survivability of the species could be significant. Flowers of this plant could be crossed with clones of the existing grafted plants. Once a number of naturally rooted plants can be produced, a breeding program involving outcrossing among seedlings and the parent clone will maximize the diversity of the existing genetic material of the species.

Recovery of *Kokia cookei* is contingent upon growing plants that produce viable seeds. Without natural seed production, outplantings can serve only as reservoirs of grafted, cloned plants. If seeds can be artificially produced through embryo culture or introgressive hybridization, outplanting into favorable habitat could produce natural regeneration of *Kokia cookei*, which could allow for the recovery of the species to levels that will allow downlisting or delisting.

Downlisting to threatened could occur when the following criteria are met:

1) five field populations (3 on Molokai, 1 on Lanai, 1 on Maui), each with 80-100 mature individuals are secure, and managed in perpetuity;

2) natural regeneration from viable seeds is occurring at all of the five outplanting sites for at least 3 consecutive years;

3) five consecutive years of monitoring shows that the populations have a stable age structure; and

4) all threats to these field populations are mitigated or eliminated.

Delisting could occur when the downlisting criteria are met plus the following additional criteria:

1) three additional field populations (1 on Molokai, 1 on Lanai, 1 on Maui), each with 80-100 mature individuals are secure, and managed in perpetuity;

2) natural regeneration from viable seeds is occurring at all eight outplanting sites for at least 5 consecutive years;

3) five consecutive years of monitoring shows that the populations have a stable age structure; and

4) all threats to these populations are reduced to the point that *Kokia cookei* can successfully reproduce without assistance from humans with a 10-year average of 80-100 reproductive plants in each of the populations.

STEPDOWN OUTLINE

1. Increase number of grafted plants to at least 100 individuals.

2. Continue research and development of cloning propagation methods such as grafting, air layering, and tissue culture.

    21. Conduct directed research with grafting techniques and materials.

    22. Conduct directed research with air layering techniques.

    23. Conduct directed research with tissue culture.

3. Continue research and propagation efforts on plants that produce viable seeds.

    31. Continue directed research on embryo culture methodology.

    32. Establish a program of artificially controlled introgressive hybridization of *Kokia cookei* with another *Kokia* species.

4. Establish and maintain 8 field populations, each with at least 80-100 mature plants, on the islands of Molokai (4 populations), Lanai (2 populations), and Maui (2 populations).

    41. Establish and maintain four outplanted wildland populations within large exclosures on Molokai.

        411. Produce and select plants for reintroduction efforts.

        412. Identify four specific areas on Molokai for reintroduction.

        413. Secure sites identified in Task 412.

        414. Restore and manage sites.

            4141. Fence reintroduction sites and exclude ungulates.

            4142. Establish vegetation and threat monitoring.

            4143. Manage sites to ensure protection via actions prescribed by fire management plan.

4144. Plant other native dryland species in the fenced reintroduction sites.

415. Plant *Kokia cookei* plants in fenced reintroduction sites.

416. Provide post-planting care for *Kokia cookei.*

42. Establish and maintain two outplanted wildland populations on Lanai.

421. Produce and select plants for reintroduction efforts.

422. Identify two specific areas on Lanai for reintroduction.

423. Secure sites identified in Task 422.

424. Restore and manage sites.

4241. Fence reintroduction sites and exclude ungulates.

4242. Establish vegetation and threat monitoring.

4243. Manage sites to ensure protection via actions prescribed by fire management plan.

4244. Plant other native dryland species in the fenced reintroduction sites.

425. Plant *Kokia cookei* plants in fenced reintroduction sites.

426. Provide post-planting care for *Kokia cookei.*

43. Establish and maintain two outplanted wildland populations on Maui.

431. Produce and select plants for reintroduction efforts.

432. Identify two specific areas on Maui for reintroduction.

433. Secure sites identified in Task 432.

434. Restore and manage sites.

4341. Fence reintroduction sites and exclude ungulates.

4342. Establish vegetation and threat monitoring.

4343. Manage sites to ensure protection via actions prescribed by fire management plan.

4344. Plant other native dryland species in the fenced reintroduction sites.

435. Plant *Kokia cookei* plants in fenced reintroduction sites.

436. Provide post-planting care for *Kokia cookei.*

5. Validate recovery criteria.

51. Validate the number of individuals and populations necessary for recovery of *Kokia cookei.*

52. Refine and revise downlisting and delisting criteria, as necessary.

53. Evaluate species for downlisting and delisting.

NARRATIVE

1. Increase number of grafted plants to at least 100 individuals.

The objective is to increase the number of stock plants by cloning techniques. An increased number of individuals of *Kokia cookei* will both reduce the potential of extinction due to random naturally occurring events as well as increase the availability of material of *Kokia cookei* for directed research.

Maintain a minimum of 100 individuals distributed evenly among at least 5 collections. Some of the collections should be established at centers of directed plant research, such as Lyon Arboretum, Waimea Arboretum and Botanical Garden, and the National Tropical Botanical Garden. These collections will be maintained in perpetuity to provide cultivated material for research on the genetics, reproductive biology, and propagation of *Kokia cookei* as sources for outplantings.

2. Continue research and development of cloning propagation methods such as grafting, air layering, and tissue culture.

Until plants of *Kokia cookei* can bear viable seed without assistance, it is important to continue development of cloning techniques. The objective of this task is to produce long-lived cloned plants to both facilitate directed research and ensure the immediate survival of the species.

21. Conduct directed research with grafting techniques and materials.

Conduct experimental trials in grafting *Kokia cookei* onto rootstocks of both *Kokia drynarioides* and *Kokia kauaiensis*. Use identical techniques and plant materials of equivalent size and vigor to facilitate comparisons. Conduct as many trials as possible with available material. Compare grafted plants of the two rootstock species in terms of the percent of successful grafts, growth rate (total height, basal diameter, and number of ramettes), reproductive potential (time to first flowering, number of flowers per year, and number of fruits per year), and other pertinent vigor notes (such as phenology, resistance to pests).

Explore the potential of grafting onto a rootstock of another genus in the family Malvaceae.

22. Conduct directed research with air layering techniques.

Previous air layering efforts have been unsuccessful. As the number of stock plants increases and new techniques are developed, efforts at air layering should be continued.

23. Conduct directed research with tissue culture.

Previous efforts with tissue culture have been unsuccessful. Additional tissue culture work should be pursued as new methods are developed.

3. Continue research and propagation efforts on plants that produce viable seeds.

Failure of *Kokia cookei* to produce viable seed may be the greatest threat to the long term survival of the species. The methods used to propagate plants with viable seeds should be supplemented as more information and better techniques become available in the future.

31. Continue directed research on embryo culture methodology.

This technique is a type of micropropagation where the immature embryo is extracted from the seed and raised in a sterile culture medium. This technique was initiated by Dr. Gregory Koob, formerly of the University of Hawaii Lyon Arboretum, using material furnished by Waimea Arboretum and Botanical Garden. There is a the possibility that a *Kokia cookei* plant produced by embryo culture will have increased vigor due to its natural root system and could set viable seed without human intervention. This effort will require that seedlings produced by embryo culture be grown to maturity and then checked for production of viable seeds.

32. Establish a program of artificially controlled introgressive hybridization of *Kokia cookei* with another *Kokia* species.

Due to the historically low numbers of wild individuals and the long-standing loss of pollination agents, *Kokia cookei* may be suffering from severe inbreeding depression. If inbreeding depression is the problem, the species may never produce viable seeds. Or if seeds are viable and capable of germination, plants may lack vigor due to loss of genetic diversity. If loss of diversity is the problem, *Kokia cookei* would be a likely candidate for an artificially controlled introgressive hybridization breeding program (C. Morden and C. Lamoureux, personal communications 1996).

This technique potentially provides for the survival of the original genotype as well as potentially increasing vigor through increased genetic diversity (C. Morden and C. Lamoureux, personal communication 1996). In this case, *Kokia cookei* would be hybridized with another closely related *Kokia* species. A survey should assess the level of genetic diversity of all populations of each of the three surviving species of the genus. The survey should identify which *Kokia* species, either *Kokia drynarioides* or *Kokia kauaiensis*, is genetically most similar to *Kokia cookei* and should be used in the artificially controlled introgressive hybridization breeding program.

Hybrid crosses could be made with *Kokia cookei* as both the pollen donor and the pollen recipient. The hybrid seeds would be raised to reproductive age and back-crossed with the pollen of *Kokia cookei*. The resultant second generation seeds would be grown to flower and the process repeated for successive generations, always backcrossing with pollen of *Kokia cookei*. Backcrossed progeny would progressively become more genetically similar to *Kokia cookei*. If the initial hybridization and four subsequent generations can be backcrossed with *Kokia cookei*, then the progeny would have a 96% rate of recovery of the genotype of *Kokia cookei* (C. Morden and C. Lamoureux, personal communications 1996). Besides having most of the genes of *Kokia cookei*, these backcrossed progeny would have increased genetic heterogeneity

and would, theoretically, be much more vigorous than existing individuals of *Kokia cookei* (C. Morden and C. Lamoureux, personal communications 1996).

In a Hawaiian plant group, naturally occurring intergeneric hybrids of *Argyroxiphium sandwicense* x *Dubautia menziesii* were backcrossed with *Dubautia menziesii* for three generations. The resulting plants were virtually indistinguishable from pure strains of *Dubautia menziesii* and chromosome problems in the hybrid had normalized (Carr 1995, Gerald Carr, Botany Department, University of Hawaii at Manoa, personal communication 1996).

Given a 4- to 6-year period from germination to first flower (which may be optimistic), a breeding program with *Kokia cookei* through five generations (one hybridization and four backcrosses) would require 20-30 years. Despite some limitations, the genus *Kokia* is well suited to a breeding program, as it is relatively easy to grow in cultivation. The artificially controlled introgressive hybridization strategy could occur concurrently with other efforts, such as embryo culture work.

Ecologically and morphologically, *Kokia drynarioides* is most similar to *Kokia cookei* and perhaps the most likely candidate for an introgressive hybridization breeding program (Wagner *et al.* 1990). Both species are small trees of seasonally arid dryland forest. *Kokia kauaiensis* is a larger tree of more mesic forests (Wagner *et al.* 1990). A genetic survey of the three surviving species of the genus could indicate which species is most genetically similar to *Kokia cookei*.

4. Establish and maintain 8 field populations, each with at least 80-100 mature plants, on the islands of Molokai (4 populations), Lanai (2 populations), and Maui (2 populations).

Establish and maintain 8 field populations, each with at least 80-100 mature plants. Four populations should be on Molokai, two populations on Lanai, and two on Maui. Currently there are 2 small field outplantings containing a total of 15 plants (see Table 1). None of these outplantings meet the size criteria or plant densities recommended in this recovery plan (see Task 414 below).

41. Establish and maintain four outplanted wildland populations within large exclosures on Molokai.

Once *Kokia cookei* are produced that bear viable seeds, efforts should begin to reestablish plants in the wild. Reestablishing plants in the wild should reduce the likelihood of extinction of the species and provide a setting where natural regeneration can occur. Each site should ultimately contain at least 80-100 mature plants of *Kokia cookei*. Plantings should begin with 50 plants and should be continued as long as needed to reach and maintain the minimum population size at each location.

411. Produce and select plants for reintroduction efforts.

When there are sufficient numbers of plants of *Kokia cookei* that bear viable seeds [see task 3], these plants should be used to establish Molokai field populations. An area of suitable habitat will be required that is large enough to sustain planted individuals and allow for reproduction of *Kokia cookei*. The current small field outplantings (see table 1) are not adequate for this purpose due to their small size and close proximity to one another.

412. Identify four specific areas on Molokai for reintroduction.

The size of the fenced outplanting sites should be 250-300 meters square (820-984 feet square), which is approximately 62,500-90,000 square meters (672,400-968,300 square feet). Populations should be separated by at least 1 kilometer (0.6 mile) to reduce the likelihood of extirpation by wildland fire.

Three of the four populations should be located in dry leeward sites with 38-76 centimeters (15-30 inches) of annual rainfall. The fourth population should be in a moister area with 76-127 centimeters (30-50 inches) of annual rainfall. Land ownership and access should be considered in site selection, and the land parcel should be perpetually dedicated to the conservation of this species.

Sites should be selected in as intact and diverse a native dryland ecosystem as is available and practical. The only known habitat of *Kokia cookei* was in leeward forests at approximate 200 meters (660 feet) elevation. Native vegetation similar to that described for the only known habitat suggests sites of remnant native dryland forest on Molokai, Lanai, and Maui at approximately 300-600 meters (1,000-2,000 feet) elevation. See the Habitat Description section for a presentation of the native plant community associated with the only known habitat of *Kokia cookei.*

Where possible, selected sites should fall within areas that have been identified in other Hawaiian plant recovery plans. This will add the benefits of habitat protection identified in these plans to the recovery of *Kokia cookei.* Many federally protected dryland plant taxa occur on Lanai, Maui, and Molokai. All of these taxa should be considered for outplanting along with *Kokia cookei.* Final listing rules give the general locations of these plant taxa. Recovery plans have also been prepared for some of these taxa: Recovery Plan for *Gouania hillebrandii* (USFWS 1990), Recovery Plan for the Hawaiian Gardenia (USFWS 1993), Recovery Plan for *Caesalpinia kavaiensis*, and *Kokia drynarioides* (USFWS 1994), Lanai Plant Cluster Recovery Plan (USFWS 1995), Recovery Plan for the Molokai Plant Cluster (USFWS 1996a), Draft Recovery Plan for the Multi-Island Plant Cluster (USFWS 1996b); and the Recovery Plan for the Maui Plant Cluster (USFWS 1997). These plans may aid in selecting sites that would be appropriate for several listed dryland plants.

Fire history and potential for wildfire should be considered an important factor in site selection. Sites with vegetation dominated by fire-prone weed species, such as *Eucalyptus*, should not be selected, or if selected, the fire-prone vegetation should be removed. Sites should have at least some well-developed soils present and not primarily hard pan substrates.

413. Secure sites identified in Task 412.

Once the reintroduction site has been selected, it will be necessary to

secure the site through designation by the Hawaii Department of Land and Natural Resources or through negotiations with the landowners, and through development of long-term conservation and management agreements.

414. Restore and manage sites.

Nearly all leeward sites in the Hawaiian Islands that are suitable for planting of *Kokia cookei* will require at least some restoration. Generally, restoration will involve protection from ungulates by fencing, and control of disruptive alien weeds manually or chemically. Monitoring schemes for individual plants, general vegetation, and potential threats (such as rodents and invertebrates) will be important for guiding management. Active management of the outplantings will be mandatory to assure long-term protection of *Kokia cookei* populations from herbivores, seed predators, alien plant competitors, and diseases or pathogens.

4141. Fence reintroduction sites and exclude ungulates.

Assume fencing standards to exclude domestic cattle, feral pigs, and axis deer. Exclosure fencing should use heavy duty (Class III), woven (hog) wire fencing. The fence should be constructed in a manner that will provide 10-20 years of protection with minimum maintenance. The exclosure fencing should be strong enough to exclude cattle and high (2.5 meters; 8.2 feet) enough to exclude axis deer. The fencing should be attached low enough to the ground with wire aprons and reinforcement pins to exclude feral pigs. Upon completion of fence construction, the area should be cleared of all ungulates from within the exclosure.

4142. Establish vegetation and threat monitoring.

Baseline vegetation monitoring should be established using fixed and relocatable stations. Monitoring should be done by a trained botanist familiar with the local flora and should include baseline techniques such as point-intercept, frequency, and cover estimates in permanent plots and

count plots for selected species. Vegetation monitoring should focus on changes of frequency and cover of selected weed species known to modify native ecosystems, such as *Eucalyptus* species, *Melinis minutiflora*, *Pennisetum clandestinum*, *Pennisetum setaceum*, *Panicum maximum*, *Schinus terebinthifolius*.

Monitoring should be established for status and threats of individual *Kokia cookei* plants and long-term records should be maintained on the exact location, genetic origin, size (height, basal diameter, number of ramettes), and vigor of individual plants. Monitoring should also be established for damage by ungulates, rodents, birds, arthropods, or disease. Records should be maintained on all types, extent, and causes of damage that is detected, including the type of organism and developmental stage (larva, juvenile, or adult). Collected arthropods should be identified by a specialist and recommended controls should be pursued. In addition, monitoring should document the role of native and nonnative insects and birds in pollination. The duration of the monitoring period is discussed in Task 419.

Chemical treatment of *Kokia cookei* plants and their outplanting sites may be required to prevent inadvertent introduction of damaging nonnative invertebrates or pathogens.

4143. Manage sites to ensure protection via actions prescribed by fire management plan.

Cut back or control with herbicides surrounding vegetation with highly flammable foliage, such as *Eucalyptus* species.

4144. Plant other native dryland species in the fenced reintroduction sites.

The intent of this task is to help restore the native dryland community of the original habitat of *Kokia cookei* by planting seed and individuals of native dryland plant species. Such a native community

will provide suitable microhabitat for the establishment of many dryland forest tree species. Native vegetation will provide habitat for native arthropod species. Stands of native vegetation will also provide physical protection for planted *Kokia cookei* from sustaining storm wind damage. Native leeward species such as *Dodonaea viscosa*, *Osteomeles anthyllidifolia*, *Coprosma* spp., and *Mariscus* spp. are quick growing in suitable conditions (after winter rains, without dense thickets of alien species) and will germinate readily from distributed seeds.

415. Plant *Kokia cookei* plants in fenced reintroduction sites.

Kokia cookei plants should be carefully planted in holes that are backfilled with soil from the site. Without inducing root disturbance, potting soil should be mostly removed prior to planting. Experimentally, a slow release, organic, commercially available fertilizer product could be mixed with root zone soil in some planting holes. After planting, each plant should be watered thoroughly. At the discretion of the field manager, staking should be done if deemed necessary.

416. Provide post-planting care for *Kokia cookei*.

For the first 6 months after planting, each transplanted plant should be visited monthly. Thereafter, site visits should be every 3 months for the following 1.5 years. Subsequent monitoring should be done at least bi-annually or more often, as determined by the field botanists that are responsible for the sites. The minimum duration of monitoring should cover the reproductive life span of the transplanted generation and the first naturally seeded generation. This time frame will allow for an assessment of the success or failure of seedlings. Subsequent monitoring should occur as needed.

During each site visit, the perimeter of the fence should be walked to determine if there are breaks through or under the wire. The area within the exclosure should be checked to determine if there are fresh signs of

ungulates (fresh droppings, animals tracks, or rooting disturbance). Damaged fence sections should be repaired promptly and any animals should be removed from within the exclosure. *Kokia cookei* plants should be checked for obvious signs of damage from ungulates, rodents, or insects. Staking should be checked to make sure wires are of appropriate tension and not causing damage to the plant. If needed, plants should be lightly irrigated during the first 2 years after planting.

42. Establish and maintain two outplanted wildland populations on Lanai.

These sites should ultimately contain at least 80-100 mature plants of *Kokia cookei*.

421. Produce and select plants for reintroduction efforts.

See narrative for Task Number 411.

422. Identify two specific areas on Lanai for reintroduction.

See narrative for Task Number 412.

423. Secure sites identified in Task 422.

See narrative for Task Number 413.

424. Restore and manage sites.

See narrative for Task Number 414.

4241. Fence reintroduction sites and exclude ungulates.

See narrative for Task Number 4141.

4242. Establish vegetation and threat monitoring.

See narrative for Task Number 4142.

4243. Manage sites to ensure protection via actions prescribed by fire management plan.

See narrative for Task Number 4143.

4244. Plant other native dryland species in the fenced reintroduction sites.

See narrative for Task Number 4144.

425. Plant *Kokia cookei* plants in fenced reintroduction sites.

See narrative for Task Number 415.

426. Provide post-planting care for *Kokia cookei*.

See narrative for Task Number 416.

43. Establish and maintain two outplanted wildland population on Maui.

The sites should ultimately contain at least 80-100 mature plants of *Kokia cookei*.

431. Produce and select plants for reintroduction efforts.

See narrative for Task Number 411.

432. Identify two specific areas on Maui for reintroduction.

See narrative for Task Number 412.

433. Secure sites identified in Task 432.

See narrative for Task Number 413.

434. Restore and manage sites.

See narrative for Task Number 414.

4341. Fence reintroduction sites and exclude ungulates.

See narrative for Task Number 4141.

4342. Establish vegetation and threat monitoring.

See narrative for Task Number 4142.

4343. Manage sites to ensure protection via actions prescribed by fire management plan.

See narrative for Task Number 4143.

4344. Plant other native dryland species in the fenced reintroduction sites.

See narrative for Task Number 4144.

435. Plant *Kokia cookei* plants in fenced reintroduction sites.

See narrative for Task Number 415.

436. Provide post-planting care for *Kokia cookei*.

See narrative for Task Number 416.

5. Validate recovery criteria.

Progress and feasibility of recovery efforts should be periodically evaluated. As new information is generated by implementation of the recovery plan and by independent or related scientific research, alteration of specific objectives and recovery criteria may be necessary.

51. Validate the number of individuals and populations necessary for recovery of *Kokia cookei*.

Using life history data collected during the monitoring of transplanted *Kokia cookei*, evaluate the minimum population size and the number of populations necessary for the continued survival of this species (Soule 1987). Extending the duration of monitoring will provide more data that can be used to refine the population viability model.

52. Refine and revise downlisting and delisting criteria, as necessary.

Based on scientific information gathered during recovery efforts, recovery criteria for *Kokia cookei* should be revised to reflect new information. Until additional sound information is available, the criteria presented in this recovery plan should be used as the basis for downlisting and delisting.

53. Evaluate species for downlisting and delisting.

As the recovery objectives are implemented and specific tasks are accomplished, the number of individuals of *Kokia cookei* should begin to increase. Populations should increase in size, vigor, and stability. Monitoring of the transplanted populations should provide the factual basis for determining when downlisting or delisting of the species is appropriate.

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III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated cost (including cost for salaries) for the *Kokia cookei* 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 organizations involved and/or responsible for committing funds, and lastly, estimated costs. When more than one organization 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 the species, stabilize the existing populations, and increase the population sizes and numbers. Monetary needs for all parties involved are identified to reach this point, whenever feasible.

Priorities in Column 1 of the following Implementation Schedule are assigned according to the following guidelines:

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 population or 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

BOT	-	Various Botanical Gardens (e.g., National Tropical Botanical Garden, Lyon Arboretum, Waimea Arboretum and Botanical Garden, etc.)
BRD	-	Biological Resources Division, U.S. Geological Survey
DLNR	-	Hawaii Department of Land and Natural Resources
NPS	-	National Park Service
OTHER	-	Various Private Landowners
TNCH	-	The Nature Conservancy of Hawaii
UH	-	University of Hawaii
USFWS	-	U.S. Fish & Wildlife Service, Pacific Islands Ecoregion, Honolulu, Hawaii

Key to Other Codes Used in the Implementation Schedule

C	-	Task will need to be performed continuously
O	-	Task is ongoing
TBD	-	Funding or timing of task has yet to be determined
*	-	Lead organization

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR *KOKIA COOKEI*

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost through FY 2027 ($1,000's)	Cost Estimates ($1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
1	1	Increase number of grafted plants to at least 100 individuals.	O	DLNR*	150.0	5	5	5	5	5
				BOT	150.0	5	5	5	5	5
TOTAL COST OF NEED 1 TASKS					**300.0**	**10**	**10**	**10**	**10**	**10**
2	21	Conduct directed research with grafting techniques and materials.	O	DLNR*	50.0	10	10	10	10	10
				BOT	50.0	10	10	10	10	10
2	22	Conduct directed research with air layering techniques.	O	DLNR*	50.0	10	10	10	10	10
				BOT	50.0	10	10	10	10	10
2	23	Conduct directed research with tissue culture techniques.	TBD	BOT	500.0	50	50	50	50	50
2	31	Continue directed research on embryo culture methodology.	O	BOT	500.0	50	50	50	50	50
2	32	Establish a program of artificially controlled introgressive hybridization of *Kokia cookei* with another *Kokia* species.	TBD	DLNR*	750.0	25	25	25	25	25
				BOT	750.0	25	25	25	25	25
TOTAL COST OF NEED 2 TASKS					**2,700.0**	**190**	**190**	**190**	**190**	**190**
1	411	Produce and select plants for reintroduction efforts on Molokai.	TBD	DLNR*	TBD					
				BOT	TBD					
1	412	Identify four specific areas on Molokai for reintroduction.	1	DLNR*	1.0			1.0		
				BOT	TBD					
				NPS	TBD					
				BRD	TBD					
				TNCH	TBD					
				USFWS	TBD					
				OTHER	TBD					

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost through FY 2027 ($1,000's)	Cost Estimates ($1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
1	413	Secure sites identified in Task # 412.	5	DLNR*	166.3			166.3		
				TNCH	166.3			166.3		
				USFWS	166.2			166.2		
				OTHER	166.2			166.3		
1	4141	Fence reintroduction sites and exclude ungulates.	3	DLNR*	50.0				50	
				TNCH	50.0				50	
				USFWS	50.0				50	
				OTHER	TBD					
2	4142	Establish vegetation and threat monitoring.	C	DLNR*	TBD					
				BOT	TBD					
				NPS	TBD					
				TNCH	TBD					
1	4143	Manage sites to ensure protection via actions prescribed by fire management plan.	C	DLNR*	120.0	4	4	4	4	4
				BOT	120.0	4	4	4	4	4
				TNCH	120.0	4	4	4	4	4
				OTHER	TBD					
3	4144	Plant other native dryland species in the fenced reintroduction sites.	5	DLNR*	5.0	1	1	1	1	1
				BOT	5.0	1	1	1	1	1
				NPS	5.0	1	1	1	1	1
				TNCH	5.0	1	1	1	1	1
1	415	Plant *Kokia cookei* in the fenced reintroduction sites.	O	DLNR*	10.0	1	1	1	1	1
				BOT	10.0	1	1	1	1	1
1	416	Provide post-planting care for *Kokia cookei.*	C	DLNR	120.0	4	4	4	4	4
				BOT	120.0	4	4	4	4	4
				BRD	120.0	4	4	4	4	4
				TNCH	120.0	4	4	4	4	4
				OTHER	TBD					
1	421	Produce and select plants for reintroduction efforts on Lanai.	TBD	DLNR*	TBD					
				BOT	TBD					

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost through FY 2027 ($1,000's)	Cost Estimates ($1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
1	422	Identify two specific areas on Lanai for reintroduction.	1	DLNR*	1.0			1		
				BOT	TBD					
				BRD	TBD					
				TNCH	TBD					
				USFWS	TBD					
				OTHER	TBD					
1	423	Secure sites identified in Task # 422.	5	DLNR*	75.0			75		
				TNCH	75.0			75		
				USFWS	75.0			75		
				OTHER	75.0			75		
1	4241	Fence reintroduction sites and exclude ungulates.	3	DLNR*	25.0				25	
				TNCH	25.0				25	
				USFWS	25.0				25	
				OTHER	TBD					
2	4242	Establish vegetation and threat monitoring.	C	DLNR*	TBD					
				BOT	TBD					
				NPS	TBD					
				TNCH	TBD					
1	4243	Mange sites to ensure protection via actions prescribed by fire management plan.	C	DLNR*	60.0	2	2	2	2	2
				BOT	60.0	2	2	2	2	2
				NPS	60.0	2	2	2	2	2
				TNCH	60.0	2	2	2	2	2
3	4244	Plant other native dryland species in the fenced reintroduction sites.	5	DLNR*	2.5	0.5	0.5	0.5	0.5	0.5
				BOT	2.5	0.5	0.5	0.5	0.5	0.5
				NPS	2.5	0.5	0.5	0.5	0.5	0.5
				TNCH	2.5	0.5	0.5	0.5	0.5	0.5
1	425	Plant *Kokia cookei* in the fenced reintroduction sites.	O	DLNR*	5.0	0.5	0.5	0.5	0.5	0.5
				BOT	5.0	0.5	0.5	0.5	0.5	0.5

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost through FY 2027 ($1,000's)	Cost Estimates ($1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
1	426	Provide post-planting care for *Kokia cookei.*	C	DLNR*	60.0	2	2	2	2	2
				BOT	60.0	2	2	2	2	2
				TNCH	60.0	2	2	2	2	2
				OTHER	TBD					
1	431	Produce and select plants for reintroduction efforts on Maui.	TBD	DLNR*	TBD					
				BOT	TBD					
1	432	Identify two specific areas on Maui for reintroduction.	1	DLNR*	1.0			1		
				BOT	TBD					
				NPS	TBD					
				BRD	TBD					
				TNCH	TBD					
				USFWS	TBD					
				OTHER	TBD					
1	433	Secure sites identified in Task # 432.	5	DLNR*	75.0			75		
				TNCH	75.0			75		
				USFWS	75.0			75		
				OTHER	75.0			75		
1	4341	Fence reintroduction sites and exclude ungulates.	3	DLNR*	25.0				25	
				NPS	25.0				25	
				TNCH	25.0				25	
				USFWS	25.0				25	
				OTHER	TBD					
2	4342	Establish vegetation and threat monitoring.	C	DLNR*	TBD					
				BOT	TBD					
				NPS	TBD					
				TNCH	TBD					
1	4343	Manage sites to ensure protection via actions prescribed by fire management plan.	C	DLNR*	60.0	2	2	2	2	2
				BOT	60.0	2	2	2	2	2
				TNCH	60.0	2	2	2	2	2
				OTHER	TBD					

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost through FY 2027 ($1,000's)	Cost Estimates ($1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
3	4344	Plant other native dryland species in the fenced reintroduction sites.	5	DLNR*	2.5	0.5	0.5	0.5	0.5	0.5
				BOT	2.5	0.5	0.5	0.5	0.5	0.5
				NPS	2.5	0.5	0.5	0.5	0.5	0.5
				TNCH	2.5	0.5	0.5	0.5	0.5	0.5
1	435	Plant *Kokia cookei* in the fenced reintroduction sites.	O	DLNR*	5.0	0.5	0.5	0.5	0.5	0.5
				BOT	5.0	0.5	0.5	0.5	0.5	0.5
1	436	Provide post-planting care for *Kokia cookei.*	C	DLNR*	60.0	2	2	2	2	2
				BOT	60.0	2	2	2	2	2
				NPS	60.0	2	2	2	2	2
				TNCH	60.0	2	2	2	2	2
				OTHER	TBD					
TOTAL COST OF NEED 3 TASKS					**3,353.0**	**68**	**68**	**1336**	**393**	**68**
3	51	Validate the number of individuals and populations necessary for recovery of *Kokia cookei.*	3	USFWS*	3.0					
				DLNR	3.0					
				BRD	3.0					
3	52	Refine and revise downlisting and delisting criteria, as necessary.	2	USFWS*	3.0					
3	53	Evaluate species for downlisting and delisting.	O	USFWS*	TBD					
TOTAL COST OF NEED 4 TASKS					**12.0**					
TOTAL COST OF THE ALL RECOVERY TASKS					**6,365.0**	**268**	**268**	**1,536**	**593**	**268**

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APPENDIX B - RECOVERY PRIORITY SYSTEM

The Recovery Priority System uses the criteria of (1) degree of threat, (2) recovery potential, and (3) taxonomy (level of genetic distinctiveness). By applying these criteria, all listed species are assigned a species priority number 1 through 18. A fourth factor, conflict, is a supplementary element in determining what actions are to be implemented for recovery of a species. In addition, the fourth factor gives priority, within each category, in preparation of recovery plans to those species that are, or may be in conflict with construction or development projects. Thus, the species retains its numerical rank and acquires the letter designation of "C," indicating conflict (1C-18C) (48 FR 43098).

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic genus	1	1/1C
		Species	2	2/2C
		Subspecies	3	3/3C
	Low	Monotypic genus	4	4/4C
		Species	5	5/5C
		Subspecies	6	6/6C
Moderate	High	Monotypic genus	7	7/7C
		Species	8	8/8C
		Subspecies	9	9/9C
	Low	Monotypic genus	10	10/10C
		Species	11	11/11C
		Subspecies	12	12/12C
Low	High	Monotypic genus	13	13/13C
		Species	14	14/14C
		Subspecies	15	15/15C
	Low	Monotypic genus	16	16/16C
		Species	17	17/17C
		Subspecies	18	18/18C

APPENDIX C - SUMMARY OF COMMENTS

The U.S. Fish and Wildlife Service received comments on the Draft Recovery Plan for *Kokia cookei* from the Office of Hawaiian Affairs, County of Maui Department of Parks and Recreation, and the U.S. Geological Survey's Biological Resources Division. These comments provided additional information on additional numbers of populations/plants and editorial changes and have been incorporated into the final plan. Additional comments of a technical nature are addressed specifically below. Philosophical comments regarding the likelihood of the recovery of Kokia cookei are not addressed.

Comment 1: What is the specific selection process that will be used in selecting reintroduction sites? Who are the decision makers in selecting the sites? Without specific site suggestions, the discussion of specific weed species to monitor and other native dryland species to outplant seems out of place.

Service Response: Reintroduction sites will be based on the identification of suitable sites that meet the criteria detailed in Task 412 and willing landowners. The decision-making process will involve all stakeholders, including Federal, State, and private land managers, the U.S. Fish and Wildlife Service, landowners, and cooperators. The U.S. Fish and Wildlife Service considers potential outplanting sites to occur anywhere within the acceptable elevational and climatic limits identified in Task 412. The descriptions of native communities and likely management actions are included as parameters of the type of habitat that seemed most appropriate and to give some indication of critical management concerns within this type of habitat.

Comment 2: *Kokia cookei* may be downlisted to threatened status when natural regeneration from viable seeds is occurring at 5 managed out-planted sites; each with at least 100 reproductive individuals. How does the establishment of five populations /out-planted sites with a total of 500 plants all from the same gene pool of a single grafted plant branch assure a viable population with genetic diversity free from imminent extinction?

Service Response: Limited genetic diversity does not necessarily imply a lack of vigor. Numerous individuals of *Kokia cookei* were grown from seed on Molokai in the 1930s from a few sibling plants. Until the elimination of all naturally rooted individuals of this species by the Molokai fire of the 1970s, this species routinely produced seed by either selfing or outcrossing with closely related siblings. Each situation is unique. Limited genetic diversity, or perhaps more pointedly, the accumulation of deleterious alleles, should always be acknowledged in appraising the recovery potential of a species. However, considering the relatively recent history of this species, limited genetic diversity should by no means be considered as an absolute barrier toward efforts promoting its recovery.

Comment 3: The criteria for downlisting to threatened status is outlined. What is the significance of 3 years in assuring that the species is not in imminent danger of extinction? What is the establishment period of the species, and when is it considered established?

Service Response: There is no special significance to 3 years. The recommendation of 3 years was intended to provide a time guideline to assure that the spontaneous reproduction was repeated and not a single isolated occurrence. For an individual tree, the time period of establishment cannot be quantified well, but considering this is a deciduous species, a successful completion of a single growth cycle could be a criterion, i.e. flowering>shedding leaves>dormancy>new leaves produced>flowering. For a population, time of establishment is a stable or regenerating age structure over a number of years.

Comment 4: How do you determine that established seedlings have obtained a "stable age structure" after only 5 years of monitoring, especially considering this species lives up to 39 years?

Service Response: Stand or age structure is merely a tallying of all the size classes of a given species occurring within a given area. A stable age structure implies that all life stages of a given species are represented in an area, i.e. seedlings, saplings and larger reproductive individuals implying periodic natural recruitment and natural levels of mortality across size classes. As such, an assessment of stand or age structure is a one-time survey. The monitoring strategy is based on the assumption that seedlings are spontaneously produced from relatively large numbers of naturally rooted *Kokia cookei.* There is every reason to believe that these individuals will be capable of producing seed. Five years should be ample time to assess this seed-producing ability. The 5-year monitoring was intended to demonstrate the presence of naturally occurring seedlings, the healthy growth of seedlings into saplings, and acceptable survivability levels of the original planted population.

Comment 5: Are 760 mature plants a viable population for genetic diversity, and does this assure survival?

Service Response: It is not possible to assure the survival of any species. However, the establishment of 8 spatially separated, naturally reproducing populations of 80-100 reproductive size individuals in protected areas subject to regular monitoring and threat management may indicate the species is reasonably stable and definitely out of danger of imminent extinction.

Comment 6: In reference to the criteria for delisting, what is 5 years based on for natural regeneration?

Service Response: Five years was intended to provide a time guideline to assure that spontaneous reproduction was repeated.

Comment 7: The inability of *Kokia cookei* to produce viable seed, for example, might be triggered by nutrient deficiency, water stress, or other unfavorable environmental factors. Hence, in addition to improved propagation techniques, the plan must include agronomic strategies that would increase the likelihood of successful plant establishment.

Service Response: Currently, there is little evidence to suggest that growing conditions (nutrients and water availability) are possible causes of infertility. This species previously freely produced seeds when in cultivation on Molokai under conditions similar to those where infertile cloned individuals are currently being raised.