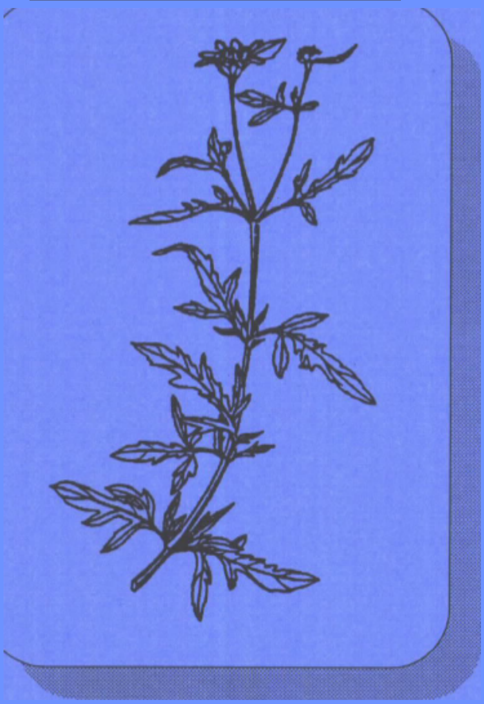
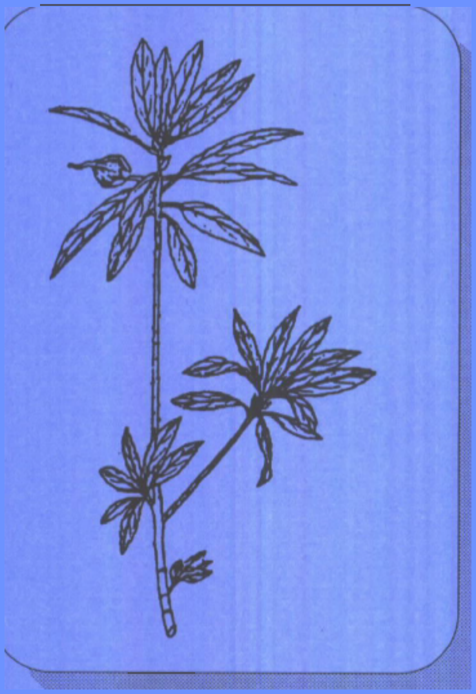
RECOVERY PLAN FOR
LIPOCHAETA VENOSA AND ISODENDRION HOSAKAE

JUNE, 1994



Lipochaeta venosa



Isodendrion hosakae

U.S. Fish and Wildlife Service, Pacific Region

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RECOVERY PLAN FOR
Lipochaeta venosa AND *Isodendrion hosakae*

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

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ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR *Lipochaeta venosa* AND *Isodendrion hosakae*

Current Status of Species: *Lipochaeta venosa* and *Isodendrion hosakae* are both federally listed as endangered species. The distribution of these species is limited to seven sites in the South Kohala District on the island of Hawaii. Six of these sites are located on the Parker Ranch, and one is located on Hawaiian Home Lands.

On the Parker Ranch, populations of *Lipochaeta venosa* occur on five cinder cones, while *Isodendrion hosakae* occurs on two of these sites and at one additional cinder cone. There may be only a few dozen *I. hosakae* plants remaining. According to the last survey, the estimated number of *L. venosa* plants on the Parker Ranch range from 24 to approximately 2,000 at each of the five sites where they occur. Most Parker Ranch sites have not been surveyed since 1982.

On Hawaiian Home Lands, *Lipochaeta venosa* occurs at one site. This population, discovered in June 1993, is estimated to consist of more than 100 individuals.

Habitat Requirements and Limiting Factors: These plants are located on the western slope of Mauna Kea, a long-dormant volcano. The area is typically dry and windy. The soils of the region are well drained and their composition is largely determined by the volcanic cinder or ash materials. The *Lipochaeta venosa* population located on Hawaiian Home Lands occurs on the gentle slope of a cinder hill. At the Parker Ranch, both species occur on the steep slopes of cinder cones. The latter is interpreted as an indication that these steep cones are havens from grazing animals, not necessarily preferred habitats. Research needs to be conducted to determine habitat requirements for both species. Threats to these taxa include grazing and trampling by cattle and feral ungulates, competition from introduced plant species, fire, and cinder mining.

Recovery Objective: Downlist to threatened status.

Recovery Criteria: These species may be downlisted when identified threats are controlled for the population on Hawaiian Home Lands, and when identified threats are controlled for the populations on the Parker Ranch and both species are established on all six Parker Ranch sites where one or both now exist. All populations must be naturally-reproducing, include seedlings, juveniles, and adults, have an age distribution allowing for a stationary or growing population size, and be maintained for at least 10 years.

The eventuality of delisting appears unlikely as the prevalence of fire-promoting fountain grass and continuation of ranching in the

area precludes rehabilitation of land between the cinder cones, leaving each site vulnerable to disaster from fire and breach of ungulate control fences by cattle.

Actions Needed:
1. Secure and stabilize the existing populations.
2. Research factors limiting expansion of populations.
3. Establish and expand populations of both species on all six sites at the Parker Ranch, and expand the population of *Lipochaeta venosa* on Hawaiian Home Lands.
4. Validate recovery objectives.

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

Year	Need 1	Need 2	Need 3	Need 4	Total
1994	13.5	6.0	0.0	0.0	19.5
1995	523.0	42.0	0.0	0.0	565.0
1996	53.75	54.0	20.0	0.0	127.75
1997	53.75	42.0	62.0	0.0	157.75
1998	53.75	37.0	62.0	0.0	152.75
1999	40.25	27.0	62.0	16.0	145.25
2000	34.25	0.0	52.0	16.0	102.25
2001	23.75	0.0	52.0	16.0	91.75
2002	17.25	0.0	42.0	0.0	59.25
2003	17.25	0.0	0.0	0.0	17.25
2004	14.75	0.0	0.0	0.0	14.75
2005	14.75	0.0	0.0	0.0	14.75
2006	14.75	0.0	0.0	0.0	14.75
2007	14.75	0.0	0.0	0.0	14.75
2008	14.75	0.0	0.0	0.0	14.75
2009	14.75	0.0	0.0	0.0	14.75
2010	14.75	0.0	0.0	0.0	14.75
2011	14.75	0.0	0.0	0.0	14.75
2012	14.75	0.0	0.0	0.0	14.75
Total	963.25	208.0	352.0	48.0	1,571.25

Date of Recovery: Downlisting to Threatened status should initiate in 2012, if recovery criteria are met.

TABLE OF CONTENTS

** Appendix B is not distributed with Recovery Plan. The U.S. Fish and Wildlife Service will consider requests for figures on a case-by-case basis.*

LIST OF TABLES

LIST OF FIGURES *

** Figures appear as Appendix B, which is not distributed with Recovery Plan. The U.S. Fish and Wildlife Service will consider requests for figures on a case-by-case basis.*

RECOVERY PLAN FOR

Lipochaeta venosa AND Isodendrion hosakae

I. INTRODUCTION

BRIEF OVERVIEW

Lipochaeta venosa was listed by the U.S. Fish and Wildlife Service (Service) as endangered in 1979 (44 *Federal Register* 62469). *Isodendrion hosakae* was listed as endangered in 1991 (56 *Federal Register* 1457). Critical habitat was not designated for either species.

The ranges of these species are limited to the South Kohala District on the island of Hawaii. Populations of *Lipochaeta venosa* occur at six sites; *Isodendrion hosakae* occurs on two of these and at one additional site. One of the populations of *L. venosa*, with numbers estimated at over 100 plants, was discovered on Hawaiian Home Lands in June 1993 (Jon Giffin, Division of Forestry and Wildlife, personal communication 1993). The remaining populations all occur on the Parker Ranch. Population size for the Parker Ranch populations, based on a 1982 survey and subsequent observations, are estimated at only a few dozen *I. hosakae* and over 3,000 remaining *L. venosa* plants (Cuddihy *et al*. 1983; C. Corn, Division of Forestry and Wildlife, pers. comm. 1992).

The native vegetation of most of this area was long ago converted to pasture. The steep slopes of the Parker Ranch cinder cones are interpreted as refuges that have allowed these and other native plants to escape from domestic and feral herbivores. The population on Hawaiian Home Lands occurs on a gentle slope, although it faces similar threats. In addition to habitat destruction and browsing by domestic cattle and feral animals, threats to these species include fire, cinder mining and competition from introduced species. The six cinder cones on the

Parker Ranch afford discrete management units that can be greatly improved by fencing, control of alien plant species, and development of a fire plan. The same measures would need to be taken with the Hawaiian Home Lands population.

TAXONOMY

Lipochaeta venosa

Lipochaeta venosa is endemic to the island of Hawaii and is known by the common Hawaiian name, nehe, which is applied to other species of Lipochaeta as well. It is in the tribe Helianthoideae of the Family Asteraceae (Compositae) and the class Dicotyledonae of the phylum Anthophyta (flowering plants). This species is placed in Group B of the Section Aphanopappus with the other diploid species (Gardner 1976). Closest phylogenetic relationships are with Lipochaeta subcordata, a polymorphic species that overlaps the range of Lipochaeta venosa. Potential problems in differentiating these two species are discussed under "Species Description".

Based on J. F. Rock's 1910 collection from a cone in South Kohala, Sherff (1933) named this species Lipochaeta venosa. The type specimen, Rock's no. 8349, is in the Field Museum of Natural History, Chicago, Illinois. An isotype with Rock's same collection number is in the Bishop Museum in Honolulu, Hawaii, bearing the accession number, 1690. Another isotype is in the Gray Herbarium, Cambridge, Massachusetts. E. Y. Hosaka identified collections he made at a crater in 1938 as Lipochaeta venosa var. malvacea. Gardner (1976) re-identified this material as L. venosa.

Collections of Lipochaeta from another cinder cone in South Kohala, about 8 kilometers (5 miles) from the type locality, were originally described as two new species, L. pinnatifida St. John and L. setosa St. John (St. John 1984). These collections have been reinterpreted as Lipochaeta venosa and these two binomials are considered synonyms of L. venosa (Wagner et al. 1986).

Lipochaeta venosa was listed as endangered by the Service based largely on a population on the island of Hawaii in Kipuka Kalawamauna, North Kona (Herbst 1979, 44 Federal Register 62468). This site is within Area 5 of the Pohakuloa Training Area. The pre-listing report (Herbst 1979) also refers to a possible population of L. venosa on Mauna Loa at 2300 meters (7500 feet) elevation collected by Degener et al. in 1949. However, since this listing, the Lipochaeta collections from Kipuka Kalawamauna and those from 2300 meters on Mauna Loa have been determined to be extreme forms of the polymorphic L. subcordata (Wagner et al. 1986). For the purposes of this recovery plan, the known population of L. venosa is limited to those five populations named in the new flora (Wagner et al. 1990) and a newly discovered population located northeast of the five originally known (see "Current Range and Population Status").

Isodendrion hosakae

Isodendrion hosakae St. John was named in 1952 from the type specimen collected by E. Y. Hosaka in 1948 (no. 3593, Bishop Museum) (St. John 1952). No pertinent synonyms are applied to this taxon. All members of the genus Isodendrion are known by the common Hawaiian name, aupaka (Wagner et al. 1990).

Isodendrion is an endemic Hawaiian genus within the Family Violaceae and the class Dicotyledonae of the flowering plants. The genus is placed within the subfamily Violoideae, but its affinities with the various tribes of the subfamily are confused (Wagner et al. 1990).

Isodendrion pyrifolium, formerly believed to be extinct (Wagner et al. 1990), was rediscovered in 1991 in North Kona, island of Hawaii. This slightly-taller shrub can be distinguished from I.

hosakae by leaf and floral characteristics (Wagner et al. 1990). However, because the known ranges of these two rare species do not overlap, no confusion is anticipated.

SPECIES DESCRIPTION

Lipochaeta venosa

Lipochaeta venosa is a semi-woody shrub usually described as low or trailing. The semi-prostrate stems may be up to 50 centimeters (20 inches) long. The species is at least partly deciduous, reportedly losing most leaves during drought periods (Cuddihy et al. 1983). Data are insufficient to determine if leaf-drop is a predictable annual event. Leaves are generally 2 to 3 centimeters (1 inch) long, but the leaf shape is variable. Leaves are generally deltate, usually with basal lobes. Some have deeply dissected margins and others are entire. The yellow flowers occur in small heads of 4 to 6 ray florets and 20 to 30 disk florets. Seeds are often spotted with purple (Wagner et al. 1990).

In the past, difficulties have arisen in distinguishing Lipochaeta venosa from Lipochaeta subcordata. The two species are closely related (Gardner 1976) and occur together in the Waikoloa region (Cuddihy et al. 1983). The two are differentiated by the combination of characters used in the key by Wagner et al. (1990) that can be summarized as follows: L. venosa has leaves generally 2.1 to 2.8 centimeters (0.8 to 1.1 inches) long, low spreading stems that may be somewhat arching, and flowering heads that are single or in clusters of two or three; L. subcordata has leaves usually 3.4 to 10 centimeters (1.3 to 3.9 inches) in length, more erect stems, and more numerous heads occurring in compound cymes. However, L. subcordata is extremely variable. Recognition of L. venosa can also be made difficult because it may lose its leaves during drought (Cuddihy et al. 1983).

A third species, Lipochaeta lavarum, also occurs near or with L. venosa but can be easily differentiated.

Isodendrion hosakae

Isodendrion hosakae is a branched, upright, evergreen shrub. Reproductively mature plants range from 8 to 82 centimeters (3 to 32 inches) in height, and flowers and fruit occur on the woody stems (Cuddihy et al. 1983; Wagner et al. 1990). The leathery leaves are lance-shaped, 3.0 to 7.0 centimeters (1.2 to 2.8 inches) long and 0.6 to 2.0 centimeters (0.2 to 0.8 inches) wide. The stipules are persistent and conspicuously cover the ends of the stems. Like other members of the violet family, the flowers are bilaterally symmetrical. The petals are yellowish-green to white, up to 18 millimeters (0.7 inches) long. The fruit is a red-tinged, green elliptical capsule 12 to 16 millimeters (4.7 to 6.3 inches) long, containing obovoid seeds about 2 by 3 millimeters (0.08 by 0.12 inches) (Nagata 1982; Wagner et al. 1990).

The plants are often found within the crown outline of other native shrubs or alien grass clumps suggesting that there may be a beneficial association between Isodendrion hosakae and these other plants (Cuddihy et al. 1983).

HISTORIC RANGE AND POPULATION STATUS

Both Lipochaeta venosa and Isodendrion hosakae became known to science long after most of the native vegetation of the region was extirpated or severely altered by human use (Rock 1913). L. venosa was first collected in 1910 and named in 1933 (Sherff 1933). I. hosakae was named in 1952 from a 1948 collection (St. John 1952).

Today, both species are found at all sites where they were historically known, and Lipochaeta venosa is found at one additional site. Since there is no information concerning either species before recent time, the range and status of these species are discussed in the section below, "Current Range and Population Status."

CURRENT RANGE AND POPULATION STATUS

Maps or descriptions of the exact locations of known sites will not be included in this Plan due to the possibility that vandalization or unauthorized collection could be encouraged by the public release of this information. The seven sites on which these two species occur will be referred to as Sites #1-7 in this plan (Table 1). The Service will maintain the figures listed as Appendix B in its files, and will consider requests for these figures on a case-by-case basis.

Table 1. Presence of Isodendrion hosakae and Lipochaeta venosa in South Kohala.

	Site #	Isodendrion hosakae	Lipochaeta venosa
Parker Ranch			
	1	X	X
	2	X	X
	3	X	
	4		X
	5		X
	6		X
Hawaiian Home Lands			
	7		X

Isodendrion hosakae and Lipochaeta venosa are localized and rare. They occur in the Waikoloa region of the South Kohala District on the island of Hawaii. Both species occur together at two sites, and I. hosakae and L. venosa occur separately at one and four other sites, respectively.

The two species occur together at Sites #1 and 2. Isodendrion hosakae occurs alone at Site #3 and Lipochaeta venosa occurs alone at Sites #4-7. All of these confirmed occurrences are between 770 and 1097 meters (2500 and 3600 feet) elevation. It is inferred that their ranges once included, at the least, the lands between the cones where they are now extant; however, there is no way to know what their ranges and population densities might have been historically.

Range of Lipochaeta venosa

There are six populations of Lipochaeta venosa. At four of these sites, present and historical occurrence of L. venosa is well documented near the 860 meter (2800 foot) contour in Waikoloa, South Kohala District, island of Hawaii. L. venosa was first collected by Rock in 1910 in the crater of Site #1 and in 1938 by Hosaka at Site #4 (Herbst 1979). As of 1982, sizable populations had been found at both of these sites and at Sites #2 and 5 (Cuddihy et al. 1983). The 1980-1982 survey of 12 cinder cones and several gulches in the Waikoloa ahupuaa of South Kohala found L. venosa at all four sites named above (Cuddihy et al. 1983). This survey included the vicinity of Site #6 but did not record the population of L. venosa subsequently found and reported near there under the synonyms of L. pinnatifida and L. setosa (St. John 1984; see Taxonomy section). The most recently discovered population of L. venosa occurs at Site #7. These plants were discovered in June 1993, by a representative of the U.S. Soil Conservation Service while developing a soil conservation plan for Hawaiian Home Lands (J. Giffin, pers. comm. 1993), and identified as L. venosa in October 1993 (D. Herbst, U.S. Army Corps of Engineers, pers. comm. 1993).

The population of Lipochaeta in Area 5 of the Pohakuloa Training Area and collections from the edge of the 1859 Mauna Loa lava flow had been misidentified as Lipochaeta venosa (see Taxonomy section). The range of L. venosa is not considered to include these areas.

Population Status of Lipochaeta venosa

Collectors in the first half of this century provided very little information about the status of this plant. Rock's collections are accompanied by no information. Hosaka's 1938 collection at Site #4 simply says "rare."

The observations between 1980 and 1984 of the five populations known at this time report some fairly sizable colonies of seemingly vigorous flowering and fruiting plants. The largest population was at Site #1. Although the high density and matted habit of the plant made an exact count impossible, it was estimated that a total of at least 2,000 individuals were growing in two large areas and four smaller patches (Cuddihy et al. 1983; Hawaii Heritage Program EOCODE: PDAST5ZONO.002). The following counts were reported for the other four sites: Site #2 - 90 plants; Site #4 - 709 plants; Site #5 - 1,350 plants; and Site #6 - 24 to 48 plants (Cuddihy et al. 1983, St. John 1984).

A fire was reported to have burned over Site #1 in 1983 (Carolyn Corn, pers. comm. 1992). Although no Lipochaeta venosa were seen after the fire during a brief visit to the site by a botanist (Hawaii Heritage Program EOCODE: PDAST5ZONO.002), large numbers of the plant were seen in September 1991, by a team of forestry personnel and botanists from the National Tropical Botanical Garden (NTBG) (Steve Bergfeld, Division of Forestry and Wildlife, pers. comm. 1992).

The presence of "several hundred" plants at Site #5 was reconfirmed in 1990 (S. Bergfeld, pers. comm. 1992; Hawaii

Heritage Program EOCODE: PDAST5ZONO.001). The status of Site #4 and Site #2 populations has not been reconfirmed since 1982 (Cuddihy et al. 1983). No observations of Site #6 are known since 1981 (St. John 1984).

The population at Site #7, discovered in 1993, is estimated at greater than 100 individuals (Giffin, pers. comm. 1993).

Range of Isodendrion hosakae

Isodendrion hosakae is known to exist at three sites. These populations occur within an area of about a 2.4 kilometer (1.5 mile) radius. The known range of this species has changed very little in the 44 years since it was first discovered in 1948 by E. Y. Hosaka on an unspecified cinder cone in Waikoloa, South Kohala. This species was again collected in 1980 at Site #1 in Waikoloa, South Kohala, sparking further searches by Division of Forestry and Wildlife (DOFAW) botanists. These searches led to the discovery of a major population at nearby Site #3 and a lesser colony at another site described as less than 1 mile (1.6 kilometer) northeast of Site #1 near Site #2 (Cuddihy et al. 1983). Cuddihy et al. (1983) speculate that Hosaka's original collections were made at Site #3.

There are no additional records of sightings of this species. Although no scientific evidence is available to indicate what its maximum former range may have been, it is reasonable to assume that, at the least, Isodendrion hosakae once occupied sites between the three cones where it is now known. The present-day restriction to the three cones is likely due to extirpation by cattle in all accessible locations.

Population Status of Isodendrion hosakae

Population and size class data for Isodendrion hosakae recorded for the Site #3 population during the 1980-1982 DOFAW survey indicate that the population may have been stable at that time

(Cuddihy et al. 1983), although it has been damaged subsequently (C. Corn, pers. comm. 1992). The populations at the other two sites are sufficiently small that they may be considered relictual or ephemeral.

The major population at Site #3 was estimated during the 1980-1982 survey to contain 300 plants dispersed over about 1 acre. A sample of 168 of these plants was measured. The plants ranged between 7 and 75 centimeters (3 and 30 inches) in height. Since plants occurred in all height classes, it appeared that the population was successfully recruiting reproductive plants. Furthermore, in April 1982, seedlings less than 7 centimeters (3 inches) tall were found under 50 percent of the shrubs at Site #1 (Nagata 1982).

The population and habitat of Isodendrion hosakae at Site #3 was severely damaged by intensified grazing in 1988. The vegetation was generally reduced and plants of I. hosakae were broken; at that time, only 25 to 50 living plants were seen (C. Corn, pers. comm. 1992). This population was again seen in January 1991, but no count of plants was made (S. Bergfeld, pers. comm. 1992).

The populations at the other two sites are so small that population structure analysis is meaningless. In 1980-82, eight plants were counted at Site #1 in approximately 8 square meters (86 square feet) (Cuddihy et al. 1983). Grass fires burned the habitat of Isodendrion hosakae on this cinder cone in 1983. A few months after the fire at least one of the plants was observed alive with green leaves (C. Corn, pers. comm. 1992). Although a determined search in September 1992 by DOFAW personnel and botanists from NTBG failed to relocate this plant (S. Bergfeld, pers. comm. 1992), another plant was spotted about 30 meters (100 feet) away.

In 1980-82, eight plants were also counted near Site #2 in approximately 30 square meters (300 square feet) (Cuddihy et al. 1983). The population near Site #2 has apparently not been revisited since 1982. Its current status is not known.

Only two Isodendrion hosakae plants are known in cultivation, and there are no other germ plasm reserves.

LIFE HISTORY

Reproductive Biology of Lipochaeta venosa

The reproductive biology of Lipochaeta venosa has never been directly studied. Hybridization and systematic studies of Lipochaeta have yielded limited data. Species of this genus are usually both self-compatible and capable of out-crossing. The flowers are not adapted for specialized pollination and, like most members of the Asteraceae family, appear to be pollinated by non-specific insects (Gerald Carr, University of Hawaii at Manoa, pers. comm. 1992). Number of seeds produced per plant and other aspects of seed biology are not known.

Cuttings of all species of Lipochaeta tested were easily rooted in greenhouse cultivation forming adventitious roots at many nodes (G. Carr, pers. comm. 1992). L. venosa has been grown from cuttings in the DOFAW Hilo Baseyard nursery (S. Bergfeld, pers. comm. 1992). It is likely that vegetative reproduction occurs in nature.

Life Stages and Demography of Lipochaeta venosa

No population structure information is available for Lipochaeta venosa. Field observations consist only of counts of individuals with no enumeration by size class or life stage (Cuddihy et al. 1983). Nothing is known about growth rates, age at reproductive maturity, or longevity of L. venosa in nature.

Phenology of Lipochaeta venosa

A phenological pattern can be pieced together from scant information available from herbarium labels and other observations, particularly Cuddihy et al. (1983). The following generalization is based on a total of 15 observations unevenly distributed throughout the year (Table 2). Twelve of these observations were made in the period of 1980-1982 at various cinder cones. This generalized pattern is based on consistent observations in more than 1 year.

It appears that many plants are flowering in March, but flowering is much reduced by June. Seeds were observed as early as April and are present on many plants in June. No flowering was observed in September or October. In these autumn months the plants were described as "dry," with only dried inflorescences. Cuddihy et al. (1983) comment that during dry periods, Lipochaeta venosa is hard to find because it is dry with few leaves. It is possible that this phenological pattern is not a seasonal rhythm, but rather a response to climatic conditions. Herbst (1979) suggests that flowering is brought on by winter rains.

Table 2. Phenological observations of Lipochaeta venosa.

MONTH	OBSERVATION #1	OBSERVATION #2	OBSERVATION #3	OBSERVATION #4
Jan	[No Obs]			
Feb	[No Obs]			
Mar	flowers	flowers	flowers	
Apr	flowers & seed	flowers & seed	flowers	flowers
May	[No Obs]			
Jun	few flowers & many seeds			
Jul	[No Obs]			
Aug	[No Obs]			
Sep	plants dry			
Oct	plants dry	plants dry		
Nov	[No Obs]			
Dec	[No Obs]			

Reproductive Biology of Isodendrion hosakae

Nothing is known about the mechanisms of sexual reproduction utilized by this species. No pollinating agents have been identified (Nagata 1982), although the white flowers produce a sweet scent and numerous moths have been seen in the habitat at night (C. Corn, pers. comm. 1993). Although it has been suggested that the seeds may be wind dispersed (Nagata 1982), seedlings found underneath mature plants (Nagata 1982) in this windy area may indicate that this is not the dispersal mechanism.

Production of fruit and viable seed may be low (Nagata 1982). Nagata (1982) found that the number of fruits per plant was very low and that 8 mature fruits collected in April 1982 contained only 14 seeds. In a subsequent germination trial, only 3 of 20 seeds germinated. However, it should be noted that these observations may have been made before the peak of the fruiting season.

There are no reports of vegetative reproduction of this species in nature. Attempts to grow Isodendrion hosakae from cuttings using several techniques have failed (Nagata 1982; David Orr, Waimea Arboretum and Botanic Garden, pers. comm. 1992).

Life Stages and Demography of Isodendrion hosakae

Although more research is needed on the seedling ecology and demography of Isodendrion hosakae in nature, size class measurements and some life stage observations were made of all three populations in 1980-1982 (Cuddihy et al. 1983). Similar data believed to be from the same source were presented by Nagata (1982). These data show a wide range of plant sizes but do not indicate the minimum size at which plants flower; thus, it is not possible to determine the distribution of life stages in the population. Although it is clear that the population includes many reproductively mature plants, it is not clear if plants in the lower height class are seedlings and juveniles, or simply dwarfed mature plants. Nagata (1982) does report that seedlings less than 7 centimeters (3 inches) tall were found under 10 of 20 mature plants sampled in April 1982. Nagata (1982) and Cuddihy et al. (1983) interpret these data to mean that reproduction and seedling establishment have been successful at these sites and that the population is stable, but probably not expanding.

Data from greenhouse-cultivated plants at NTBG give a few hints about this species' life cycle (Melanie Chapin, National Tropical Botanical Garden, pers. comm. 1992). Seeds were sown in September

1990 in a nursery at NTBG. The germination date was not recorded, but germination usually requires several months. These plants flowered for the first time in March 1991, and have flowered twice since. Seeds did not appear to be viable. The plants were producing new leaves in January 1992. These data show that greenhouse plants begin flowering when still small and at an age of a few months. The reasons for lack of viability of seeds are not known.

Phenology of Isodendrion hosakae

Field observations noting phenology of Isodendrion hosakae have been made in the months of January, February, March, April, and November (Cuddihy et al. 1983; Bishop Museum herbarium labels). Flowers were reported in all of these months, and fruits were seen in all of these months except January. Nagata (1982) reported that flowering and fruiting occur from November through June. Greenhouse-grown plants are known to have flowered in March and other months, and to have set new leaves in January (see paragraph above). Clearly, these data are far too few for a reliable picture of this species' phenology.

HABITAT DESCRIPTION

Topography and Physiographic Position

The cattle pastures of the expansive Parker Ranch and the adjacent Hawaiian Home Lands are the setting for the existing populations of Lipochaeta venosa and Isodendrion hosakae. These populations are located on the western slope of Mauna Kea, a long-dormant volcano. The slope of this leeward side is gentle to moderate (0 to 20 percent), but studded with the steep cinder cones that are formed in the late phase of the volcanic life of Hawaiian shield volcanoes. The Lipochaeta venosa population located on Hawaiian Home Lands occurs on a gentle slope. At the Parker Ranch, both species occur on steep slopes. The base and summit elevations of the six Parker Ranch cinder cones range between 725 and 1136 meters (2,360 and 3,728 feet). In 1982, the largest and densest patches of Isodendrion hosakae occurred at Site #3 on the summit and northeast face of a cinder cone. Cuddihy et al. (1983) speculated that this topographic position was favored by moisture brought by the prevailing northeasterly trade winds. No such microsite specificity was found for Lipochaeta venosa.

Climate

The South Kohala District is typically dry and windy. Drought conditions often occur from May to November with winter and spring rains bringing most of the average annual precipitation of 50 centimeters (20 inches) (Blumenstock and Price 1961). Mean annual temperature is 62.9° F (17.2° C) (Anonymous 1922 in Nagata 1982). February is the coldest month, with a mean temperature of 60.6° F (15.9° C), and September is the warmest month, with a mean monthly temperature of 65.3° F (18.5° C) (Anonymous 1922 in Nagata 1982). Because ground-level clouds are a frequent phenomenon, fog drip may be a significant source of moisture.

Substrate

The soils of the region are largely determined by volcanic cinder or ash materials. For the most part, the soil maps do not show the soils of cinder cones to be different from their surroundings, although they are much steeper in slope. The prevalent soils of the region are fine, sandy loams or loamy, fine sands of the Waikoloa, Kilohana, Puupa, and Kamakoa series (Sato et al. 1973). The first three soils named are derived from varying depths of volcanic ash over lava, the fourth is formed largely from alluvial materials washed down from the higher slopes of Mauna Kea.

All of these soils are well-drained or excessively drained (Sato et al. 1973), exacerbating the climatic dryness of the region. To different degrees, these soils are stony with rock outcrops. The Puupa series is a shallow, extremely stony soil over a'a lava.

The substrates where Isodendrion hosakae and Lipochaeta venosa actually occur may not be typical of the soil series but tend to be more coarsely cindery (Nagata 1982). Specific reports often mention occurrences on rocky outcrops. The I. hosakae population near Site #2 is reportedly growing on an a'a flow with very little soil (Nagata 1982). It is assumed that this does not indicate preference for rocky substrates, but escape from herbivores in these inaccessible and inhospitable microsites.

Biological Characteristics

The regional vegetation is Montane Dry Shrubland dominated by exotic grasses, but containing some native scrub. The general physiognomy and most of the dominant species of this scrubland are the same on all of these sites, with some variation in species composition. These remnants of scrub that are still characterized by native woody plants are classified as 'A'ali'i (Dodonaea) Montane Shrubland, a subdivision of the Montane Dry Shrubland (Gagne and Cuddihy 1990).

The alien fountain grass (Pennisetum setaceum) dominates the ground cover. A variety of other alien and native herbs and grasses combine with it to make up an open ground layer about 2 feet high. The native shrub, 'a'ali'i (Dodonaea viscosa), dominates the very sparse shrub layer which rarely extends above 1.3 meters (4.0 feet) high. Additionally, a surprising variety of native woody plants and a few alien shrubs are scattered about these cones. Native plants found at the six Parker Ranch sites are listed in Table 3. The total number of plant taxa found at each of these sites range from 38 at Site #3 to 84 at Site #1.

Table 3. Native species of flowering plants found on one or more Parker Ranch site within the ranges of _Lipochaeta venosa_ or _Isodendrion hosakae_. Extracted from Cuddihy _et al_. 1983.

Argemone glauca Pope
Bidens menziesii (Gray) Sherff var. _filiformis_ Sherff
Bidens menziesii (Gray) Sherff var. _menziesii_
Carex wahuensis C. A. Mey. var. _rubiginosa_ R. W. Krauss
Chenopodium oahuensis (Meyen) Aellen
Cocculus trilobus (Thunb.) DC
Dodonaea viscosa Jacq.
*** _Dubautia_ sp.
Eragrostis _atropioides_ Hbd.
Chamaesyce celastroides (Boiss.) Croizat & Degener
* _Chamaesyce olowaluana_ (Sherff) Croizat & Degener
Gnaphalium sandwicensium Gaud.
Ipomoea indica (J. Burm.) Merr.
Ipomoea tuboides Degener & van Ooststr.
Lipochaeta lavarum (Gaud.) DC var. _lavarum_
Osteomeles anthyllidifolia (Sm.) Lindl.
Oxalis corniculata L.
Panicum pellitum Trin.
** _Portulaca sclerocarpa_ Gray
Santalum ellipticum Gaud. var. _ellipticum_
Sicyos sp. nov.
Sida fallax Walp.
Silene struthioloides Gray
Sophora chrysophylla (Salisb.) Seem.
Styphelia tameiameiae (Cham.) F. Muell. var. _tameiameiae_
** _Vigna o-wahuensis_ Vogel
Wikstroemia pulcherrima Skottsb.

* C2 - Candidate for listing under the Endangered Species Act of 1973, but insufficient information to determine if listing is warranted.

** PE - Proposed for listing under the Endangered Species Act of 1973. Recovery of _Portulaca sclerocarpa_ addressed in Recovery Plan for the Hawaii Cluster Plants.

*** Species not identified. Some species in this genus are C2 and some listed as endangered.

The percentage of total taxa that is native ranges from 32 at Site #1 to 47 at Site #4 (Cuddihy et al. 1983).

REASONS FOR DECLINE AND CURRENT THREATS

Overview

The principal threats to these two species include habitat destruction by domestic cattle and feral herbivores, fire, cinder mining, and competition by introduced plant species, particularly fountain grass.

The course of decline of these species was not documented. Neither species was ever documented to be more widely distributed than it is today. Destruction of the native vegetation of the Waimea region was well-advanced by the middle of the 19th century (Anon 1856 in Nagata 1982). Today, the ranchland surrounding these species is nearly treeless pasture for many miles. Hardy native shrubs and trees survive in topographic sites that reduce access to cattle, such as gullies, rough a'a lava flows, and the steep slopes of cinder cones. Communities with many native plants, such as the habitats of these endangered species, are very small and widely scattered.

Cattle and other Herbivores

Conclusive evidence that domestic or feral herbivores actually eat either of these endangered species is lacking (Nagata 1982; Cuddihy et al. 1983). Plants of *Lipochaeta subcordata*, however, are reportedly browsed by goats during seasonal drought (Herbst 1979), and it is likely that *L. venosa* is also palatable. The presumed decline of *Isodendrion hosakae* and *Lipochaeta venosa* is undoubtedly the result of the severe habitat loss described above. Today, on the Parker Ranch, trampling and browsing damage results when cattle are concentrated in the area of the plants. Such damage to *I. hosakae* and other native shrubs was noted at Site #3 in 1988 after intensive grazing management had been used in the area (C. Corn, pers. comm. 1992). Although there is presently no grazing at the Hawaiian Home Lands site, this lot is leased for pasture and active ranching is anticipated (James Dupont, Department of Hawaiian Home Lands, pers. comm. 1993).

Fire and Fountain Grass

These rangelands and much of leeward Hawaii have been invaded by the fire-promoting, alien fountain grass (*Pennisetum setaceum*). This bunchgrass has poor palatability and increases the fuel load (Tunison 1992). A fire burned at Site #1 in 1983 (C. Corn, pers. comm. 1992) and may have destroyed all but one *Isodendrion hosakae* plant at that site (S. Bergfeld, pers. comm. 1992). *Lipochaeta venosa*, on the other hand, may be somewhat fire-resistant. Herbst (1979) reports that other *Lipochaeta* species frequently sprout back from the roots after fire. The occurrence of thriving *L. venosa* at Site #1 following the 1983 fire supports this observation.

Cuddihy *et al*. (1983) found that *Isodendrion hosakae* frequently grew within the crown outline of native shrubs or fountain grass clumps. It is suggested that these associated plants may afford some benefit to the *Isodendrion hosakae*, such as shelter (Nagata 1982) or fog drip. As a community dominant, fountain grass assumes a role in determining vegetation structure and site characteristics. Possible negative impacts, such as exposure to wind and soil loss, should be considered as attempts are made to eradicate fountain grass in the immediate vicinity of *I. hosakae* or *Lipochaeta venosa*.

Cinder Mining

Cinder cones in the area are often mined. Mining represents a direct mechanical threat to vegetation. Site #1 was mined for several years (Nagata 1982), but mining at this site has ceased (S. Bergfeld, pers. comm. 1992). Cinder is now being mined near, but not on, Site #3 (S. Bergfeld, pers. comm. 1992). Cinder mining remains a threat to these species, particularly to the population on Hawaiian Home Lands. The lot on which the Hawaiian Home Lands population occurs has been leased and cinder mining is a possible future use of this land (James Dupont, pers. comm. 1993).

Military Maneuvers

In the past, large parts of this region have been leased to the U.S. Army for training maneuvers (Nagata 1982). Such maneuvers threaten these habitats with trampling and fire.

Zoning and Land Use

The land supporting these two species has no protective zoning or conservation classification. The State of Hawaii land use classification is Agricultural. The continued permitted use of these sites for cattle grazing and cinder mining is a threat to these species.

CONSERVATION EFFORTS

Federal Actions

Lipochaeta venosa was listed as an endangered species in 1979 (44 *Federal Register* 62469). *Isodendrion hosakae* was listed as an endangered species in 1991 (56 *Federal Register* 1457). Both are assigned recovery priority 5 on a scale from 1-18. No critical habitat has been designated for either species.

State Actions

These species are listed by the State of Hawaii as endangered (Hawaii Revised Statutes 195). This is of particular importance as this status protects these plants on private lands (while Federal listing alone does not). The habitat of *Isodendrion hosakae* and the majority of *Lipochaeta venosa* habitat are privately owned. The State has initiated conservation management of these two species, as outlined below.

A cooperative agreement between Parker Ranch and DOFAW governs management efforts of these species on Parker Ranch land. To date, these efforts are aimed at preventing grazing and wildfire on three of the cinder cones that are habitat for one or both of these species. DOFAW completed a fence around the base of the cinder cone at Site #1 in December 1991 (S. Bergfeld, pers. comm. 1992). It is a "hog wire" (rectangular mesh) fence with a strand of barbed wire at the top and at the bottom. Such a fence should exclude all domestic cattle and feral pigs, goats, and sheep. The cinder cones containing Sites #5 and 3 were each fenced with barbed wire at an earlier date (S. Bergfeld pers. comm. 1992). These fences exclude domestic cattle but may not be effective in excluding the feral herbivores. No fencing or other management is known to have been undertaken at Sites #2, 4, or 6.

DOFAW has considered clearing firebreaks immediately outside the exclosure fences. Such a firebreak may be in place at Site #5. However, because firebreaks are not as effective in this area as in less dry, windy regions, it may be a better strategy to rely on grazing to prevent the build-up of dry grass (S. Bergfeld, pers. comm. 1992).

No actions have been taken by the State of Hawaii with regard to the populations at Sites #2, 4, 6, or 7.

Cultivation and Germ plasm Reserves for *Lipochaeta venosa*

Lipochaeta venosa can be grown from cuttings. Plants at the DOFAW Hilo Baseyard nursery (S. Bergfeld, pers. comm. 1992) and the Botany Department, University of Hawaii at Manoa (G. Carr, pers. comm. 1992) were grown from cuttings taken at the Parker Ranch. Attempts to grow *L. venosa* from seed at NTBG failed as no seeds germinated (M. Chapin, pers. comm. 1992). It is not known if this species has ever been grown from seed.

The number of plants in cultivation is believed to be very few. A few plants taken from cuttings are now growing in the DOFAW Hilo Baseyard nursery (S. Bergfeld, pers. comm. 1992). The Lyon Arboretum (Karen Shigematsu, H. L. Lyon Arboretum, pers. comm. 1992), Waimea Arboretum (D. Orr, pers. comm. 1992), and NTBG (M. Chapin, pers. comm. 1992) report no Lipochaeta venosa within their collections.

No seeds are in the NTBG seed bank, and no seeds are known to be in any other seed bank.

Cultivation and Germ Plasm Reserves for Isodendrion hosakae

Attempts to grow Isodendrion hosakae from seed and from cuttings have had meager success. Cuttings failed to take root at Lyon Arboretum (Nagata 1982) and at Waimea Arboretum (D. Orr, pers. comm. 1992). Seeds have been successfully germinated at Lyon Arboretum, but the germination rate was only 15 percent after 5 months with no more germination in the ensuing 11 months (Nagata 1982). Nagata reported that two plants of Isodendrion hosakae were growing at the arboretum.

Two Isodendrion hosakae plants are now growing at NTBG (M. Chapin, pers. comm. 1993). The plants were grown from seed treated with an 8 hour cold water soak prior to planting in a tray (M. Chapin, pers. comm. 1992). Germination required several months, and the germination rate was low. Following the formation of the second pair of true leaves, the seedlings were potted with a cindery soil mix. The plants have since flowered numerous times.

No seeds are stored in the NTBG seed bank (M. Chapin, pers. comm. 1992).

STRATEGY OF RECOVERY

The strategy of recovery calls for an initial securing and stabilizing of the existing populations of these species. This may be done by expanding the current cooperative agreement with Parker Ranch, entering into a cooperative agreement with the Department of Hawaiian Home Lands, enclosing management sites with ungulate-proof fencing, establishing firebreaks and developing a fire suppression plan, controlling alien plant species, and backing-up wild populations with germ plasm reserves. Research will be conducted on the control of alien plants, and reproduction and cultivation, habitat requirements, and pollinators of the species. Populations of both species will be expanded or established on all six Parker Ranch sites where one or both now occur. The *Lipochaeta venosa* population on Hawaiian Home Lands will be expanded. The introduction of *Isodendrion hosakae* is not considered appropriate at this site because it does not occur in this area historically and it is not found elsewhere on this type of gently sloping habitat. Finally, recovery objectives will be validated.

II. RECOVERY

OBJECTIVE

This plan provides a framework to establish, protect, and manage populations of Lipochaeta venosa and Isodendrion hosakae with the objective of downlisting them to threatened status. To achieve this goal, identified threats must be controlled and both species must be present at Sites #1-6 located on the Parker Ranch and L. venosa must be present at Site #7. Each site must have naturally-reproducing populations that include seedlings, juveniles, and adults, with an age distribution allowing for a stationary or growing population size. They should be maintained for at least 10 years. Activities that must be completed toward this end include: construction and maintenance of ungulate-proof fences around each population; establishment of firebreaks and development of a fire response and suppression plan for both Parker Ranch and the area around Site #7; establishment of a germ plasm reserve for both species; control of fountain grass and restoration of native habitat; and successful expansion of each species to Sites #1-6 (utilizing the results of research outlined in the plan).

Delisting of these species cannot be foreseen at this time. Continuation of ranching, cinder mining, and the nearly complete destruction of the native vegetation have left only small remnants of habitat for these plants. Even if vigorous populations of each species can be successfully established at each of the proposed sites, the entirety of each site is vulnerable to disaster from fire or cattle.

1. Secure and stabilize existing populations.
The intent of this task is to secure the existing wild plants in areas where they now occur, to reduce immediate threats to the populations, and to back up the wild populations with genetic reserves in the form of seed banks and living plant collections. In order to accomplish this task, it will be necessary to secure landowner cooperation.

11. Secure habitat.

Steps should be taken to secure these populations via long-term easement, cooperative agreement, lease, or fee purchase. In the case of the Parker Ranch populations, it may be necessary to supplement or replace the cooperative agreement currently in effect between DOFAW and Parker Ranch.

In addition, legal protection in the form of protective zoning or critical habitat designation may be considered for these sites to ensure that they are protected in perpetuity and to ensure that the plants are not damaged by activities of agencies unaware of their presence. Because most of the sites are remote, the risk of damage by vandals or curiosity seekers seems less than the risk from ill-informed use of the area. On a Federal level, designation of the management sites as critical habitat would preclude the Federal government from leasing land near the Parker Ranch sites for military maneuvers, as has been done in the past. On the state level, designation of the sites as Plant Sanctuaries or as Protected Subzones of the Conservation District would prevent cattle grazing and cinder mining, both of which threaten these species.

12. Confirm current status of these species.

As a first step toward recovering these species, location of these species must be established with certainty. A field check should be made to verify that the populations of these two species are still extant at Sites #1-6, where they were found in 1980-1982 (Cuddihy et al. 1983). If possible, other potential sites in the region should be surveyed. This recovery plan should be adjusted to accommodate new findings.

13. Control ungulate damage.

Feral sheep, goats and pigs, as well as domestic cattle, cause severe damage to vegetation via grazing and trampling. As an example, the population of Isodendrion hosakae at Site

#3, estimated at 300 successfully recruiting plants in 1980-1982, was reduced to 25-50 plants by intense grazing in 1988. Fencing of endangered plant populations and hunting of feral ungulates is needed to control ungulate damage.

131. Control ungulate damage at management sites.

Each of the areas containing one or both of these species will be treated as a management site. Each site must be protected with a fence that prevents entry by all grazing ungulates, including domestic cattle and feral sheep, goats, and pigs. The usual materials are 6-inch mesh woven wire with a strand of barbed wire at the bottom and, sometimes, at the top.

The populations on only one of the seven sites, Site #1, are presently protected from all ungulates by exclosure fencing. Sites #3 and 5 are reportedly now fenced with barbed-wire which will keep cattle out, but not pigs. The remaining cones do not have any fencing.

The fences at all sites must be inspected routinely to ensure they have not been broken down. Quarterly inspection is suggested. Inspection of the fences should be addressed in any cooperative agreements made. Parker Ranch personnel carrying out their regular duties may be able to report fence conditions at Sites #1-6. Fencing supplies and tools should be on-hand so that maintenance can be carried out as quickly as possible.

1311. Control ungulate damage at Site #1.

The existing fence at Site #1 is woven wire and probably ungulate-proof. It should be inspected to ensure that it is ungulate-proof and in good repair.

1312. Control ungulate damage at Site #2.

See narrative for task #131. Note that fencing at Site #2 should include the area to the southwest where *Isodendrion hosakae* and *Portulaca sclerocarpa*, also a listed species, were found in 1980-82 (Cuddihy *et al.* 1983) as well as the cone itself where *Lipochaeta venosa* grows.

1313. Control ungulate damage at Site #3.

Barbed wire fences should be replaced with ungulate-proof fences as described above to ensure exclusion of pigs from management area as well as cattle.

1314. Control ungulate damage at Site #4.

See narrative for task #131. An ungulate-proof fence needs to be constructed around the base of the site.

1315. Control ungulate damage at Site #5.

See narrative for task #1313.

1316. Control ungulate damage at Site #6.

See narrative for task #131. Note that the *Lipochaeta venosa* at Site #6 is several hundred meters north of the cone. This population may require a separate fence from the one that may be built around the cone. *Portulaca sclerocarpa*, also a listed species, is reported on the cone itself.

1317. Control ungulate damage at Site #7.

See narrative for task #131.

132. Control feral ungulates outside of exclosures.

Hunting of feral ungulates should be encouraged as it will help to ensure that these and other endangered and threatened species are protected from damage caused by feral animals.

14. Reduce the risk of catastrophic fire.

Isodendrion hosakae appears to be vulnerable to grass fire, while *Lipochaeta venosa* may be somewhat resistant. The major factor promoting fire in this region is the accumulation of dry fountain grass. Region-wide control of this ubiquitous fire-adapted grass is highly desirable. However, until this is achieved, site specific measures such as firebreaks and manual weeding around the plants must be taken.

141. Reduce conditions that promote fire.

A firebreak is needed around each of the management units. It was noted earlier in this plan that mowed or bulldozed firebreaks in this dry, windy region are not as effective as they may be elsewhere. Alternative strategies for achieving an effective firebreak need to be investigated. Possible alternative strategies are addressed below. Firebreaks on those sites with both species should be given first priority, those with Isodendrion hosakae only should be given second priority, and those with Lipochaeta venosa only should be given third priority.

One alternative strategy would be to develop a firebreak consisting of fire-resistant trees around the base of each of the steeper, Parker Ranch cinder cones. A native species that might be used for this purpose is Acacia koa. It is an evergreen tree with a low, branching habit and a thick canopy, and is drought tolerant. Initially, fountain grass would be removed in the area surrounding the cinder cones, probably via bulldozer. Seedlings would be grown in a nursery in the fall and, at 3 to 4 months of age (during the rainy season), planted 2 meters apart in 3 rows, with each row placed 3 meters apart in a staggered fashion. Supplementary watering would not be necessary but fountain grass should be controlled around the break for the first year to check competition with the seedlings. Fences should be constructed prior to planting.

Another alternative strategy is to promote grazing by cattle to prevent the build-up of dry grass by concentrating cattle within a 100 meter (325 feet) band around the base of the cinder cones. Water sources, mineral feeders, shade trees and fertilization to make the grass more palatable to cattle may be provided in this band to attract cattle. In examining this alternative it should be cautioned that while cattle may be useful in helping to control accumulation of fountain grass, they also present an increased threat of break-in to the management unit. Fertilization of an alien species that is deleterious to the area's native species would also need to be considered.

In addition to establishing a fire break, some fountain grass removal will be needed within the exclosure, particularly because the complete exclusion of cattle from the management sites may lead to greater accumulation of dry fountain grass within the management units. Although alien plant control in general is addressed in task #151, as an immediate means of fire control it is recommended that fountain grass be removed just outside the colonies of endangered plants (but within exclosure fences) using standard mechanical removal techniques. Extreme caution should be used near the endangered plants to prevent mechanical damage and to prevent negative effects of exposure following grass removal.

1411. Reduce conditions that promote fire at Site #1.

See narrative for task #141.

1412. Reduce conditions that promote fire at Site #2.

See narrative for task #141.

1413. Reduce conditions that promote fire at Site #3.

See narrative for task #141.

1414. Reduce conditions that promote fire at Site #4.

See narrative for task #141.

1415. Reduce conditions that promote fire at Site #5.

See narrative for task #141.

1416. Reduce conditions that promote fire at Site #6.

See narrative for task #141.

1417. Reduce conditions that promote fire at Site #7.

See narrative for task #141.

142. Develop fire response and suppression plans.

Fire response and suppression plans, one for Sites #1-6 and one for Site #7, should be developed by the county fire department, Parker Ranch, Hawaiian Home Lands and other responsible agencies as appropriate. Plans should place these management sites among the facilities that have priority protection during a fire on the ranch.

Plans should require improved access to management sites if and where necessary, and filing of access maps with the local fire department.

Plans should also identify individuals to serve as liaisons with the fire department in order to facilitate the response plan (identify the location of the plants within the sites, equipment that might be available from Parker Ranch or other agencies, etc.). They may also establish a water reservoir for each management site. Excess water can be used for irrigation during establishment of endangered or other native plants on the management sites or for watering cattle to attract them to the firebreak zone around the cone, if this is determined to be desirable.

15. Restore native habitat.

Restoration of the habitat to its native form will assist in achieving the goals for downlisting of these species. Removal of intrusive alien species, restoration of native plant species, and management to encourage pollinators should all be undertaken.

151. Carry out alien plant control.

Employ weeding and other methods of alien plant control identified in task #212, paying special attention to fountain grass.

152. Restore native plant species.

Removal of fountain grass may lead to a natural wave of regeneration from the native seed bank. However, grass removal may need to be coupled with efforts to increase the cover of native plants, making use of the native species that are common and most dominant on the site or on other management sites. Easy to grow shrubs to be encouraged include 'a'ali'i and 'ilima (*Sida fallax*). Two species of native morning glory (*Ipomoea* spp.) that occur on these sites may make useful ground cover, as may *Lipochaeta venosa* itself. Native flowering plants that occur on one or more of the cinder cones are listed in Table 3.

16. Establish and maintain germ plasm reserve for both species.

Very few plants of either species are known to be in cultivation and no seeds are in the NTBG seed bank. Yet it is essential to create a back-up genetic reserve for these species, particularly for Isodendrion hosakae which exists in dangerously low numbers. Lipochaeta venosa plants grown from cuttings are at the DOFAW Hilo Baseyard and the University of Hawaii at Manoa. One Isodendrion hosakae plant is in cultivation at the Lyon Arboretum and two at NTBG. More plants should be grown in cultivation for research purposes and as a genetic reserve, and should be distributed among botanical gardens as germ plasm reserves. A seed reserve should be established at NTBG and other institutions. Since seed production of both species may be low, seed should be carefully divided among those purposely left for natural regeneration, those taken for research, and those taken for a properly managed seed bank. This division requires coordination of all parties working under this recovery plan. Methods for long-term storage of seeds may need to be determined.

2. Research factors limiting expansion of populations.

Research on the impacts of and methods for removing alien plants, and reproduction and cultivation, habitat requirements, and methods of pollination for these species is necessary to expand existing populations and establish new populations.

21. Research control of fountain grass and other alien species within the sites.

At the present time, fountain grass is the dominant plant and largely determines the character of the habitat. Because this species aggressively competes with Lipochaeta venosa, Isodendrion hosakae, and other native plants for water and light, and because it promotes fire, research is needed to devise methods to achieve reduction of fountain grass and other alien plants. In doing so, it may be necessary to reestablish native plants to fulfill the ecosystem roles of alien plants after their removal. In accordance with research findings, care should be taken not to disrupt the functioning of the ecosystem and thus further endanger these plants.

211. Evaluate potential impact of removing alien plants.

Aside from the negative interactions mentioned above, alien plants probably provide certain ecosystem services such as soil stability, ground shading and cooling, and play a strong role in site hydrology -- roles that were once carried out by native plants. A complete and radical removal of alien species has the potential to negatively affect the endangered species. The potential negative impacts of removing fountain grass on soil stability, soil moisture and temperature should be evaluated. Research should be conducted on small patches of fountain grass and other alien plants using various methods of removal to see if these negative effects are serious. Attention must be given to the reported close association of some Isodendrion hosakae plants with fountain grass clumps.

In addition to fountain grass, many other alien plants occur on these sites. Some of these may continue to increase in number and further disrupt the endangered plants and the supporting native vegetation. The potentially disruptive species can be identified by their behavior on other sites or their population structures at these sites.

212. Devise appropriate methods of alien plant control.

Methods to control fountain grass and other alien species should be devised for the various sectors of the management sites, i.e. within the site but not near colonies of endangered plants, and in close proximity to the endangered plants.

Ultimately, securing and rehabilitating the habitat of these endangered plant species is dependent upon achieving regional control of fountain grass through techniques such as biological control. Research of both regional and local fountain grass control should be supported as part of this recovery plan.

22. Research reproduction and methods for cultivation of these species.

Very little is known about the reproduction and cultivation of these species. Research needs to be conducted in these areas and the results utilized to establish and expand current populations.

221. Research reproductive biology and cultivation of Lipochaeta venosa.

Little is known about the natural reproductive biology of and cultivation techniques for Lipochaeta venosa. While it is appropriate that cultivation techniques focus on reproduction from cuttings, sexual reproduction should not be ignored. It is important to maintain the genetic variation in new colonies through the use of seed. Little is known about the pollinators of the species. Because the habitat may need to be managed to assure the survival of the pollinators, necessary numbers and species of pollinators should be included in such an investigation.

Best methods for establishing new colonies using both cuttings and seedlings should be developed. On-site germination should be favored over out-planting of nursery stock in order to avoid introducing pathogens and insects.

222. Research reproductive biology and cultivation of *Isodendrion hosakae*.

High priority should be given to understanding and overcoming the factors that are limiting reproduction of *Isodendrion hosakae* in nature. Current numbers of populations and plants of *Isodendrion hosakae* are dangerously low. Field and greenhouse observations indicate that production of viable seed may be abnormally low. A comprehensive study of all aspects of reproductive biology and seedling establishment in nature should be undertaken, and the results used to devise a means to improve seed production and viability.

Results from studies of the reproductive biology of this species should be used in designing management practices to improve on-site regeneration. Greenhouse cultivation techniques should be developed in conjunction with the above research. Observations of nursery-raised plants may also provide life history and reproductive information. On-site germination should be favored over out-planting of nursery stock in order to avoid introducing pathogens and insects.

23. Determine habitat requirements for both species.

Today, both of these species survive in remnants of habitat that have been somewhat protected from grazing. It is likely that these sites do not represent the optimum habitat for either species. Habitat requirements, including substrate type, soil moisture, and sun/shade tolerance and preference, should be investigated from detailed field observations and simple greenhouse experiments when feasible. These findings can be used in selecting sites for new colonies and populations.

24. <u>Investigate pollinators of each species</u>.

Little is known about the pollinators of these plants, yet habitat may need to be managed to assure the survival of, and even encourage, the pollinators. Research is necessary to identify the species of pollinators and their habitat needs.

3. <u>Expand and establish populations</u>.

The heart of this recovery plan is the establishment of both of these species at Sites #1-6 and the expansion of the populations at each site. It is hoped that existing populations will naturally expand with control of threats by ungulates and alien species. If this is not the case, augmentation of existing populations should be accomplished <u>in situ</u> whenever possible. Likewise, propagation of plants for establishment on sites where they don't now exist, should be accomplished in the field, if possible, in order to avoid introducing new pathogens, parasites and/or insects from greenhouse stock.

31. <u>Propagate genetically suitable plants</u>.

Plants with which to expand existing, genetically diverse populations should be derived from that population in order to maintain its genetic integrity. In management areas where no plants of this species presently exists, genetically diverse populations composed of all genetic stocks should be established.

32. <u>Establish and/or expand populations</u>.

Existing populations should be augmented and new populations established where necessary. Establishment and expansion of populations should utilize on-site germination rather than depending on out-planting of nursery stock. Locations for new colonies should be chosen following habitat preference findings.

New colonies of <u>Lipochaeta venosa</u> can probably be started from cuttings from nearby plants or transplanting whole plants. Cuttings should be taken from as many individual plants as possible to maximize genetic diversity. However, care must be taken that the amount of cuttings or transplants taken does not endanger the parent colony. Plantings should be made early in the winter to take advantage of the usually wetter months from December to April. It may be necessary or beneficial to provide new plantings with artificial shade or water, if available. In order to increase genetic variability in new colonies, it would be desirable to establish some plants from seed, if research shows this to be feasible.

Careful observation may point to some simple methods to promote seedling establishment. These may include some careful weeding and dispersal of seeds to more favorable parts of the management sites. If water is available near any of the sites, portable pumps (perhaps solar powered) might be used to provide irrigation water for a few months during times of germination and seedling establishment. Care should be taken not to develop a vegetation requiring constant irrigation. Due to dangerously low numbers of plants, high priority should be given to increasing the numbers of Isodendrion hosakae in existing populations and to establishing new populations at Site #4, Site #5, and Site #6.

321. Expand populations at Site #1.

See narrative for task #32.

322. Expand populations at Site #2.

See narrative for task #32.

323. Establish Lipochaeta venosa and expand Isodendrion hosakae at Site #3.

See narrative for task #32.

324. Establish Isodendrion hosakae and expand Lipochaeta venosa populations at Site #4.

See narrative for task #32.

325. Establish Isodendrion hosakae and expand Lipochaeta venosa populations at Site #5.

See narrative for task #32.

326. Establish Isodendrion hosakae and expand Lipochaeta venosa populations at Site #6.

See narrative for task #32. Colonies should be started on the slopes of cinder cone #6 because it is presently growing a few hundred meters north of the puu.

327. Expand population at Site #7.

See narrative for task #32 regarding expansion of the Lipochaeta venosa population. The introduction of Isodendrion hosakae at this site is not considered appropriate because it does not occur in this area historically and it is not found elsewhere on this type of gently sloping habitat.

4. Validate recovery objectives.

Too little is presently known about the demography and life history of these two species to permit evaluation of population stability, and to verify the scientific validity of the stated recovery objectives in this plan. In the course of securing and augmenting these populations, field studies should be supported and data used to devise Population Viability Analysis (PVA) models.

41. Conduct basic demographic and life history studies.

Data on demography and life history should be collected from the existing wild populations and from any newly established colonies.

42. Determine the number of populations needed to ensure long-term survival.

It is necessary to know whether or not establishment of six populations is adequate to safeguard against catastrophic events over the next 200 years.

43. Determine the number of individuals needed to ensure the long-term survival of each population.

It is necessary to determine the number of individuals needed to ensure the long-term survival of each population.

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III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated cost for the recovery program for the endangered plants *Lipochaeta venosa* and *Isodendrion hosakae*, 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, agencies responsible for committing funds, and lastly, estimated costs. Estimated costs include salaries and staff time. The agencies responsible for committing funds are not, necessarily, the entities that will actually carry out the tasks. When more than one agency is listed as the responsible party, an asterisk is used to identify the lead entity.

The actions identified in the implementation schedule, when accomplished, should protect habitat for the species, stabilize the existing populations and increase the population sizes, and establish populations where necessary so that both species occur on all six of the Parker Ranch sites. Monetary needs for all parties involved are identified to reach this point.

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

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

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

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

Key to Acronyms Used in Implementation Schedule

ES - Fish and Wildlife Service, Ecological Services, Honolulu, Hawaii

DLNR - Hawaii Department of Land and Natural Resources

HHL - Department of Hawaiian Home Lands

PR - Parker Ranch

NBS - National Biological Survey

Key to Other Codes Used in Implementation Schedule

C - Continuous

O - Ongoing (already begun as of writing of plan)

Recovery Plan Implementation Schedule for Isodendrion hosakae and Lipochaeta venosa.

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comments
Need 1 (Secure and stabilize existing populations)											
1	11	Secure habitat.	2	ES*	2	1	1				
				DLNR	0.5	0.25	0.25				
				PR	0.5	0.25	0.25				
1	12	Confirm current status of species.	1	ES*	1		1				
				DLNR	0.5		0.5				
1	1311	Control ungulate damage at Site #1.	O	ES*	2.75	1	1	0.25	0.25	0.25	
				DLNR	2.75		2	0.25	0.25	0.25	
				PR	1.75		1	0.25	0.25	0.25	
1	1312	Control ungulate damage at Site #2.	C	ES*	31.75	1	30	0.25	0.25	0.25	
				DLNR	18.75		18	0.25	0.25	0.25	
				PR	12.75		12	0.25	0.25	0.25	
1	1313	Control ungulate damage at Site #3.	C	ES*	36.75	1	35	0.25	0.25	0.25	
				DLNR	18.25		17.5	0.25	0.25	0.25	
				PR	18.25		17.5	0.25	0.25	0.25	
1	1314	Control ungulate damage at Site #4.	C	ES*	61.75	1	60	0.25	0.25	0.25	
				DLNR	61.5		36	0.25	0.25	0.25	
				PR	24.75		24	0.25	0.25	0.25	
1	1315	Control ungulate damage at Site #5.	C	ES*	61.75	1	60	0.25	0.25	0.25	
				DLNR	36.75		36	0.25	0.25	0.25	
				PR	24.75		24	0.25	0.25	0.25	
1	1316	Control ungulate damage at Site #6.	C	ES*	31.75	1	30	0.25	0.25	0.25	
				DLNR	18.75		18	0.25	0.25	0.25	
				PR	12.75		12	0.25	0.25	0.25	
1	1317	Control ungulate damage at Site #7.	C	ES*	31.75	1	30	0.25	0.25	0.25	
				DLNR	18.75		18	0.25	0.25	0.25	
				HHL	12.75		12	0.25	0.25	0.25	
1	132	Control feral ungulates outside of exclosures.	C	DLNR*	8		2	2	2	2	
				PR	8		2	2	2	2	
1	1411	Reduce fire conditions at Site #1.	C	DLNR*	6		1.5	1.5	1.5	1.5	
				ES	6		1.5	1.5	1.5	1.5	
				PR	2		0.5	0.5	0.5	0.5	

Recovery Plan Implementation Schedule for Isodendrion hosakae and Lipochaeta venosa.

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comments
2	325	Establish and expand at Site #5.	6	DLNR* ES	4 8				2 4	2 4	
2	326	Establish and expand at Site #6.	6	DLNR* ES	4 8				2 4	2 4	
2	327	Expand subpopulation at Site #7.	6	DLNR* ES	4 8				2 4	2 4	
		Need 3 (Expand subpopulations)			132	0	0	20	62	62	
Need 4 (Validate recovery objectives)											
3	41	Conduct demographic and life history studies of populations.	3	ES DLNR NBS*	0 0 0						
3	42	Determine number of subpopulations needed for long-term survival.	3	ES* DLNR	0 0						
3	43	Determine number of individuals needed for long-term survival.	3	ES* DLNR	0 0						
		Need 4 (Validate recovery objectives)			0	0	0	0	0	0	
		TOTAL COST			1022.75	19.5	565	127.75	157.75	152.75	

Recovery Plan Implementation Schedule for Isodendrion hosakae and Lipochaeta venosa.

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comments
1	1412	Reduce fire conditions at Site #2.	C	DLNR*	6		1.5	1.5	1.5	1.5	
				ES	6		1.5	1.5	1.5	1.5	
				PR	2		0.5	0.5	0.5	0.5	
1	1413	Reduce fire conditions at Site #3.	C	DLNR*	6		1.5	1.5	1.5	1.5	
				ES	6		1.5	1.5	1.5	1.5	
				PR	2		0.5	0.5	0.5	0.5	
1	1414	Reduce fire conditions at Site #4.	C	DLNR*	4.5			1.5	1.5	1.5	
				ES	4.5			1.5	1.5	1.5	
				PR	1.5			0.5	0.5	0.5	
1	1415	Reduce fire conditions at Site #5.	C	DLNR*	4.5			1.5	1.5	1.5	
				ES	4.5			1.5	1.5	1.5	
				PR	1.5			0.5	0.5	0.5	
1	1416	Reduce fire conditions at Site #6.	C	DLNR*	4.5			1.5	1.5	1.5	
				ES	4.5			1.5	1.5	1.5	
				PR	1.5			0.5	0.5	0.5	
1	1417	Reduce fire conditions at Site #7.	C	DLNR*	6		1.5	1.5	1.5	1.5	
				ES	6		1.5	1.5	1.5	1.5	
				HHL	2		0.5	0.5	0.5	0.5	
1	142	Develop fire response and suppression plans.	1	DLNR*	2		2				
				ES	1		1				
				PR	1		1				
				HHL	1	1					
1	151	Carry out alien plant control.	C	DLNR*	10	2	2	2	2	2	
				ES	10	2	2	2	2	2	
1	152	Restore native plant species.	5	DLNR*	0						
				ES	0						
1	16	Establish/support a scientifically-managed germ plasm reserve for both species.	3	DLNR*	18			6	6	6	
				ES	12			4	4	4	
				NTBG	18			6	6	6	
		Need 1 (Secure and stabilize population)			697.75	13.5	523	53.75	53.75	53.75	

Recovery Plan Implementation Schedule for Isodendrion hosakae and Lipochaeta venosa.

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comments
Need 2 (Research factors limiting expansion of populations)											
2	211	Evaluate impact of removing alien plants.	5	DLNR	5	1	1	1	1	1	
				ES	5	1	1	1	1	1	
				NBS*	20	4	4	4	4	4	
2	212	Devise methods for alien plant control.	3	DLNR	3			1	1	1	
				ES	3			1	1	1	
				NBS*	6			2	2	2	
2	221	Research reproductive biology and cultivation of L. venosa.	5	DLNR	11		3	4	2	2	
				ES	11		3	4	2	2	
				NBS*	22		5	7	5	5	
2	222	Research reproductive biology and cultivation of I. hosakae.	5	DLNR	11		3	4	2	2	
				ES	11		3	4	2	2	
				NBS*	22		5	7	5	5	
2	23	Determine habitat requirements of both species.	5	DLNR	4		1	1	1	1	
				ES	16		4	4	4	4	
				NBS*	16		4	4	4	4	
2	24	Investigate pollinators of each species.	3	DLNR	3		1	1	1		
				ES	6		2	2	2		
				NBS*	6		2	2	2		
		Need 2 (Research factors limiting expansion)			181	6	42	54	42	37	
Need 3 (Establish and expand subpopulations)											
2	31	Propagate genetically suitable plants.	6	DLNR*	30			10	10	10	
				ES	30			10	10	10	
2	321	Expand subpopulation at Site #1.	6	DLNR*	4				2	2	
				ES	8				4	4	
2	322	Expand subpopulation at Site #2.	6	DLNR*	4				2	2	
				ES	8				4	4	
2	323	Establish and expand at Site #3.	6	DLNR*	4				2	2	
				ES	8				4	4	
2	324	Establish and expand at Site #4.	6	DLNR*	4				2	2	
				ES	8				4	4	

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