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RECOVERY PLAN FOR
CHAMAESYCE SKOTTSBERGII var. SKOTTSBERGII
AND ACHYRANTHES SPLENDENS var. ROTUNDATA

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Portland, Oregon

DRAFT

Approved: _____
Regional Director, U.S. Fish and Wildlife Service

Date: _____

THIS IS THE COMPLETED RECOVERY PLAN FOR CHAMAESYCE SKOTTSBERGII var. SKOTTSBERGII AND ACHYRANTHES SPLENDENS var. ROTUNDATA. 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

This recovery plan for Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata was initially prepared by Ken Nagata, Kaneohe, Hawaii. Modifications have been made by the U.S. Fish and Wildlife Service.

EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR
CHAMAESYCE SKOTTSBERGII var. SKOTTSBERGII AND
ACHYRANTHES SPLENDENS var. ROTUNDATA

Current Species Status: Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata are both federally listed as endangered species. They were listed as Euphorbia skottsbergii var. kalaeloana and Achyranthes rotundata, respectively. There are currently two regions in which each species occurs.

Chamaesyce skottsbergii var. skottsbergii occurs in four populations on the 'Ewa Plain of the island of O'ahu and four populations on the island of Moloka'i. The 'Ewa Plain populations are approximated at several hundred plants (with the majority occurring in one population), and the Moloka'i populations number over 30,000 plants. Achyranthes splendens var. rotundata occurs also on the 'Ewa Plain as well as on Ka'ena Point, both on the island of O'ahu. The four 'Ewa Plain populations number approximately 1,400 plants. The three Ka'ena populations number approximately 70 plants.

Habitat Requirements and Limiting Factors: On the 'Ewa Plain, both species occur on limestone substrate characterized by sinkholes and coralline rubble. Only thin soils and pockets of humus are present. However, Chamaesyce skottsbergii var. skottsbergii appears to occur at higher elevations and farther from the shoreline than Achyranthes splendens var. rotundata. As a result of decades of habitat alteration, no native plant communities remain on the 'Ewa Plain. Both species exist in open or closed forests dominated by kiawe (Prosopis pallida), an introduced species. Koa haole (Leucaena leucocephala), another introduced species, is the dominant shrub, although other plants

such as Pluchea spp. and naio (Myoporum sandwicense) also occur in the area (AECOS 1981).

Three populations of Achyranthes splendens var. rotundata occur near the base of the talus slopes along the western coast of O'ahu just south of Ka'ena Point. Rock debris covers more than 50 percent of the surface and the soils are sparse and well-drained. Thickets of koa haole dominate these slopes.

Chamaesyce skottsbergii var. skottsbergii on Moloka'i are found on lithified and raised limestone while the populations along the western coast occur on basaltic substrata. It is found in predominantly native communities.

Current threats are habitat loss due to development (including nearly complete loss of native habitat in the 'Ewa Plain), invasion of habitat by alien and parasitic native plant species, fire, infestation by damaging insects, destruction by cattle and feral animals, trampling by humans, potential runway disaster, natural disaster, over-utilization for commercial use (in the case of Achyranthes), and chemical spills and pollutants.

Recovery Objective: Downlist to threatened status.

Recovery Criteria: In order to consider downlisting for either taxon, there must be at least three self-reproducing populations with a minimum of 1,000 reproductive plants per population in each of the two geographically distinct regions in which they occur. Populations should be growing beyond or stable at the minimum size and threats should be removed or controlled for at least ten years prior to downlisting. Land area for each of these populations should be sufficient to provide a buffer of 30-50 meters around the expanded population. The population containing 30,000

Chamaesyce skottsbergii var. skottsbergii plants on Moloka'i should be maintained at this number.

Actions Needed:

1. Protect and manage existing populations.
2. Augment or re-establish populations, if necessary.
3. Validate recovery objectives.

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

<u>Year</u>	<u>Need 1</u>	<u>Need 2</u>	<u>Need 3</u>	<u>Total</u>
1994	81	0	0	81
1995	61.5	0	0	61.5
1996	46.75	0	8	54.75
1997	32.25	TBD	9	41.25
1998	31.5	TBD	0	31.5
1999	30	TBD	0	30
2000	31.5	TBD	0	31.5
2001	30	TBD	0	30
2002	31.5	TBD	0	31.5
2003	30	TBD	0	30
2004	30	TBD	0	30
2005	28.5	TBD	0	28.5
2006	30	TBD	0	30
2007	28.5	TBD	0	28.5
2008	30	TBD	0	30
2009	28.5	TBD	0	28.5
<u>Total</u>	<u>581.5</u>	<u>TBD*</u>	<u>17.0</u>	<u>598.5</u>

* TBD - To Be Determined

Date of Recovery: Downlisting to Threatened should initiate in 2009, if recovery criteria are met.

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RECOVERY PLAN FOR CHAMAESYCE SKOTTSBERGII var. SKOTTSBERGII AND
ACHYRANTHES SPLENDENS var. ROTUNDATA

I. INTRODUCTION

1. BRIEF OVERVIEW

In the millennium since the first Polynesian colonists arrived in Hawai'i, and especially in the 200 years since the Western discovery of the islands, habitat alteration and the concomitant extinction of Hawai'i's unique biota have proceeded at a rapid pace. Today, agricultural and urban development have encroached upon much of the native habitat located in the lowland areas of the State. The nearly complete habitat destruction in the 'Ewa Plain of O'ahu is an example of such habitat loss.

Chamaesyce skottsbergii (Sherff) Croizat & Degener var. skottsbergii of the Euphorbiaceae (spurge) family and Achyranthes splendens Mart. ex Moq. var. rotundata Hillebr. of the Amaranthaceae (amaranth) family are both found in the Barbers Point region of the 'Ewa Plain on the island of O'ahu. A. splendens var. rotundata also occurs in the Ka'ena region of O'ahu and C. skottsbergii var. skottsbergii also occurs on west Moloka'i. C. skottsbergii var. skottsbergii is still found in spots throughout its known historic range. A. splendens var. rotundata is believed extirpated on the islands of Lana'i and Moloka'i (USFWS 1986).

Chamaesyce skottsbergii var. skottsbergii was listed as endangered on 24 August 1982, as Euphorbia skottsbergii var. kalaeloana, (USFWS 1982) (See TAXONOMY section). Critical habitat was not designated because, at the time of listing, this species was known only from the Barbers Point region on O'ahu where the

ecosystem had been altered to such an extent that it was deemed no longer essential to its conservation (USFWS 1982).

Achyranthes splendens var. rotundata was listed as endangered on 26 March 1986, as Achyranthes rotundata (USFWS 1986) (See TAXONOMY section). Critical habitat was not designated for fear that publicity would attract undesirable attention to the plants and their location (USFWS 1986). Maps and/or descriptions of the exact locations of known individuals will not be included in this Plan due to the possibility that vandalism or unauthorized collection could be encouraged by public release of this information. The U.S. Fish and Wildlife Service (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.

2. TAXONOMY

(1) Chamaesyce. Chamaesyce skottsbergii var. skottsbergii was first collected on O'ahu in 1912 by C. N. Forbes and C. M. Cooke Jr., near Sisal on the 'Ewa Plain. Five more collections were made between Sisal, Pearl Harbor and Barbers Point in the next 24 years. In 1936, Earl Edward Sherff described Euphorbia skottsbergii, separating out var. kalaeloana (the variety listed as endangered) based on plant habit and leaf characters. He also described two other varieties, var. audens and var. vaccinioides, from west Moloka'i (Sherff 1936). Shortly thereafter, Otto Degener and Leon Croizat, convinced that the subgenus Chamaesyce was distinct at the generic level, transferred the taxa to Chamaesyce (Degener and Croizat 1936). This combination was retained in the most recent treatment of the genus (Koutnick and Huft 1990), but the characters distinguishing varieties audens and kalaeloana were found to be without taxonomic merit. These two

subspecific taxa, as well as Euphorbia multiformis var. kapukiensis f. pekelonis were included in C. skottsbergii var. skottsbergii. Variety vaccinioides was retained.

Nine collections of Chamaesyce skottsbergii var. skottsbergii are known historically from the 'Ewa Plain and eight from Moloka'i. The most recent O'ahu collection was made in 1978 and the latest from Moloka'i was made in 1979. Herbarium specimens have been deposited in the Bishop Museum, United States National Herbarium, Field Museum of Natural History, Gray Herbarium, New York Botanical Garden, Missouri Botanical Garden, and Lyon Arboretum. The taxon is known as the 'Ewa Plain 'akoko, 'akoko, koko, 'ekoko and kōkōmālei.

(2) Achyranthes. Achyranthes splendens var. rotundata was first collected by Charles Gaudichaud-Beaupre during the voyage of the Uranie in 1819 and described half a century later by Wilhelm Hillebrand (1888). In 1979, Harold St. John divided A. splendens into five species, raising var. rotundata to specific rank as A. rotundata (Hillebr.) St. John (St. John 1979). Subsequently, Warren L. Wagner, Derral R. Herbst, and Seymour H. Sohmer (1990) found the characters used to separate these entities to be taxonomically insignificant and reinstated var. rotundata Hillebr. They also included in A. splendens var. rotundata, A. maneleensis St. John, which is known from a single collection on Lāna'i, and A. reflexa (Hillebr.) St. John (A. splendens var. reflexa Hillebr.), which is known from a single collection on Moloka'i.

The population of Achyranthes splendens var. rotundata on the 'Ewa Plain has been well-documented with 19 historical collections. In addition, there have been several other collections, most with less specific documentation: seven from the Ka'ena Point area; one from cultivated material; one from "the

Waianae Mts.;" two from "O'ahu;" three from the "Sandwich Islands;" and one each from Lāna'i and Moloka'i. Herbarium specimens have been deposited in the Bishop Museum, Gray Herbarium, Natural History Museum Paris, United States National Herbarium, Lyon Arboretum and University of Hawaii at Manoa Botany Department. No common names have been recorded for the taxon.

3. DESCRIPTION

(1) Chamaesyce. Chamaesyce skottsbergii var. skottsbergii is a perennial, erect to prostrate shrub measuring 0.5 feet (0.2 meters) to 3.3 feet (1 meter) tall (occasionally reaching as tall as 6.6 feet or 2 meters), with brittle, slender, usually jointed branches that are minutely hairy, especially when young (Figure 1). The opposite, two-ranked, oval leaves measure 0.5 to 0.8 inches (12 to 20 millimeters) long and 0.1 to 0.5 inches (3 to 12 millimeters) wide, often have toothed margins, and have a hairless upper surface. Each cyathium (flower cluster resembling a single flower) is situated singly in a leaf axil and consists of a female flower made up of one pistil surrounded by several male flowers, each with a single stamen. The green capsules are 0.06 to 0.08 inches (1.5 to 2 millimeters) in length, have a curved stalk, and open to release gray to brown seeds measuring from 0.04 to 0.05 inches (1 to 1.3 millimeters) long. This species differs from other Hawaiian members of the genus by the combination of the following characters: its growth habit; its leaf arrangement; its curved capsule stalk; and the presence and length of the leaf stalk. Chamaesyce skottsbergii var. skottsbergii can be distinguished from var. vaccinoides, the only other subspecific taxon, by its smaller size and its wider, often toothed leaves (Koutnik and Huft 1990).

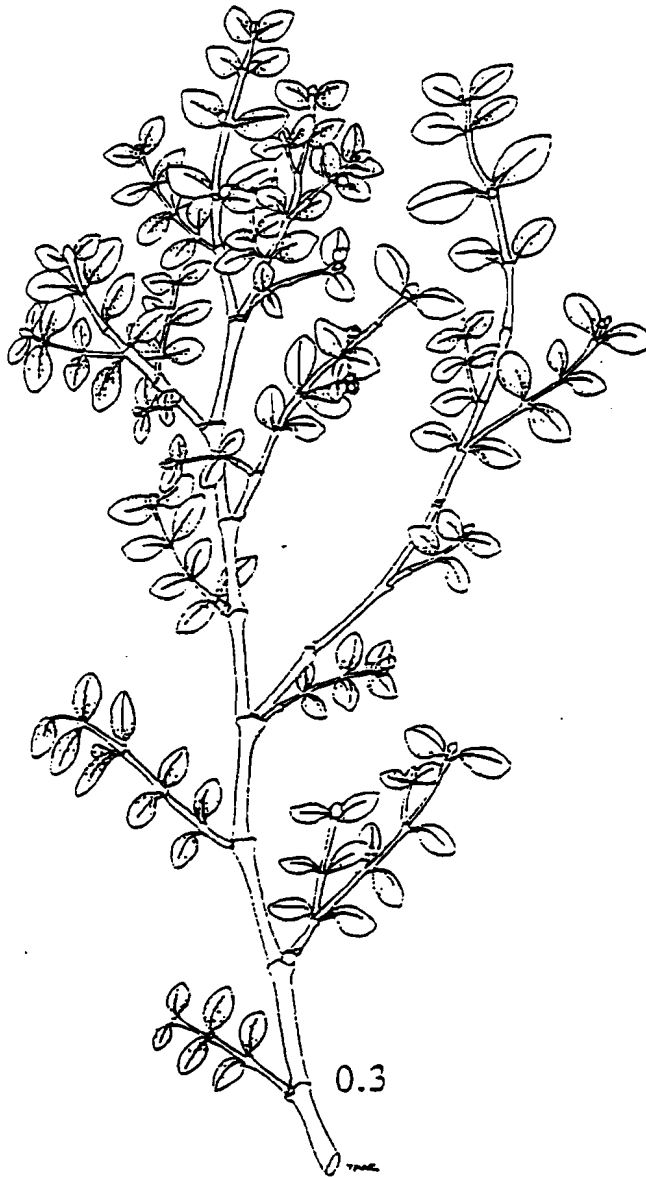


Figure 1. Habit of Chamaesyce skottsbergii var. skottsbergii (Wagner et. al., 1990).

(2) Achyranthes. Achyranthes splendens var. rotundata is a shrub 1.6 to 6.6 feet (0.5 to 2 meters) tall with opposite, broad, elliptic or nearly circular leaves (Figure 2). The leaves are covered with white silky hairs and measure 0.8 to 4.7 inches (2 to 12 centimeters) long and 0.6 to 2.9 inches (1.5 to 7.3 centimeters) wide. Flowers are arranged in 1.2 to 9.8 inch (3 to 25 centimeter) spikes (unbranched clusters of unstalked flowers) which are covered with white hairs, and located at the ends of the stems. Each flower has sepals about 0.3 inches (6.5 to 8 millimeters) long and is subtended by three spine-tipped bracts. The one-seeded, unopening fruit is 0.06 to 0.1 inches (1.5 to 3 millimeters) long. This species is distinguished from others of the genus by its growth habit, its white silky hairs, its congested flowering stalk, and the length of its sepals. This variety intergrades with var. splendens but has shorter sepals (Wagner et al. 1990).

4. HISTORIC RANGE AND POPULATION STATUS

(1) Chamaesyce. Chamaesyce skottsbergii var. skottsbergii has historically been restricted to the arid coral plain of 'Ewa, O'ahu, and arid coastal sites on northwestern Moloka'i (HHP 1991a; Figures 3 and 4). On O'ahu, C. skottsbergii var. skottsbergii was known to have occurred on the 'Ewa Plain between Sisal, Pearl Harbor and Barbers Point. It is possible that it was a common element in the original ecosystem that existed on the Plain, although, judging by the paucity of collections made, the population may have been reduced to scattered remnants by the turn of the century. It may have remained rather common in pockets, however, as it was recorded by F. R. Fosberg as "abundant" in one locality in 1936. Subsequent to this finding, the taxon was not

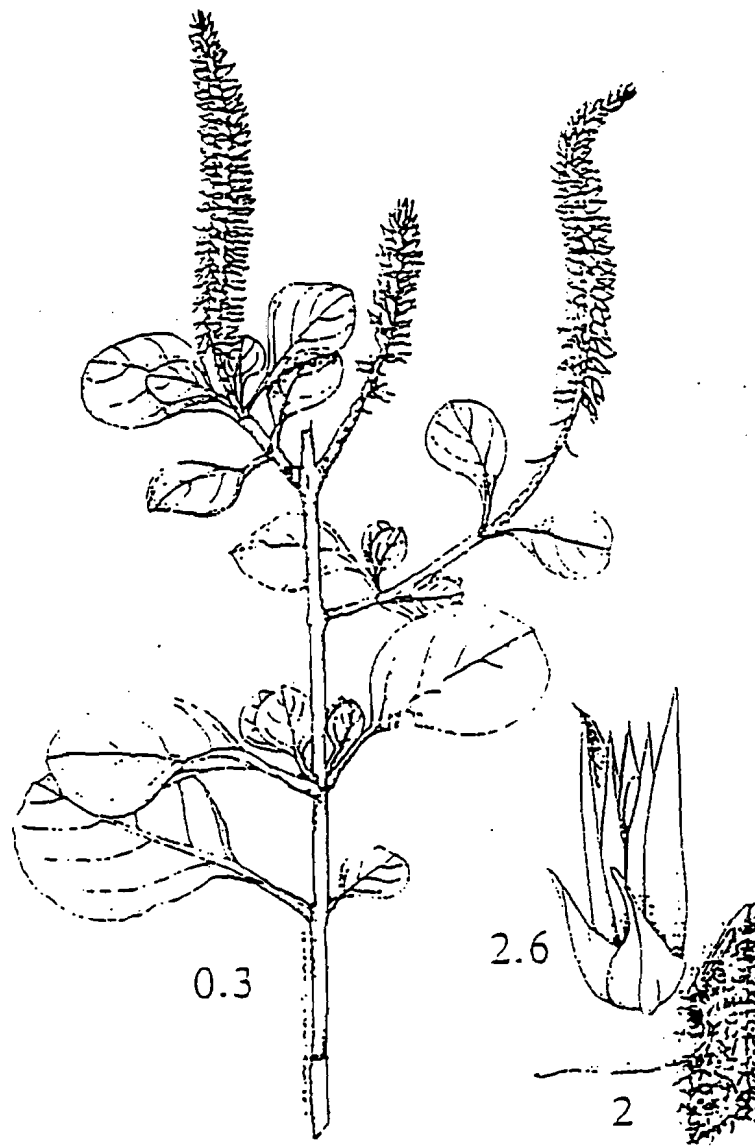


Figure 2. Habit of Achyranthes splendens var. rotundata (Wagner et. al., 1990).

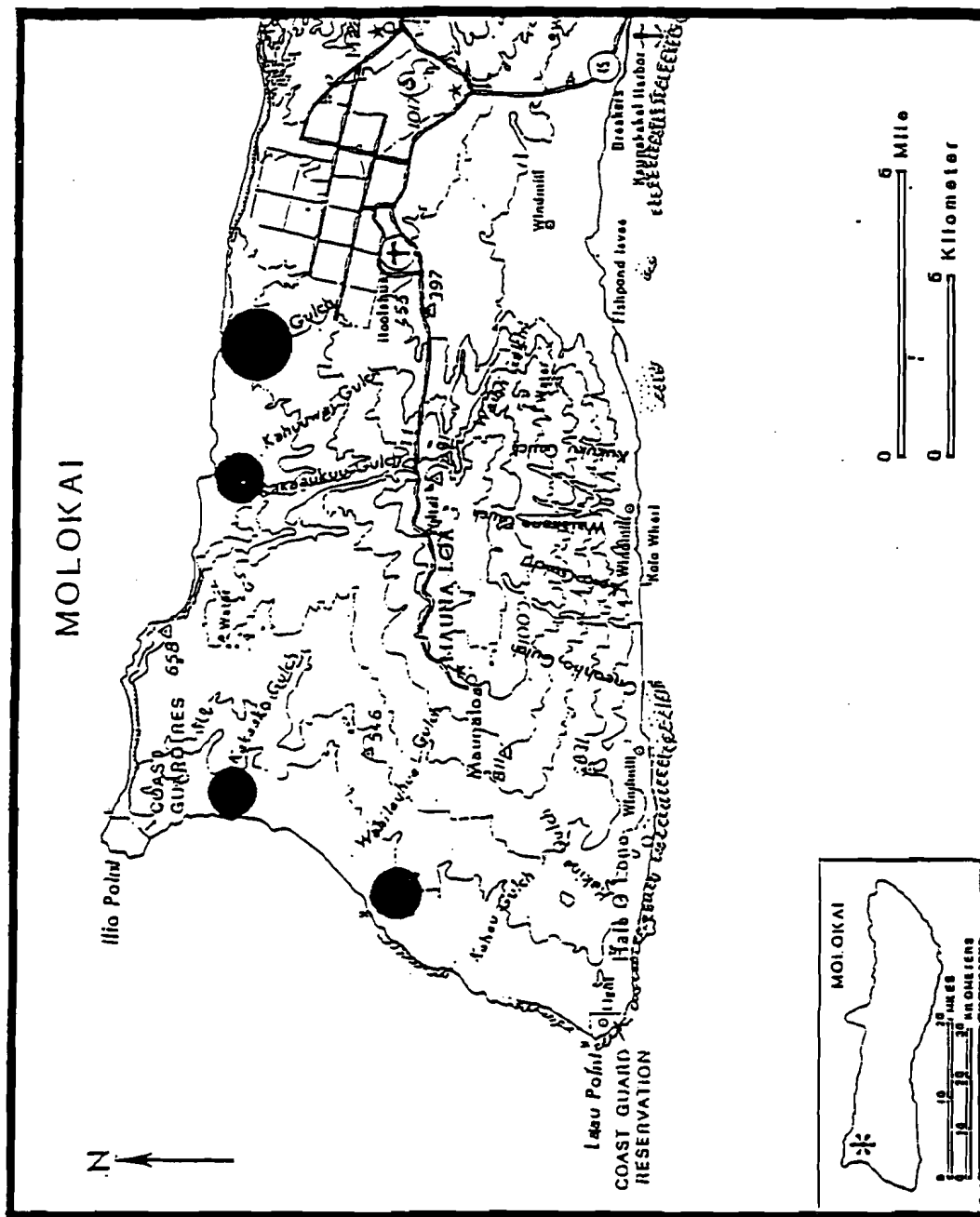


Figure 4. Distribution of *Chamaesyce skottsbergii* var. *skottsbergii* on Moloka'i.

documented again for 40 years and was presumed extinct. It was rediscovered in 1976 in the vicinity of what is now the deep-draft harbor. Isolated populations and individuals have since been discovered at Barbers Point Naval Air Station and in Campbell Industrial Park.

On Moloka'i, the eight known collections of Chamaesyce skottsbergii var. skottsbergii are from various localities along the island's northwest coast from Waiakanapō and Pōhakumāuliuli to Mo'omomi. No indications of abundance were noted in the early collections.

(2) Achyranthes. Historically, Achyranthes splendens var. rotundata was found on the 'Ewa coral plain of O'ahu, along the western coast from Ka'ena Point to Mākua at the northwest tip of the island (Figure 5), and on Lana'i and Moloka'i (Figure 6) (HHP 1991b). It was common to abundant on the 'Ewa Plain, rare in the Ka'ena Point area, and very rare on Lāna'i and Moloka'i (HHP 1991b).

Although no records exist, Achyranthes splendens var. rotundata may have been distributed all along the arid and semi-arid coast between Ka'ena Point and Barbers Point on O'ahu. It may have been a prominent element in the original 'Ewa Plain ecosystem as it still persisted in moderate to large numbers well after the turn of the century. According to herbarium labels, it was regarded as "frequent" in 1937 and "common" as recently as 1968. A. splendens var. rotundata apparently has always been rare in the Ka'ena Point area, as it was collected only seven times between 1911 and 1958 (Joel Lau, The Nature Conservancy Hawai'i, personal communication 1991).

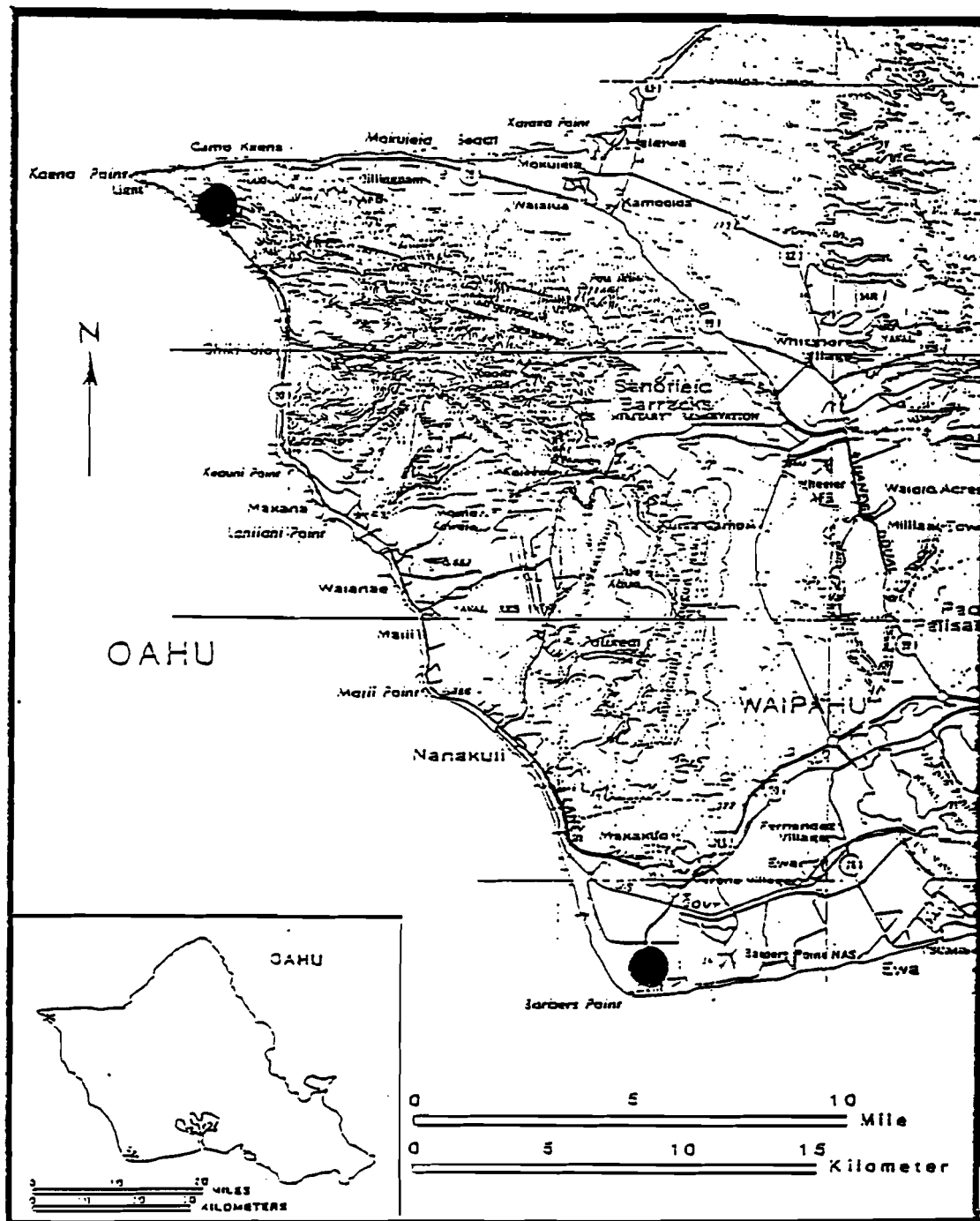


Figure 5. Distribution of Achyranthes splendens var. rotundata on O'ahu.

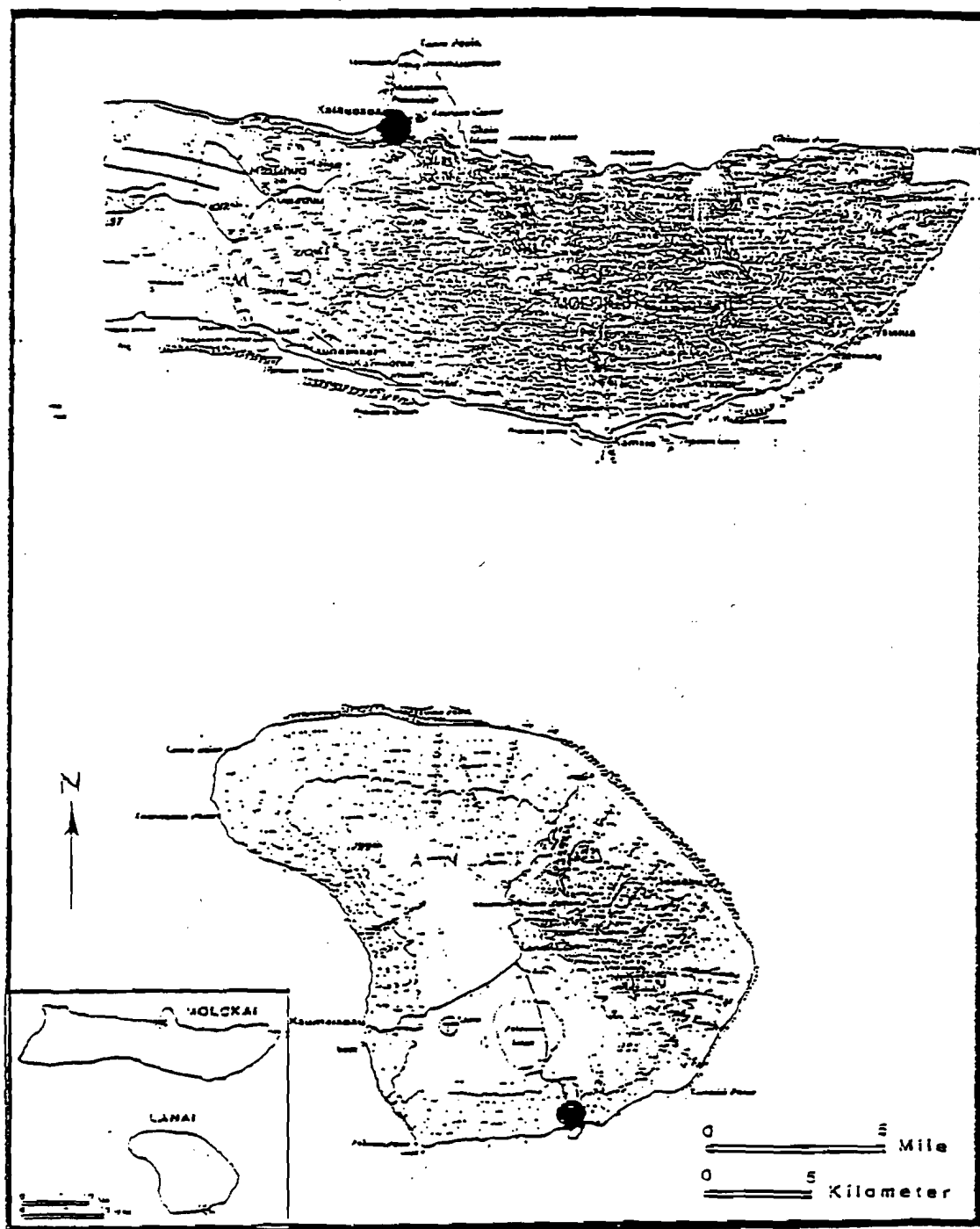


Figure 6. Former distribution of Achyranthes splendens var. rotundata on Lana'i and Moloka'i.

Achyranthes splendens var. rotundata was collected once on Lāna'i at Mānele Bay in 1910 (later described as Achyranthes maneleensis by St. John (1979)), and once on Moloka'i on the cliffs behind Kalaupapa sometime prior to 1871 (HHP 1991b). This specimen was later described and named A. reflexa by St. John (1979).

5. CURRENT RANGE AND POPULATION STATUS

(1) Chamaesyce. Chamaesyce skottsbergii var. skottsbergii remains extant in its historical range. There are currently four known populations on the 'Ewa Plain region of O'ahu and four in northwestern Moloka'i. Some of these may once have been part of the same population and subsequently isolated.

Most of the current Chamaesyce skottsbergii var. skottsbergii plants on O'ahu are in the vicinity of Barbers Point Naval Air Station (Table 1; HHP 1991a). Three populations (some largely extirpated) may exist on the Naval Air Station itself, and one exists just west of it. A thorough survey of the area needs to be conducted to obtain more accurate population estimates.

Records indicate that Population 1 consisted of approximately 5,000 plants as of 1983 (HHP 1991a). This population continues to exist today but recent site visits reveal that this population probably occurs in numbers at least an order of magnitude smaller (Marie Bruegman, U.S. Fish and Service, personal communication 1994) and may be as small as 100 plants (Dan Moriarty, U.S. Navy, personal communication 1994).

In 1984, Population 2, located in the northwestern portion of the Air Station, consisted of approximately 20 plants (HHP 1991a). This estimate probably remains valid (M. Bruegman, personal communication 1994). Seven plants were found during a

Table 1. Populations of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata.

Chamaesyce skottsbergii var. skottsbergii

Population #	Location	Number of Plants
'Ewa Plain, O'ahu		
1	NAS Barbers Point	100 - 500
2	NAS Barbers Point	20
3	NAS Barbers Point	?
4	West of NASBP	30
Moloka'i		
5	Na'aukahihi	30,000
6	Mo'omomi	3,000
7	Mo'omomi	200
8	Papohaku Beach	?

Achyranthes splendens var. rotundata

Population #	Location	Number of Plants
'Ewa Plain, O'ahu		
1	NAS Barbers Point	86
2	Cook Inlet	65
3	Lighthouse Point	49
4	Campbell Industrial Park	1,187
Ka'ena Point, O'ahu		
5	closest to Point	7
6	further south	9
7	southernmost	55

1993 survey of a portion of this area (Whistler 1993), and four additional plants were found by Service and Hawaii Department of Land and Natural Resources personnel on a survey of a different portion of this area in January 1994 (C. Corn, personal communication 1994).

Population 3, unknown in number, was transplanted to a runway clear zone of the air station from other populations (Stan Kato, Barbers Point Naval Air Station, personal communication 1992). The populations from which Population 3 was transplanted were virtually eliminated by the construction of the Barbers Point Deep Draft Harbor and associated facilities (Carolyn Corn, Hawai'i Department of Land and Natural Resources, personal communication 1991). In 1992, Population 3 consisted of only a half-dozen individuals, and the population may not persist for much longer (L. Mehrhoff, personal communication 1993).

Population 4, located just west of the Air Station, consisted of 30 plants in 1980 (HHP 1991a), and remains extant today (E. Shigaki, personal communication 1993).

Of the four extant Moloka'i populations, at least 30,000 plants are estimated to occur between Naaukahihi and Anahaki Gulch (Population 5), at least 3,000 on the Mo'omomi Preserve inland of Kalani (Population 6), and at least 200 on the Mo'omomi Preserve along the Preserve Road (Population 7) (HHP 1991a). No estimate has been made for the Population 8 between Papohaku Beach and Kaunala Bay (HHP 1991a).

(2) Achyranthes. Achyranthes splendens var. rotundata is now considered restricted to the island of O'ahu in the 'Ewa Plain and Ka'ena regions (HHP 1991b). The taxa has not been seen on Lāna'i and Moloka'i in over 70 years and are presumed extirpated (USFWS 1985). When the final rule was published establishing

A. splendens var. rotundata as an endangered species in 1986, the total number of plants in the 'Ewa Plain region was estimated to be about 400 and the Ka'ena Point population was believed to consist of two plants (USFWS 1986). In 1987, three populations, totalling approximately 70 plants, were discovered in the Ka'ena region (J. Lau, personal communication 1991). There are currently four known populations on the 'Ewa Plain and three near Ka'ena Point. Some of these may once have been part of the same population and subsequently isolated.

There are presently four populations of Achyranthes splendens var. rotundata in the Barbers Point area. In 1991, Population 1 consisted of 86 plants within a 240 square meter (287 square yard) area of the Naval Air Station, but the habitat was found overgrown with kiawe and other alien species (HHP 1991b). Population 2 consisted of 65 plants as of 1985 (HHP 1991b). This population has since been fenced, and all land around it has been bulldozed and broken up into lots for a new industrial park.

Populations 3 and 4 saw a dramatic decline in the 1980s, although the latter was augmented in 1991. Population 3, which occurs on both Federal land and land owned by the Campbell Estate, has been bulldozed. In May 1985, there were 212 plants found on Federal land (D. Herbst, unpublished data), and in 1991, the number for the population had declined to 49 individuals (HHP 1991b). The vegetation is heavily beset with Cassytha filiformis.

Population 4 occurs in three separate, fenced colonies, two of which are surrounded by bulldozed land, and one of which is adjacent to an industrial plant. Two of these sanctuaries were created in 1990 when, through various permits and under obligation to preserve the population in situ, the lessee of that parcel was allowed to develop most of the land (see discussion under Conservation Efforts). The third sanctuary, consisting of nursery

stock, was established adjacent to the industrial plant. A total of 1,187 plants were observed in the three sanctuaries in 1991 amidst competing non-native species such as kiawe (Prosopis pallida) and koa haole (Leucaena leucocephala) (HHP 1991b).

The three Ka'ena populations occur along the coast on the west-facing talus slope just south of Ka'ena Point. The species is rare in all three locations (HHP 1991b). Closest to the Point, seven plants were observed in 1991; two mature and five juvenile. Further south, 8 flowering plants and 1 seedling were discovered in 1987. The southernmost population consisted of 55 mature plants of various ages and two juveniles in 1991.

6. LIFE HISTORY

(1) Chamaesyce. In anticipation of Chamaesyce skottsbergii var. skottsbergii being listed as an endangered species, the United States Army Corps of Engineers initiated by contract a detailed study of the taxon's population biology, reproductive ecology, phenology, and horticulture (AECOS 1981). The following observations result from this study.

The phenology of Chamaesyce skottsbergii var. skottsbergii is strongly correlated with seasonal rainfall and drought. Plant growth and flowering occur with the onset of the winter rains and continue through the wet season. The onset of the dry season causes a reduction in these activities, and the plants lose their leaves and become dormant during the peak of the summer drought. The length of the wet season and intensity of the summer drought are the controlling factors in the population dynamics of the taxon, as survival of the seedlings is extremely dependent on moisture availability.

Although seed germination rates were found to be rather low (10 to 30 percent), the sheer abundance of seed produced often results in the appearance of many seedlings after the first heavy rains. Subsequent survival of the seedlings is dependent on the frequency and abundance of winter rains as well as microsite suitability.

Seedlings survive best on coralline substrate in semi-shaded sites which do not dry out as quickly as sunny, exposed sites. Chamaesyce skottsbergii var. skottsbergii plants grow slowly and require insect pollinators for adequate fertilization. These insects are non-native "generalists," i.e., widespread and non-host specific. Seeds, distributed by explosive discharge from their capsules, have no germination inhibitors in their seed coats and are not dependent on exposure to sunlight for germination (AECOS 1981).

(2) Achyranthes. In 1986, the lessee of the land containing Population 4 commissioned an ecological and horticultural study of Achyranthes splendens var. rotundata (Nagata 1986). Research results and field observations indicate that this taxon does not respond as dramatically to seasonality as Chamaesyce skottsbergii var. skottsbergii. More vegetative growth occurs during the wet winter season and, as the dry summer months approach, vegetative growth slows and flowering occurs. In mid-summer to early fall, after fruiting, plants become dormant but do not lose their leaves. Seeds, dispersed by wind and gravity, germinate during the summer.

Preliminary data indicate that seedling survival rates may approach 50 percent between June and September, before the onset of the winter rains. Seedling survival is determined by available moisture, but the moisture required by Achyranthes splendens var.

rotundata appears to be much less than that required by Chamaesyce skottsbergii var. skottsbergii.

Germination rates obtained by private propagators, botanic gardens and arboreta range from 50 to 90 percent and may indicate that no inhibitors are present and no preconditions are necessary for germination. Cultivated plants readily set viable seeds, indicating that specific pollinators are probably not required.

7. HABITAT DESCRIPTION

(1) Chamaesyce.

(a) Barbers Point. The 'Ewa Plain is a broad plain of low relief consisting largely of a reef formed during the Pleistocene when sea level was about 25 feet (7.6 meters) higher than at present. The habitat occupied by Chamaesyce skottsbergii var. skottsbergii, like that of Achyranthes splendens var. rotundata, consists of limestone topography characterized by sinkholes and coralline rubble. However, C. skottsbergii var. skottsbergii appears to occur at somewhat higher elevations and farther from the shoreline than A. splendens var. rotundata (C. Corn, personal communication 1993). The vegetation in this area is almost entirely dependent on calcareous substrate, as only thin soils and pockets of humus are present. Although the entire region suffers from prolonged summer drought, the water table is near the ground surface. The water level in the sinkholes rises and falls with the tide, and ground water is probably brought close to the surface by capillary movement within the porous limestone (AECOS 1981).

As a result of decades of habitat alteration, no native plant communities remain on the 'Ewa Plain. Today,

populations of Chamaesyce skottsbergii var. skottsbergii exist in open or closed forests dominated by kiawe (Prosopis pallida) and in ruderal plant communities consisting largely of such weedy species as feathery pennisetum (Pennisetum polystachion), Australian saltbush (Atriplex semibaccata) and swollen fingergrass (Chloris inflata). Other species occurring in the kiawe forests include Pluchea (Pluchea indica and P. symphytifolia), Asystasia (Asystasia gangetica), false mallow (Malvastrum coromandelianum), Achyranthes aspera and 'ilie'e (Plumbago zeylanica). Koa haole (Leucaena leucocephala) is the dominant shrub (AECOS 1981). The coastal strand community is dominated by the indigenous naupaka (Scaevola sericea) and akulikuli (Sesuvium portulacastrum) and exotic species such as pickle weed (Batis maritima). The only other confirmed endangered or threatened plant in the Barbers Point area is Achyranthes splendens var. rotundata (Table 2). The Hawaiian stilt or Ae'o (Himantopus mexicanus knudseni) utilizes the area's wetlands. One Abutilon menziesii plant, also an endangered species, was found in an abandoned canefield in 1981 (Char 81.002, BISH). However, this plant was thought to represent an escape from cultivation descended from the Puako, Hawaii population (Wagner et al., 1990). Maiapilo (Capparis sandwichiana) is a potential candidate for listing (C2) species.

(b) Moloka'i. The population at Mo'omomi is found on lithified and raised limestone in predominantly native communities of 'ilima (Sida fallax), 'āhinahina (Heliotropium anomalum) and another 'akoko species

Table 2. Endangered, Threatened, Proposed, and Candidate taxa occurring with Achyranthes splendens var. rotundata and Chamaesyce skottsbergii var. skottsbergii.

<u>Achyranthes splendens</u> var. <u>rotundata</u> *	Endangered
<u>Abutilon menziesii</u> *	Endangered ^{1,2}
<u>Capparis sandwichiana</u> *	Candidate (C2)
<u>Centaurium sebaeoides</u> ***	Endangered ³
<u>Chamaesyce celastroides</u> var. <u>kaenana</u> ***	Endangered ³
<u>Chamaesyce skottsbergii</u> var. <u>skottsbergii</u> *	Endangered
<u>Chelonia mydas</u> **	Threatened ⁶
<u>Fulica americana alai</u> **	Endangered ⁷
<u>Himantopus mexicanus knudseni</u> */**	Endangered ⁷
<u>Lobelia niihauensis</u> ***	Endangered ³
<u>Marsilea villosa</u> **	Endangered ⁴
<u>Nototrichium humile</u> ***	Endangered ³
<u>Sesbania tomentosa</u> **	Proposed Endangered ⁵
<u>Tetramolopium rockii</u> var. <u>rockii</u> **	Threatened ⁶

* Barbers Point, Oahu

** Mo'omomi Preserve, Molokai

*** Ka'ena Point, Oahu

¹ Believed escaped from Hawai'i population

² To be addressed in Lana'i Plant Cluster Recovery Plan

³ To be addressed in Wai'anae Plant Cluster Recovery Plan

⁴ To be addressed in Marsilea villosa Recovery Plan

⁵ To be addressed in Multi-Island Recovery Plan, if listed

⁶ To be addressed in Moloka'i Plant Recovery Plan

⁷ Addressed in Hawaiian Waterbirds Recovery Plan

⁸ To be addressed in Pacific Sea Turtle Recovery Plan

(Chamaesyce degeneri). Marsilea villosa, listed as endangered, Tetramolopium rockii var. rockii, listed as threatened, and Sesbania tomentosa, proposed for listing as endangered, also occur on the preserve.

The populations along the western coast of Moloka'i occur on basaltic substrata. At Pu'u Koa'i, for example, herbarium labels indicate that they occur on boulder-strewn soils along with native 'āhinahina and pā'ū-o'hi'iaka (Jacquemontia ovalifolia ssp. sandwicensis) (Nagata, unpublished data).

(2) Achyranthes

(a) Barbers Point. The habitat occupied by Achyranthes splendens var. rotundata, like that of Chamaesyce skottsbergii var. skottsbergii, consists of limestone topography characterized by sinkholes and coralline rubble, with only thin soils and pockets of humus present. However, A. splendens var. rotundata populations generally occur closer to the shoreline than those of Chamaesyce skottsbergii var. skottsbergii and may be subject to a higher water table (Nagata 1981).

Achyranthes splendens var. rotundata occurs in the kiawe forest community as well as in an open shrub community characterized by koa haole, marsh fleabane (Pluchea x fösbergii), and the native species, maiapilo (Capparis sandwichiana) and naio (Myoporum sandwicense). Two other taxa of Pluchea, Indian fleabane (P. indica) and sourbush (P. symphytifolia), and such wayside species as Australian saltbush, swollen fingergrass, asystasia, false mallow and feathery pennisetum may also occur in the vicinity. The

only other confirmed endangered or threatened plant in the area is C. skottsbergii var. skottsbergii (Table 2). The Hawaiian stilt or Ae'o (Himantopus mexicanus knudseni) utilizes the area's wetlands. One Abutilon menziesii plant, also an endangered species, was found in an abandoned canefield in 1981 (Char 81.002, BISH). However, this plant was thought to represent an escape from cultivation descended from the Puako, Hawaii population (Wagner et al., 1990). Maiapilo (Capparis sandwichiana) is a potential candidate for listing (C2).

(b) Ka'ena Point. Three populations of Achyranthes splendens var. rotundata occur near the base of the talus slopes along the western coast of O'ahu just south of Ka'ena Point. Rock debris covers more than 50 percent of the surface and the soils are sparse and well-drained. Thickets of koa haole dominate most of these slopes, and the herb layer, when present, consists mostly of buffelgrass (Cenchrus ciliaris) and sourgrass (Digitaria insularis) (Nagata 1981). Chamaesyce celastroides var. kaenana, Gentaurium sebaeoides, Lobelia niihauensis, and Nototrichium humile, all endangered species, also occur in the region.

8. REASONS FOR DECLINE AND CURRENT THREATS

(1) Loss of habitat. Direct human-induced loss of habitat is considered the major cause of the decline of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata on the 'Ewa Plain of O'ahu. The history of direct, human-induced disturbance in this area dates back at least 500 years to the first use of sinkholes for cultivation by native

Hawaiians. More intensive disturbances have occurred since the 19th century, when diversified agriculture became widespread throughout the Plain. More recently, urbanization and the establishment of a rock quarry, military bases, Campbell Industrial Park, and the deep draft harbor have contributed to the virtual extinction of the original ecosystem.

Today, approximately 90 percent of the Plain is occupied by residential developments, sugar cane fields, an industrial complex, a deep-draft harbor, military installations and recreational areas. As the need for urban and industrial sites on O'ahu increases, the demand for land in the 'Ewa Plain will also increase. Thus, the continued loss of habitat, albeit completely modified, must still be considered the major threat to both taxa.

Examples of the vulnerability of these species to human-induced habitat destruction have been witnessed in the past decade. In 1980 or 1981, the privately owned land on which a portion of Achyranthes splendens var. rotundata Population 3 is located was bulldozed for a parking lot by the City and County of Honolulu (Nagata, unpublished data). Remnants of that colony were subsequently grubbed and the land used as a gravel and coral dump (Nagata, unpublished data). Only a few plants escaped destruction. This population was also bulldozed in 1984, resulting in a 50 percent loss to the remaining Achyranthes splendens var. rotundata. In another instance, the construction of the Barbers Point Harbor and its associated facilities in 1982 eliminated a substantial portion of the habitat of the known population of Chamaesyce skottsbergii var. skottsbergii at that time. Plants in the vicinity were translocated to the Naval Air Station, but only a handful are estimated to remain in the translocation areas today.

Presently, the closing of Naval Air Station, Barbers Point, and subsequent transfer of land to the State of Hawaii for various uses which have yet to be determined, leaves open the possibility of further habitat loss. Areas where construction and other activities were precluded in the past due to their proximity to the end of runways or restricted areas, may now be open to development.

Loss of habitat of Chamaesyce skottsbergii var. skottsbergii on Moloka'i should not be a problem for Populations #6 and 7 due to their location on a nature preserve. Loss of habitat remains a threat to Populations #5 and 8, and these should be protected in accordance with this plan.

Achyranthes splendens var. rotundata, located at Ka'ena Point, should be protected from habitat loss due to its location on state park land.

(2) Encroachment by alien plant species. In addition to the physical loss of habitat, all populations of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata have been adversely affected by habitat degradation caused by invading alien shrubs and trees. Today, intact native plant communities are non-existent in the 'Ewa Plain; only remnant individuals remain. Aggressive species such as kiawe, Pluchea, Australian saltbush, asystasia and various grasses have altered the natural habitat and are competing with both endangered taxa for space, light, water, and nutrients. Particularly detrimental alien species are: kiawe, which often forms closed-canopied forests; Pluchea x fosbergii, which is extremely aggressive; and, grasses and Asystasia which can prevent seedling establishment.

On Moloka'i, invasion by aggressive weeds is listed by The Nature Conservancy (1991) as a threat to all rare plants on the

Hawaiian Home Lands' Ho'olehua parcel (Population 5), and weed control, specifically kiawe removal, is a part of The Nature Conservancy's management program on the Mo'omomi Preserve on Moloka'i (Populations 6 and 7) (TNCH, 1993). Similar encroachment of alien plants occurs in the Ka'ena Point area.

(3) Parasitism by *Cassytha filiformis*. The parasitic native vine, kauna'oa pehu (*Cassytha filiformis*) has been noted as a possible threat to both taxa in the Barber's Point area (AECOS 1981; Nagata 1981). This vine is locally common at Barbers Point where it enshrouds shrubs and smaller trees. Heavy infestations weaken the host plants, leaving them vulnerable to disease-causing organisms and insect predation.

(4) Fire. Fire must be considered a potential threat for all populations because of the highly localized distribution of both taxa. During long, annual drought periods, vegetation becomes exceptionally dry, particularly in the 'Ewa Plain and in western Moloka'i, and the accumulated litter during these months represents potential fuel for brush fires. In the 'Ewa Plain, residential and industrial development represents an increased threat of fire, although there tends to be a concomitant rise in awareness of such a threat and contingencies for fire are considered in urban planning.

(5) Insect predation. Potentially damaging insects have been reported on both *Chamaesyce skottsbergii* var. *skottsbergii* and *Achyranthes splendens* var. *rotundata*. An unidentified borer, the croton moth caterpillar (*Aechaea janata*), and spiralling white fly (*Aleurodicus dispersus*) have been noted on *Chamaesyce skottsbergii* var. *skottsbergii* (AECOS 1981). The croton moth caterpillar is

known to denude Chamaesyce skottsbergii var. skottsbergii of leaves and flowers (AECOS 1981). A severe infestation of white fly is usually debilitating to its host plants (Borrer, et al. 1981). A lack of seed set has been noted on heavily infested plants since the spiralling white fly has become established at Barbers Point (C. Corn, personal communication 1994).

An unidentified scale has been noted on Achyranthes splendens var. rotundata and an unidentified mite seems to be an occasional pest on cultivated specimens (Nagata, unpublished data). Nematodes (Meloidogyne spp., Pratylenchus spp., Rotylenchulus reniformis) are also known to infest cultivated Achyranthes splendens var. rotundata (Mew 1987).

(6) Destruction by cattle and feral animals. Threats on western Moloka'i include destruction of native ecosystems by feral animals and cattle (TNCH, 1991; Nagata, unpublished data). Ungulates at the Mo'omomi Preserve are actively controlled, although they remain a threat.

At Ka'ena Point, ungulates are not a threat at present, but do represent a potential threat as the range of goats in neighboring areas continues to expand.

(7) Trampling by humans. Chamaesyce skottsbergii var. skottsbergii is a low, rather inconspicuous shrub with brittle stems. It is especially difficult to discern during the dry season when it is dormant and leafless. Plants have been damaged by persons intruding into some of the populations (AECOS 1981).

(8) Runway Disaster. Populations of Achyranthes splendens var. rotundata and Chamaesyce skottsbergii var. skottsbergii occur on either end of one of the runways at NAS Barbers Point. While this

location may, in some ways, have protected them by precluding development in these areas, it also leaves them vulnerable to devastation in the case of a runaway disaster resulting in fire, a chemical spill or physical destruction of the population.

(9) Over-utilization for commercial use. Achyranthes splendens var. rotundata is an attractive shrub with striking silvery-green leaves and prominent spike-like inflorescences. In the past, its leaves and inflorescences were utilized in lei-making (Nagata 1981). This does not represent a threat if State and Federal laws, which prohibit taking of the plant, are adequately enforced.

(10) Natural disasters. The 'Ewa Plain is one of very low relief and inundation by tsunamis is thus a threat. Unusually high tides were recorded at Barbers Point during the tsunamis of 1946 and 1960. Although no damage was reported (Pararas-Carayannis 1977), no structures were located near the coast at that time.

(11) Contamination by ambient pollution or chemical spill. Potential chemical spill or contamination of the soil due to ambient pollution are threats to nearly all populations in the Barbers Point area due to heavy industrial and military activities, and there is a further potential for spread of contamination within the tsunami zone. Indeed, the possibility exists that Achyranthes Population #4 was contaminated by heavy metals from baghouse dust escaping from Hawaiian Western Steel (HWS) in the last two decades. The Estate of James Campbell, which is responsible for resolving ecological concerns resulting from HWS operations, agreed in July 1993 to take soil samples within Population 4 to determine the quantity of baghouse dust

present. In the event that contamination is found to be significant, mitigation will need to be implemented.

Another pollution problem of airborne dust results from rock crushing upwind. This dust coats leaves of Achyranthes plants within the Campbell Industrial Park (Population 4) in dry spells (C. Corn, personal communication 1994).

9. CONSERVATION EFFORTS

(1) Protection

(a) Endangered Species Laws

(i) Federal action. Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata are both listed as endangered species, and are thus subject to the provisions of the Endangered Species Act of 1973, as amended. Chamaesyce skottsbergii var. skottsbergii was listed as Euphorbia skottsbergii var. kalaeloana on 24 August 1982 (USFWS 1982), and Achyranthes splendens var. rotundata was listed as Achyranthes rotundata on 26 March 1986 (USFWS 1986).

(ii) State action. All Hawaiian species listed as endangered by the Federal government are automatically listed as endangered under State law. However, Chamaesyce skottsbergii var. skottsbergii was listed as Euphorbia skottsbergii var. kalaeloana and Achyranthes splendens var. rotundata was listed as Achyranthes rotundata. Because both of these taxonomic name changes involved combining the listed taxa with other varieties, the State of Hawaii does not recognize all populations of these taxa as

endangered. Those that are not recognized as endangered are the four populations of Chamaesyce skottsbergii var. skottsbergii on Moloka'i and the extinct populations of Achyranthes splendens var. rotundata on Lana'i and Moloka'i. All populations in the 'Ewa Plain are subject to the provisions of Chapter 195D, Hawaii Revised Statutes, which govern their taking, possession, import, export and commercial exploitation.

(b) The Nature Conservancy of Hawai'i. In 1988, Mo'omomi Preserve on the island of Moloka'i was established through a cooperative agreement between The Nature Conservancy of Hawai'i and Moloka'i Ranch. This preserve is to be managed in perpetuity by The Nature Conservancy of Hawai'i. Two populations of Chamaesyce skottsbergii var. skottsbergii, numbering over 3,000 plants, occur within this preserve. The natural resources in the preserve have been inventoried, and threats to the environment are currently being identified and management plans developed.

(c) NAS Barbers Point Natural Resources Management Plan. This plan calls for monitoring of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata on a regular basis, but does not call for active management of these species unless their numbers decrease. Formal censuses have not been conducted in recent years, but certain populations are known to have declined. All populations of these species occur in military restricted zones. Presently, several warning signs are posted near the populations, and personnel and military drills are kept from

the area (E. Shigaki, personal communication 1993). This base is slated for closing, and care should be taken to ensure that these populations are secured and managed during and after closure of the base.

(2) Recovery/Mitigation attempts. The natural ecosystems that once existed in the Barbers Point region have been virtually destroyed as a result of decades of human intervention. Indeed, Chamaesyce skottsbergii var. skottsbergii was listed without critical habitat designation because the species is no longer found in native habitat and its present habitat is not considered essential to its conservation (USFWS 1982). As a result, relocation of Chamaesyce populations for the creation of the deep-draft harbor, and the propagation and transplanting of nursery stock was conducted without regard to preservation of ecosystems. Recovery attempts for Achyranthes splendens var. rotundata have thus far consisted of in situ preservation of populations as well as establishment of a new population from nursery stock. In conjunction with the above actions, considerable research on population dynamics, horticulture, and propagation techniques has been conducted on both species, and valuable information has been obtained regarding habitat requirements, propagation, and management of these taxa (AECOS 1981, Nagata 1986).

(a) Chamaesyce. There have been several attempts to relocate Chamaesyce skottsbergii var. skottsbergii from the area where the deep-draft harbor was constructed and one comprehensive study conducted on the taxon. Three excavations of the plants were conducted by nurseries under contract to Campbell Estate, the largest private landowner in the Barbers Point area, and resulted in two

transplantations. A fourth excavation was conducted by the State of Hawai'i and, in spite of obtaining a license to relocate the plants, resulted in distribution of the surviving plants to botanic gardens and arboreta. The Army Corps of Engineers initiated a comprehensive study on the taxon to formulate a conservation/recovery program.

In 1977, Campbell Estate contracted Kawahara Nursery to excavate, propagate, and relocate individuals of Chamaesyce skottsbergii var. skottsbergii from the vicinity of the proposed deep-draft harbor. In October, approximately 360 plants were removed, potted, and held in the nursery and 400 cuttings taken. By April 1978, only 41 plants remained and all cuttings had perished. At this time, 109 additional plants were removed and 1,425 cuttings were taken. All of the cuttings died, but the surviving transplants set seed, and some of the resulting seedlings were potted. In February 1979, 218 plants were field-planted west of the drainage canal and Barbers Point Naval Air Station. By April 1981, all were presumed dead (AECOS 1981).

Another attempt to relocate Chamaesyce skottsbergii var. skottsbergii was made in September 1980 when Green Thumb Nursery, under contract to Campbell Estate, transplanted 742 plants from the harbor site directly to the runway-clear zone adjacent to Hawai'i Raceway Park. An irrigation system with sprinkler heads was installed but no provisions were made for maintenance such as weeding. Within the first month of transplantation and installation, the sprinkler system was found to be largely ineffective. Many Chamaesyce plants were not being watered and neighboring alien vegetation, particularly grasses, grew

vigorously. By December, competition from the alien species had become a serious problem. In March 1981, the irrigation system was stolen, but within the month a drip system was installed and limited remedial maintenance work commenced. In April 1981, 172 plants were inventoried and in July of that year there were 143 survivors (AECOS 1981). F1 progeny were growing near adults.

In its evaluation of the project, AECOS concluded that if a drip irrigation system had been installed at the outset and if some aftercare, e.g. routine maintenance of irrigation lines and weeding, had been provided, the survival rate of the Green Thumb Nursery project may have approached 75 percent as of the time it was evaluated. There are no records of any further activity on this project and, in a brief survey conducted by Navy personnel in February 1992, the area was found to be completely overgrown by alien vegetation. No Chamaesyce plants were observed (S. Kato, personal communication 1992). Approximately ten plants were found in an area which had had minimal maintenance in the spring of 1993 (C. Corn, personal communication 1993).

In June of 1985, the State of Hawai'i Department of Transportation, pursuant to Chapter 195-D, Hawai'i Revised Statutes (State Endangered Species Act), petitioned the State Department of Land and Natural Resources for a permit to relocate the remaining Chamaesyce skottsbergii var. skottsbergii plants from the harbor area. A license was granted to relocate 130 plants, and in 1987, 89 plants were transplanted from the harbor site into a nursery. Forty plants survived and, in late 1987, they were distributed to the following botanic gardens and arboreta: the Honolulu

Botanic Gardens, Lyon Arboretum, and the National Tropical Botanical Garden.

The United States Army Corps of Engineers contracted a consulting firm in 1981 to formulate a recovery program for Chamaesyce skottsbergii var. skottsbergii to compensate for the anticipated impacts of the proposed deep-draft harbor (AECOS 1981). Research conducted included: habitat evaluation vis-a-vis population biology; edaphic conditions; vegetation types; competition; human impact; reproductive ecology; population structure; propagation techniques; and potential sanctuary evaluation. An enormous amount of information was obtained and a comprehensive management plan was presented. The study concluded that Chamaesyce skottsbergii var. skottsbergii can be successfully propagated and reestablished. Eleven recommendations dealing with site selection and preparation and aftercare were presented (AECOS 1981).

(b) Achyranthes. Mitigation plans have been approved by the State of Hawai'i and executed for two of the populations of Achyranthes splendens var. rotundata on the 'Ewa Plain of O'ahu. These populations include Population 4, the largest population of A. splendens var. rotundata, and Population 2.

In the mid 1980s, the lessee of the land supporting Population 4 proposed to develop most of the land and contracted for a study into the feasibility of relocating the plants (Nagata 1986). Data concerning propagation, general horticulture, and maintenance requirements were obtained, and appropriate techniques were recommended. Based on the report, the lessee applied for a State of

Hawai'i license for trial propagation and planting of the taxon in late 1986.

In February 1988, the Hawai'i Department of Land and Natural Resources License granted license No. P-3 to experimentally propagate Achyranthes splendens var. rotundata (Hawaii Project Management, Inc. 1990). The intent of the project was to demonstrate the feasibility of propagating and introducing the taxon elsewhere within its historical range.

These propagation studies demonstrated that Achyranthes splendens var. rotundata can be propagated and successfully cultivated. Of the 2,105 propagules collected from this population (2,000 seeds, 30 transplants and 75 cuttings), 1,156 were successfully propagated and grown at Randy Mew's Nursery in Aina Haina (Nagata 1990). Ultimately, a site within the original habitat area and adjacent to an industrial plant was selected. Another State of Hawai'i license (License P-4) was secured in September 1989 which authorized the planting of the nursery stock of the 1,156 plants into this new site (State of Hawai'i 1989).

In March 1990, a mitigation plan summarizing the results of the propagation trials and detailed plans for the long-term survival of Achyranthes splendens var. rotundata on the property, was approved by the Department of Land and Natural Resources (Hawaii Project Management Inc. 1990). The plan provided for the securing of Population 4 into two sanctuaries which would be fenced but only minimally managed, unless circumstances dictated otherwise. It also described in detail the management plan for the out-plant site for the nursery stock.

In April 1990, the nursery stock was field-planted in the chosen site, and in November 1990, irrigation was terminated (Nagata, unpublished data). As of October 1991, the mortality rate was approximately 11.5 percent and the first generation of volunteer seedlings had produced offspring (Nagata 1991), making the likelihood of successful reestablishment of A. splendens var. rotundata appear promising. In addition, early in 1991, the two areas containing the greatest concentrations of this population of A. splendens var. rotundata were fenced per the mitigation plan, and construction activities commenced on the remaining land.

The land supporting Population 2 was sold by the U.S. Army in October 1983 (Mike Taylor, U.S. Army Corps of Engineers, personal communication 1991). A 1985 survey of the population reported 116 Achyranthes splendens var. rotundata plants (Whistler 1985). In March 1990, a mitigation plan by the lessee, which was prepared for construction of warehouse facilities, was approved by the Hawai'i Department of Land and Natural Resources. Berms were erected enclosing a 0.5 acre parcel of land containing the Achyranthes colony measuring 16 x 40 feet (4.84 x 12.12 meters) and a fence was constructed. The surrounding land has been grubbed and graded.

10. STRATEGY OF RECOVERY

The strategy of recovery calls for existing populations to be protected and managed to eliminate or control threats. Depending on the population, this may entail controlling the encroachment of alien plants and parasitic native plants, fire,

insect infestations, damage by cattle or feral ungulates, trampling by humans, potential runway or natural disasters, chemical spills and pollutants. It is hoped that restoration of habitat, particularly with regard to control of encroaching plants, will enable each population that is not already made up of 1,000 reproductive plants to reach this downlisting objective. Any populations that do not expand naturally will need to be augmented. Re-establishment of three populations of Achyranthes splendens var. rotundata where extirpated populations once existed on the islands of Lana'i and Moloka'i is necessary to meet the delisting objective, as is the persistence of all populations at the recovery goal of a minimum of 1,000 reproductive plants without any human manipulation. Recovery objectives will be evaluated.

II. RECOVERY

1. RECOVERY OBJECTIVE

The objective of this plan is to protect, enhance and manage populations of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata sufficiently to downlist the taxa from endangered to threatened status. The ultimate objective for these taxa is to delist them, completely removing them from Federal protective status.

Downlisting to threatened status

In order to consider downlisting for either taxon, there must be at least three self-reproducing populations with a minimum of 1,000 reproductive plants per population in each of the two geographically distinct regions in which they occur. These numbers were chosen because, based on current knowledge of the species, they are thought to adequately preserve the majority of existing genetic diversity and to protect against extinction due to catastrophic events. Population structures must be indicative of increasing numbers and threats should be removed or controlled for at least ten years prior to downlisting. Land area for each of these populations should be sufficient to provide a buffer of 30-50 meters around the expanded population. The population containing 30,000 Chamaesyce skottsbergii var. skottsbergii plants on Moloka'i should be maintained at this number.

Delisting

In order to consider delisting for either taxon, all criteria for downlisting should be met as well as the following criteria: at least three populations of Achyranthes splendens var.

rotundata with a minimum of 1,000 reproductive plants each should be re-established within the taxon's historical range on the island(s) of Lana'i and/or Moloka'i to ensure against losses due to a catastrophic event affecting the island of O'ahu; all populations should be stable and self-sustaining, with no human manipulation, for a minimum of ten years prior to delisting and expected to remain so into the foreseeable future.

2. RECOVERY NARRATIVE

1. Protect and manage existing populations.

There are presently eight known populations of Chamaesyce skottsbergii var. skottsbergii, four located on the 'Ewa Plain of O'ahu and four on Moloka'i, and seven populations of Achyranthes splendens var. rotundata, two located on the 'Ewa Plain of O'ahu and three in the Ka'ena region of O'ahu.

On the 'Ewa Plain, the habitat of each population of Chamaesyce skottsbergii var. skottsbergii presently located at NAS Barbers Point (with the exception of Population 3) should be protected following the closing of the base. Population 1 should be restored to its last formal population estimate of 5,000 plants. Populations 2 and 4 should be managed to control threats and expanded to a minimum of 1,000 reproductive plants each. Individuals remaining from Population 3 should either be managed to control threats and expanded to a minimum of 1,000 plants or should be transplanted at the owners expense (including followup maintenance for at least three years) to Population 1, 2 or 4.

On Moloka'i, the current range of Chamaesyce skottsbergii var. skottsbergii needs to be protected, specifically with respect to Population 5 (consisting of 30,000 plants) and Population 8. In addition, threats need to be controlled sufficiently to maintain Populations 5 and 6 at their current numbers, and to expand Populations 7 and 8 to a minimum of 1,000 reproductive plants.

Populations of Achyranthes splendens var. rotundata on the 'Ewa Plain should be protected and threats controlled to allow for their expansion. Populations 2 and 4 on the 'Ewa Plain should be maintained or increased in number to preserve the diversity of the gene pool. Populations 1 and 3 should be protected, their habitat restored and their numbers increased to a minimum of 1,000 reproductive plants.

Populations of Achyranthes splendens var. rotundata in the Ka'ena Point region should be protected and threats controlled to allow for expansion in number to a minimum of 3,000 reproductive plants.

11. Protect and manage populations at NAS Barbers Point.

Three Chamaesyce skottsbergii var. skottsbergii populations and one Achyranthes splendens var. rotundata population are located at Barbers Point Naval Air Station.

The Naval Air Station is slated for closing in the near future. The Navy will be required to ensure the long-term protection of the endangered plant species presently located at NAS Barbers Point through the consultation process under Section 7 of the Endangered Species Act. This should include sufficient land mass and long-term management to allow for expansion and eventual recovery of the endangered species found at Barbers Point Naval Air Station.

111. Protect populations at NAS Barbers Point following the closing of the base.

NAS Barbers Point populations must be protected through land transfers, conservation easements, cooperative agreements, leases, or fee purchases.

The closing of NAS Barbers Point provides an opportunity to establish protected areas which can support expanded populations of each taxon, and to work toward their recovery. Establishment of such protected areas should be given the highest priority in examining the means to recover these populations. Other options, including development of conservation easements or cooperative agreements with future landowners may be considered but may not be acceptable to new landowners and may not result in sufficient protected area necessary for recovery of these taxa. Finally, establishment of protected areas would preserve a small portion of vanishing coastal and dryland habitat in the highly developed 'Ewa Plain on O'ahu.

112. Manage populations at NAS Barbers Point following the closing of the base.

Control threats to each population in such a way as to ensure their survival and provide for expansion in the future. Current threats include encroachment by alien species, development for military uses, trampling by humans, insect infestation, fire, and the possibility

of runway disaster. Most of these threats are addressed under the auspices of the Cooperative Agreement for the Conservation and Management of Fish and Wildlife Resources at NAS Barbers Point which exists between the Service, the Navy, the National Marine Fisheries Service and the Hawaii Department of Land and Natural Resources. Threats should continue to be controlled (including the new threat of non-military development) following base closure.

NAS Barbers Point represents one of the few areas in the 'Ewa Plain with undeveloped land in parcels large enough to allow for expansion of current populations, and to supply a buffer area sufficient for providing the proper microhabitat for the species and for protecting against trampling, eradication due to runway disasters, small fires and other human intrusions. Protection and expansion of the populations found on NAS Barbers Point are necessary for securing large, self-perpetuating populations for each of these taxa in the Barbers Point area and thus for reaching the downlisting objectives of this plan. The sites at NAS Barbers Point are integral to the recovery of these endangered plants.

1121. Survey all existing NAS Barbers Point populations.

All four populations should be censused to assess their current status and to re-evaluate threats to their existence.

1122. Control threats posed by encroaching plant species at NAS Barbers Point.

Competition from alien plants as well as from the native parasitic vine Cassytha filiformis, and the resulting habitat degradation have been identified as serious threats to the survival of both species. Particularly invasive species should be removed manually. Under certain conditions (i.e. no wind, isolated from the endangered species, large spray droplet, low volume spray), herbicide may be applied under supervision of an expert. C. filiformis should be eradicated within these populations.

Populations should be monitored as per task #1126 for subsequent encroachment and remedial action taken immediately.

1123. Monitor/control insect infestations at NAS Barbers Point.

Infestations by potentially damaging insects such as the croton moth caterpillar, the spiralling white fly, and unidentified scales and mites have been documented. Although the short-term effects of infestations are known, the frequency and intensity of infestations and their long-term effect on population dynamics are not known. Infestations should be monitored to determine at what level corrective action is required. Because insect pollinators for both taxa are thought to be "generalists," pesticides should be selected for their effectiveness against the target insects and their non-phytotoxic properties.

1124. Reduce risk of fire and verify/establish fire response and suppression plans at NAS Barbers Point.

In order to reduce the risk of fire spreading into these populations, fuel load of dry grasses and other alien species should be reduced (in conjunction with task #1122) and firebreaks established for each NAS population.

Presently, populations of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata are situated in restricted areas where the chances of human-induced fires are minimal, although the possibility of runway disasters which result in fire does exist. Fire response plans should be checked to ensure that the location of endangered plant populations are identified and given a high priority for protection throughout the transition process.

When protection of these populations is transferred to the new landowner(s), fire

response and suppression plans should be developed in conjunction with the local fire department and the State Division of Forestry and Wildlife. All plans should place these populations among the priority areas for protection. A map of the location of the populations should be provided to these agencies so that they are not damaged when responding to fires in the general vicinity and in case of construction or other changes in the surrounding area.

1125. Consider fencing (and maintenance of fencing) of NAS Barbers Point populations.

Following closure of NAS Barbers Point, development of areas close to these populations may create the need for their protection via fencing. Consideration should be given to this protective step. If warranted, fencing should enclose a sufficiently large parcel of land to expand each population to a minimum of 1,000 plants (5,000 plants for Population 1) and to provide a buffer area surrounding it. If fencing is determined to be necessary, it should be maintained until the taxa is downlisted.

1126. Monitor NAS Barbers Point populations annually.

All populations of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata at NAS Barbers Point should be monitored at least twice per year to determine population levels and identify any additional actions that should be taken to produce naturally reproducing populations with a minimum of 1,000 reproductive plants each. This should be coordinated with tasks #1121 and 1123.

12. Protect and manage U.S. Coast Guard Achyranthes Population 3.

Achyranthes splendens var. rotundata Population 3 occurs on both the grounds of the U.S. Coast Guard and land owned by the Campbell Estate. All tasks mentioned here and under

task #13 should be coordinated for the most effective protection and management.

121. Protect U.S. Coast Guard Population 3.

Protect this population via cooperative agreement or long-term easement between the Service and the U.S. Coast Guard.

122. Manage U.S. Coast Guard Population 3.

Control threats to the population in such a way as to ensure its survival and provide for expansion in the future. The area is overgrown with alien plants as well as the native Cassytha filiformis vine. These threats should be controlled as should trampling by humans, possible insect infestation, and fire.

1221. Survey Population 3.

This area was last surveyed for Achyranthes splendens var. rotundata in 1991. Prior to restoration of habitat, the area should be resurveyed. This effort should be coordinated with the Campbell Estate (see task #1321)

1222. Fence and maintain fencing at Coast Guard Population 3.

The Coast Guard Achyranthes splendens var. rotundata Population 3 is surrounded by a low wooden and wire fence and is subject to trespass. This property should be protected with a more sturdy fence, allocating sufficient land mass to allow for expansion of the population and provision of a buffer zone. If possible, efforts to fence this population should be coordinated with the Campbell Estate portion of the population (see task #1323). Fencing should be maintained until taxa is downlisted.

1223. Control threats posed by encroaching plant species at Coast Guard Population 3.

An initial, crucial step to management and eventual expansion of this population is restoration of its habitat, portions of which have been bulldozed in the past decade. To achieve this, invasive species and their growth within the population should be closely monitored and controlled via manual removal or, under certain conditions (i.e. no wind, isolated from the endangered species, large spray droplet, low volume spray), by the application of an herbicide under the supervision of an expert. Cassvtha filiformis is pervasive in this area and should be manually pulled from and removed from the site of the population. Control of these species will serve to reduce competition from plant species as well as reduce conditions that promote fire. This effort should be coordinated with the Campbell Estate (see task #1324).

1224. Monitor/control insect infestation at Coast Guard Population 3.

Insect infestations should be monitored to determine at what level corrective action is required. Because insect pollinators are known to be "generalists," pesticides should be selected for their effectiveness against the target insects and their non-phytotoxic properties. This effort should be coordinated with the Campbell Estate (see task #1325) and task #1226.

1225. Reduce risk of fire and verify/establish a fire contingency plan for Coast Guard Population 3.

Removal of exotic species within the population should reduce conditions that promote fire (see Task 1223). Nonetheless, establishment of a firebreak should be considered. Proximity of the beach and a parking lot on either side of the population may serve as a partial firebreak.

Efforts toward establishing a firebreak should be coordinated with the Campbell Estate (see task #1327).

A Coast Guard fire response plan should identify the location of the Achyranthes colony, outline the means for fire control in its vicinity, and give protection for this species a high priority.

1226. Monitor Coast Guard Population 3.

The Coast Guard Achyranthes splendens var. rotundata Population 3 should be monitored at least twice a year to determine population levels and identify any additional actions that should be taken to produce a naturally reproducing population with a minimum of 1,000 reproductive plants. This effort should be coordinated with task #1224 and with the Campbell Estate (see task #1328).

13. Protect and manage populations on lands owned by Campbell Estate.

One Chamaesyce skottsbergii var. skottsbergii and two Achyranthes splendens var. rotundata populations occur on lands owned by the Campbell Estate. One of these, A. splendens var. rotundata Population 3 occurs on both the grounds of the U.S. Coast Guard and land owned by the Campbell Estate at the Barbers Point Lighthouse.

131. Protect populations on lands owned by Campbell Estate.

Protect populations occurring on Campbell Estate lands through negotiations with the landowner and, where applicable, development of cooperative agreements, conservation easements, leases, or fee purchases. Lessees of the land on which each population occurs will need to be involved in efforts to protect and enhance these species.

132. Manage populations on lands owned by Campbell Estate.

Control threats to the population in such a way as to ensure their survival and provide for expansion in the future. Threats to the population include trampling by humans, encroaching plant species, possible insect infestation, and fire.

1321. Survey all existing populations within Campbell Industrial Park.

All populations should be censused to assess their current status and identify threats to their well-being. Surveys of Achyranthes Subpopulation 3 should be coordinated with Campbell Estate (see task #1221).

1322. Consider fencing (and maintenance of fencing) for Chamaesvce Population 4.

Consideration should be given to protecting this population from human intrusion via fencing in a sufficiently large enclosure to expand the population to a minimum of 1,000 plants and provide a buffer area surrounding it. If fencing is determined to be necessary, it should be maintained until the taxa is downlisted.

1323. Fence and maintain fencing at Achyranthes Population 3.

The Campbell Estate portion of Achyranthes splendens var. rotundata Population 3 is not presently fenced. This property should be protected from human trampling via fencing in a sufficiently large enclosure to allow for expansion of the population and provision of a buffer zone. If possible, efforts to fence this population should be coordinated with the U.S. Coast Guard portion of Population 3 (see task #1222). Fencing should be maintained until the taxa is downlisted.

1324. Control threats posed by encroaching plant species.

Invasive plant species and their growth within each population should be closely monitored and controlled via manual removal or, under certain conditions (i.e. no wind, isolated from the endangered species, large spray droplet, low volume spray), by application of an herbicide under the supervision of an expert. Cassytha filiformis, if found, should be immediately eradicated (manually pulled and removed from the site for disposal) from the population.

Although the Hawaii Department of Land and Natural Resources (DLNR) and the Estate entered into a mitigation plan for Achyranthes Population 4 in 1990, this plan did not call for the maintenance of the population beyond 3-6 months after establishment of these "sanctuaries". Continued management of this population is warranted. For instance, the plants are becoming shaded by introduced species within the sanctuaries, calling for weeding.

1325. Monitor/control threats posed by insect infestation.

Insect infestations should be monitored at all populations to determine at what level corrective action is required. Because insect pollinators for both taxa are known to be "generalists," pesticides should be selected for their effectiveness against the target insects and their non-phytotoxic properties.

1326. Control threats posed by pollutants.

Potential chemical spills or contamination of the soil due to ambient pollution are threats that are particularly applicable to the Campbell Estate populations because of heavy industrial activities and traffic in the area. Actions to minimize threats to these populations such as curbing around the populations to protect them

from direct contamination as the result of a chemical spill, should be taken where necessary.

Possible damage to Achyranthes Population 4 from heavy metals released in past decades by Hawaiian Western Steel needs to be assessed and, if necessary, mitigatory steps taken. As a first step, plans by the Estate to collect soil samples should be carried out. Finally, the population should continue to be monitored by the State as well as the lessee carrying out the mitigation plan.

1327. Reduce risk of fire and verify/establish fire contingency plan for Campbell Industrial Park.

Large fires within Campbell Industrial Park are a serious hazard to the tenants and lessees, some of whose businesses involve the production and/or handling of chemicals and toxic or highly flammable material. Accordingly, the industrial park is adequately provided with fire hydrants and the fire response time to all portions in the park is about 10 minutes (Warren Haight, Hawai'i Project Management, personal communication 1991). A new fire station in the industrial park is under construction (W. Haight, personal communication). However, fire response plans should be checked to ensure that the location of endangered plant populations are identified and given a high priority for protection.

In addition to adequate fire response mechanisms, each population of these plants should be protected by a fire break. It is essential to ensure that fire breaks are established as land is developed adjacent to each population.

1328. Monitor Campbell Estate populations.

All populations of Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata should be monitored at least twice a

year to determine the population level and identify any additional actions that should be taken to produce a naturally reproducing population with a minimum of 1,000 reproductive plants. For Population #3, this effort should be coordinated with the Coast Guard (see task #1226).

14. Protect and manage Chamaesyce populations on Moloka'i.

There are four known populations of Chamaesyce skottsbergii var. skottsbergii on Moloka'i. Population 5, the largest population numbering 30,000 plants, is located on Hawaiian Homelands. Populations 6 and 7 are located within the Mo'omomi Preserve which is managed by The Nature Conservancy of Hawai'i. Population 4 is located on private lands on the west coast of Moloka'i.

141. Protect and manage Chamaesyce Population 5.

Population 5 is the largest known population of Chamaesyce skottsbergii var. skottsbergii, estimated at 30,000 plants in 1991. This population should be protected and maintained at current numbers with knowledge and pride that it is the largest population of this rare taxa in existence.

1411. Protect Chamaesyce Population 5.

Protect Population 5 through negotiations with Hawaiian Homelands Commission and local residents to develop cooperative agreements, conservation easements, leases, or fee purchases.

1412. Manage Chamaesyce Population 5.

A survey of this area was conducted by The Nature Conservancy of Hawaii in 1991 (TNCH 1991). Threats to the Chamaesyce skottsbergii var. skottsbergii Population 5 include habitat loss, grazing and trampling by feral animals, infestation by alien plant species, trampling by humans, and fire.

Development and implementation of a management plan for this population which addresses all of the above threats is essential to ensure that it is maintained at the present population level.

1413. Monitor Chamaesyce Population 5.

This population should be monitored at least biannually to determine population level and identify any additional action necessary to maintain current population numbers.

142. Continue management of populations located on Mo'omomi Preserve.

Threats to the Chamaesyce skottsbergii var. skottsbergii Populations 6 and 7, located on the Mo'omomi Preserve include grazing and trampling by feral animals, infestation by alien plant species, trampling by humans, and fire.

1421. Continue to control threats to Mo'omomi populations.

The Mo'omomi Preserve FY 1994 Operational Plan identifies activities to control the aforementioned threats such as active ungulate and weed control programs (including kiawe removal trials), and annual updating of wildfire presuppression and response plans coordinated with the Maui County Fire Department. This plan also outlines a public outreach program to build public understanding and support for the preserve and to enlist volunteer assistance for preserve management (such as hiking trails). This includes monthly interpretive hikes and controlled access by residents via a limited pass-key system. These efforts to control threats should be applauded and should continue.

1422. Formulate a strategy for the protection and expansion of Chamaesyce on the Preserve.

While the Mo'omomi Operational Plan identifies formulation of a strategy for restoring the rare

plants Sesbania tomentosa (proposed for endangered status) and Marsilea villosa (listed as endangered) to selected areas of the preserve, it does not do so for Chamaesyce skottsbergii var. skottsbergii, nor Tetramolopium rockii var. rockii (listed as threatened). A plan needs to be formulated which identifies any threats specific to these taxa on the Preserve (eg. located near hiking trail) and the means of controlling these threats. This plan should also devise a strategy for expansion of Population 7 to a minimum of 1,000 reproductive plants.

1423. Monitor Mo'omomi populations.

Populations 6 and 7 should be monitored on an annual basis to determine population level and identify any additional action necessary to maintain current population numbers for Population 6 and to expand Population 7. This should be conducted separately from the community and population monitoring, which provides trends in vegetative community types but no data specific to these taxa.

143. Protect and manage Chamaesyce Population 8.

This population is located on private lands on the west coast of Moloka'i. Its landowner(s) is unidentified at present. The landowner(s) needs to be identified, the population protected, and threats enumerated and controlled.

1431. Identify private landowner(s).

The first step toward protection of this population is to identify its landowner(s).

1432. Protect Chamaesyce Population 8.

Protect Population 8 through negotiations with the landowner(s) to develop cooperative agreements, conservation easements, leases, or fee purchases.

1433. Manage Chamaesyce Population 8.

Threats to the Chamaesyce skottsbergii var. skottsbergii Population 8 need to be identified and efforts made to control them.

15. Manage Achyranthes Population 2.

Achyranthes splendens var. rotundata Population 2 occurs on land owned by Cook Inlet Region, Inc. (previously part of the Malakole Military Reservation). Via mitigation plans approved by the Hawai'i Department of Land and Natural Resources (DLNR), Population 2 has been protected by fencing. Responsibility for the continued management of this population lies with the Cook Inlet Region, Inc.

151. Control threats posed by encroaching plant species.

This population has fewer invasive plants than the others and their control thus more easily achieved. Restoration of habitat for this population should be undertaken without reservation. Invasive plant species should be controlled via manual removal.

152. Monitor/control threats posed by insect infestation.

Insect infestations should be monitored to determine at what level corrective action is required. Because insect pollinators are known to be "generalists," pesticides should be selected for their effectiveness against the target insects and their non-phytotoxic properties. This should be conducted in conjunction with task #155.

153. Control threats posed by pollutants.

Potential chemical spills or contamination of the soil due to ambient pollution are threats that are particularly applicable to this population because of heavy industrial activities and traffic in the area. Actions to minimize threats to these populations such as curbing around the population to protect it from direct contamination as the result of a chemical spill, should be undertaken.

154. Reduce risk of fire and verify/establish fire contingency plan for Achyranthes Population 2.

It is essential to establish a fire break as land is developed adjacent to this population.

A fire response plan for Population 2 should identify the location of the Achyranthes colony to fire fighters, outline the means for fire control in its vicinity, and give protection for this species a high priority. If one does not exist, it should be established immediately.

155. Monitor Achyranthes Population 2.

This population should be monitored at least twice a year to determine the population level and identify any additional actions necessary to produce a naturally reproducing population with a minimum of 1,000 reproductive plants.

16. Protect and manage Achyranthes population in Ka'ena region.

Three populations of Achyranthes splendens var. rotundata occur in the Ka'ena region of O'ahu on State Park land.

161. Consider extension of Natural Area Reserve to include population.

Extending the boundary of the nearby Natural Area Reserve (NAR) to the area on which these plants occur would switch the focus of the state on this parcel from that of recreation to preservation. Extension of this boundary should be considered.

162. Protect Ka'ena populations.

The three populations in the Ka'ena area should be protected under the auspices of the Hawaii Division of State Parks or the Natural Area Reserve System. The State has an ongoing cooperative agreement with the Service to assist in achieving these goals.

163. Manage Ka'ena populations.

Threats to this population should be identified and a management plan developed. This plan will most likely include control of competition from alien plants and insect infestations, and reduction of the risk of fire via establishment of a fire break and reduction of fuel load. Care should be taken to ensure that the range of nearby ungulates is not allowed to expand to this area, thus becoming a threat to these populations.

164. Monitor Ka'ena populations.

These populations should be monitored at least annually to determine population level and identify any additional actions necessary to produce naturally reproducing populations with a minimum of 1,000 reproductive plants each.

17. Back-up each taxa with cultivated plants and seed storage.

A genetic reserve of each taxa should be kept in botanical gardens or arboreta via stored seed and cultivated plants. Specimens should be taken from populations representing each distinct geographic region, i.e. Barbers Point, Ka'ena Point, Moloka'i. This may require testing to determine the best method of seed storage.

171. Back up Chamaesyce skottsbergii var. skottsbergii.

See task #17.

172. Back up Achyranthes splendens var. rotundata.

See task #17.

2. Augment or re-establish populations.

It is hoped that existing populations will naturally expand with proper management, particularly with weeding of competing alien species. However, for those populations that are not naturally expanding sufficiently to reach the recovery goal, the following steps will need to be taken. Augmentation of existing populations

should be accomplished in situ whenever possible in order to avoid introducing new pathogens, parasites and/or insects from greenhouse stock. Use of wild gathered seed scattered in moist habitats is recommended.

21. Propagate genetically suitable plants, if necessary.

In order to maintain the genetic integrity of the populations, plants for a particular population should be propagated from the same population or, if numbers of that population are too limited, from within the same region, i.e. the 'Ewa Plain of O'ahu, the Ka'ena region of O'ahu, or Moloka'i.

211. Propagate Chamaesyce skottsbergii var. skottsbergii.

Propagation techniques for Chamaesyce skottsbergii var. skottsbergii may be obtained from research conducted by a consulting firm sponsored by the U.S. Army Corps of Engineers (AECOS 1981), with attention paid to lessons learned from transplanting the deep-draft harbor populations.

212. Propagate Achyranthes splendens var. rotundata.

Achyranthes splendens var. rotundata can be fairly easily propagated and successfully cultivated as demonstrated in the Campbell Industrial Park mitigation project.

22. Augment existing populations, if necessary.

Unwanted vegetation should be pulled prior to seed scatter or planting if it is considered necessary to propagate ex situ. Plants should receive regular watering until established.

Each expanded population should be monitored for survival, insect infestations and crowding by alien plant species. A spray program using an appropriate insecticide may be initiated if an insect infestation becomes too serious. Routine maintenance, particularly manual weeding, is absolutely necessary. Herbicides such as Round-Up can be used on calm days in large droplet, low volume spray to control unwanted vegetation ten feet (3 meters) or more from

nursery plants. Monitoring can initially be performed monthly then reduced to quarterly or semi-annually, but weeding must continue on a frequent basis.

23. Re-establish *Achyranthes* populations in historic range.

Consideration should be given to re-establishing both of these taxa in areas where they are no longer extant. This is particularly compelling for *Achyranthes splendens* var. *rotundata*, however, because its present existence only on the island of O'ahu leaves it vulnerable to extinction in the case of a hurricane or other wide-ranging stochastic event. This taxa once existed on the islands of Lana'i and Moloka'i, and its re-establishment in a minimum of three populations on either or both of these islands is necessary to meet the delisting objectives of the plan.

Research and trial plantings of both taxa have demonstrated the feasibility of establishing new populations from nursery stock (AECOS 1981; Hawai'i Project Management 1990; Nagata 1990, 1991). Enough pertinent information is known and adequate techniques have been developed to assure a reasonable chance of success. Propagation and field planting requirements and techniques can be found in AECOS (1981) and Nagata (1986).

3. Validate Recovery Objectives.

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

31. Conduct population viability studies on *Chamaesyce skottsbergii* var. *skottsbergii*.

Data from previous field studies (AECOS 1981; Nagata 1986) should be used to devise models to verify the scientific validity of the stated recovery objectives in this plan.

311. Determine the number of *Chamaesyce* populations needed to ensure long-term survival.

It is necessary to know the number of populations needed to adequately safeguard against catastrophic events over the next 200 years, particularly given the potential for tsunamis, development and pollution.

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

It is necessary to determine the number of individuals (total, reproductive and juvenile) needed to ensure the long-term survival of each population.

32. Conduct population viability studies on Achyranthes splendens var. rotundata.

Data from previous field studies should be used to devise models to verify the scientific validity of the stated recovery objectives in this plan.

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

It is necessary to know the number of populations needed to adequately safeguard against catastrophic events over the next 200 years, particularly given the potential for tsunamis, development and pollution.

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

It is necessary to determine the number of individuals (total, reproductive and juvenile) needed to ensure the long-term survival of each population.

33. Revise recovery objectives, if necessary.

Recovery objectives should be revised if new information suggests that the current objectives are inadequate.

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4. INDIVIDUALS CONTACTED DURING PREPARATION OF PLAN

Roger Au
Deputy Staff Civil Engineer
Barbers Point Naval Air Station
Honolulu, Hawai'i

Marie Bruegman
Botanist
U.S. Fish and Wildlife Service
Honolulu, Hawai'i

Winona Char
Char and Associates
Honolulu, Hawai'i

Carolyn Corn
State Botanist
Hawai'i Department of Land and Natural Resources
Honolulu, Hawai'i

Warren Haight
Hawaii Project Management, Inc.
Honolulu, Hawai'i

Derral Herbst
Botanist
U.S. Army Corps of Engineers
Honolulu, Hawai'i

Robert H. Johnson
RHJ Realty Service, Inc.
Honolulu, Hawai'i

Melvin A. Kaku
Director, Environmental Planning Division
Naval Facilities Engineering Command
Pearl Harbor, Hawai'i

Stan Kato
Environmental Engender
Barbers Point Naval Air Station
Honolulu, Hawai'i

Joel Lau
Botanist
The Nature Conservancy
Honolulu, Hawai'i

Dan Moriarty
Natural Resource Management Specialist
Department of the Navy
Pearl Harbor, Hawai'i

Eric Shigaki
Barbers Point Naval Air Station
Honolulu, Hawai'i

Mike Taylor
Real Estate Division
U.S. Army Corps of Engineers
Honolulu, Hawai'i

III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the recovery program for Chamaesyce skottsbergii var. skottsbergii and Achyranthes splendens var. rotundata, 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. 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 stabilize the existing populations, restore habitat for the taxa, and increase the population size and numbers. Monetary needs for all parties involved are identified to reach this point.

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

- Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
- Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.
- Priority 3 - All other actions necessary to provide for full recovery of the species.

Key to Acronyms Used in Implementation Schedule

CE	-	Campbell Estate
CIRI	-	Cook Inlet Region, Inc.
DHHL	-	Department of Hawaiian Home Lands
DLNR	-	Hawai'i Department of Land and Natural Resources
ES	-	Fish and Wildlife Service, Ecological Services, . Honolulu
NASBP	-	Naval Air Station at Barbers Point
NBS	-	National Biological Survey
TNCH	-	The Nature Conservancy of Hawaii
USCG	-	U.S. Coast Guard

Key to Other Codes Used in Implementation Schedule

C	-	Continuous
O	-	Ongoing (already begun as of writing of plan)
TBD	-	To Be Determined

Recovery Plan Implementation Schedule for *Chamaesyce skottsbergii* var. *skottsbergii* and *Achyranthes splendens* var. *rotundata*

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comments
Need 1 (Protect and manage existing population)											
1	111	Protect BPNAS populations following base closure	2	NASBP*	1		0.5	0.5			
				ES	1		0.5	0.5			
				DLNR	1		0.5	0.5			
1	1121	Survey BPNAS populations.	1	NASBP*	0.5	0.5					
				ES	0.5	0.5					
				DLNR	0.5	0.5					
1	1122	Control encroaching plants at NASBP.	C	NASBP*	4	1	1	1	1	TBD	
				ES	1	0.25	0.25	0.25	0.25	TBD	
				DLNR	1	0.25	0.25	0.25	0.25	TBD	
1	1123	Monitor/control insect infestations at NASBP.	C	NASBP*	1	0.25	0.25	0.25	0.25	TBD	
				ES	1	0.25	0.25	0.25	0.25	TBD	
				DLNR	1	0.25	0.25	0.25	0.25	TBD	
1	1124	Reduce risk of fire at NASBP.	2	NASBP*	0.25	0.25				TBD	
				ES	0.25	0.25				TBD	
				DLNR	0.25	0.25				TBD	
1	1125	Consider fencing of NASBP populations.	1	NASBP*	0					TBD	
				ES	0					TBD	
				DLNR	0					TBD	
1	1126	Monitor populations at NASBP.	C	NASBP*	2.5	0.5	0.5	0.5	0.5	0.5	
				ES	2.5	0.5	0.5	0.5	0.5	0.5	
				DLNR	2.5	0.5	0.5	0.5	0.5	0.5	
1	121	Protect U.S. Coast Guard Population 3.	1	ES*	0.25	0.25					
				USCG	0.25	0.25					
				DLNR	0.25	0.25					
1	1221	Survey USCG Population 3.	1	ES*	0.25	0.25					
				USCG	0.25	0.25					
				DLNR	0.25	0.25					
1	1222	Fence USCG Population 3.	C	ES*	6	5	0.25	0.25	0.25	0.25	
				USCG	6	5	0.25	0.25	0.25	0.25	
1	1223	Control encroaching plants at USCG Population 3.	C	ES*	5.5	2	2	0.5	0.5	0.5	
				USCG	5.5	2	2	0.5	0.5	0.5	
				DLNR	1.25	0.25	0.25	0.25	0.25	0.25	

Recovery Plan Implementation Schedule for *Chamaesyce skottsbergii* var. *skottsbergii* and *Achyranthes splendens* var. *rotundata*

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comments
1	1224	Monitor/control insect infestations at USCG Population 3.	C	ES* USCG DLNR	1.25 1.25 1.25	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	
1	1225	Reduce the risk of fire at USCG Population 3.	1	ES* USCG	1 1	1 1					
1	1226	Monitor USCG Population 3.	C	ES* USCG DLNR	1.25 1.25 1.25	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	
1	131	Protect Populations at Campbell Industrial Park.	1	ES* CE DLNR	0.25 0.25 0.25	0.25 0.25 0.25					
1	1321	Survey Populations in Campbell Industrial Park.	1	ES* CE CLNR	0.5 0.5 0.5	0.5 0.5 0.5					
1	1322	Consider fencing Chamaesyce Population 4.	1	ES* CE DLNR	0 0 0	TBD TBD TBD					
1	1323	Fence Achyranthes Population 3.	C	ES CE* DLNR	5 6 6	5 5 5	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	0.25 0.25 0.25	
1	1324	Control encroaching plants at Campbell Industrial Park.	C	ES* CE DLNR	5.5 5.5 3.5	0.5 0.5 0.5	2 2 1	2 2 1	0.5 0.5 0.5	0.5 0.5 0.5	
1	1325	Monitor/control insect infestations at Campbell Industrial Park.	C	ES* CE DLNR	2.5 2.5 2.5	0.5 0.5 0.5	0.5 0.5 0.5	0.5 0.5 0.5	0.5 0.5 0.5	0.5 0.5 0.5	
1	1326	Control pollutants at Campbell Industrial Park.	C	ES* CE DLNR	0 0 0	TBD TBD TBD					
1	1327	Reduce risk of fire at Campbell Industrial Park.	2	ES* CE DLNR	2.25 2.25 2.25	0.25 0.25 0.25	2 2 2				
1	1328	Monitor Populations at Campbell Industrial Park.	C	CE* ES DLNR	5 2.5 2.5	1 0.5 0.5	1 0.5 0.5	1 0.5 0.5	1 0.5 0.5	1 0.5 0.5	

Recovery Plan Implementation Schedule for *Chamaesyce skottsbergii* var. *skottsbergii* and *Achyranthes splendens* var. *rotunda*

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comment
1	1411	Protect <i>Chamaesyce</i> Population 5.	2	ES ¹ DIHIL DLNR	0.5 0.5 0.5	0.25 0.25 0.25	0.25 0.25 0.25				
1	1412	Manage <i>Chamaesyce</i> Population 5.	C	ES DIHIL* DLNR	0 0 0	TBD TBD TBD					
1	1413	Monitor <i>Chamaesyce</i> Population 5.	C	ES DIHIL* DLNR	1.5 1.5 1.5	0.5 0.5 0.5	0 0 0	0.5 0.5 0.5	0 0 0	0.5 0.5 0.5	
1	1421	Continue to control threats at Mo'omomi.	0	TNCII*	75	15	15	15	15	15	
1	1422	Formulate a strategy for <i>Chamaesyce</i> on Mo'omomi.	1	TNCII*	0.5	0.5					
1	1423	Monitor <i>Chamaesyce</i> on Mo'omomi.	C	TNCII*	2.5	0.5	0.5	0.5	0.5	0.5	
1	1431	Identify private landowner of Population 8.	1	DLNR* ES	0.25		0.25				
1	1432	Protect <i>Chamaesyce</i> Population 8.	1	ES* DLNR	0 0		TBD TBD				
1	1433	Manage <i>Chamaesyce</i> Population 8.	C	DLNR* ES Unidentified	0 0 0		TBD TBD TBD				
1	151	Control encroaching plants at <i>Achyranthes</i> Population 2.	C	CIRI* DLNR	1.75 0.5	0.5 0.5	0.5	0.25	0.25	0.25	
1	152	Monitor/control insect infestation at <i>Achyranthes</i> Population 2.	C	CIRI* DLNR	1.25 1.25	0.25 0.25	0.25 0.25	0.25 0.25	0.25 0.25	0.25 0.25	
1	153	Control pollution at <i>Achyranthes</i> Population 2.	2	CIRI* DLNR ES	0 0 0	TBD TBD TBD					
1	154	Reduce risk of fire at <i>Achyranthes</i> Population 2.	2	CIRI* DLNR ES	2.25 2.25 2.25	0.25 0.25 0.25	2 2 2				

Recovery Plan Implementation Schedule for *Chamaesyce skottsbergii* var. *skottsbergii* and *Achyranthes splendens* var. *rotunda*

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comment
1	155	Monitor <i>Achyranthes</i> Population 2.	C	CIRI* DLNR	1.25 1.25	0.25 0.25	0.25 0.25	0.25 0.25	0.25 0.25	0.25 0.25	
1	161	Consider extension of NAR in Ka'ena.	1	DLNR	0.25	0.25					
1	162	Protect Ka'ena populations.	1	DLNR*	0.5	0.5					
1	163	Manage Ka'ena populations.	C	DLNR* ES	34 0	10 TBD	10	10	2	2	
1	164	Monitor Ka'ena populations.	C	DLNR*	5	1	1	1	1	1	
Need 1 (Protect and manage existing population)					253	81	61.5	46.75	32.25	31.5	
Need 2 (Augment or re-establish populations)											
2	211	Propagate <i>Chamaesyce</i> , if necessary.	3	DLNR* ES	0 0				TBD TBD		
2	212	Propagate <i>Achyranthes</i> , if necessary.	3	DLNR* ES	0 0				TBD TBD		
2	22	Augment existing populatio if necessary.	3	DLNR* ES	0 0					TBD TBD	
2	23	Re-establish <i>Achyranthes</i> where extirpated.	3	DLNR* ES	0 0					TBD TBD	
Need 2 (Augment or re-establish populations)					0	0	0	0	0	0	
Need 3 (Validate recovery objectives)											
3	311	Determine number of <i>Chamaesyce</i> populations.	2	ES* NBS DLNR	1 2 1			0.5 1 0.5	0.5 1 0.5		
3	312	Determine number of <i>Chamaesyce</i> individuals.	2	ES* NBS DLNR	1 2 1			0.5 1 0.5	0.5 1 0.5		

Recovery Plan Implementation Schedule for *Chamaesyce skottsbergii* var. *skottsbergii* and *Achyranthes splendens* var. *rotunda*

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	Comment
3	321	Determine number of <i>Achyranthes</i> populations.	2	ES*	1			0.5	0.5		
				NBS	2			1	1		
				DLNR	1			0.5	0.5		
3	322	Determine number of <i>Achyranthes</i> individuals.	2	ES*	1			0.5	0.5		
				NBS	2			1	1		
				DLNR	1			0.5	0.5		
3	33	Revise recovery objectives if necessary.	1	ES	1				1		
		Need 3 (Validate recovery objectives)			17	0	0	0	9	0	
		TOTAL COST			270	81	61.5	54.75	41.25	31.5	

APPENDIX A. Reviewers of the Draft Recovery Plan

Ken Nagata
PPQ Officer
USDA, APHIS, PPQ
Terminal Box 57
Honolulu International Airport
Honolulu, Hawaii 96819

Keith Ahue
Chair, Board of Land and Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813

Roger Au
Base Closure and Transition Officer
Department of the Navy
Naval Air Station
Barbers Point, HI 96862-5050

* Michael G. Buck, Administrator
Division of Forestry and Wildlife
Dept. of Land & Natural Resources
1151 Punchbowl St.
Honolulu, Hawaii 96813

Center for Plant Conservation
Missouri Botanical Garden
P.O. Box 299
St. Louis, MO 63166-0299

Winona Char
4471 Puu Panini Avenue
Honolulu, Hawaii 96816

Bob Cook
Arnold Arboretum
125 Arborway
Jamaica Plain, MA 02130

Carolyn Corn
Division of Forestry and Wildlife
Dept. of Land & Natural Resources
1151 Punchbowl Street
Honolulu, HI 96813

Linda Cuddihy
Hawaii Volcanos National Park
P.O. Box 52
Volcano, Hawaii 96718

Patrick Dunn
The Nature Conservancy
1116 Smith St., Suite 201
Honolulu, HI 96817

Environmental Protection Agency
Hazard Evaluation Division - EEB (TS768C)
401 M Street, SW
Washington, DC 20460

Project Manager (7507C)
Endangered Species Protection Program
Environmental Fate and Effects Division
Office of Pesticide Programs
401 M Street, SW
Washington, DC 20460

The Honorable Frank F. Fasi
Mayor
City and County of Honolulu
Honolulu, Hawaii 96813

Betsy Gagne
Natural Area Reserve Program
Department of Land and Natural Resources
Kawaiahao Plaza, Suite 132
567 South King Street
Honolulu, HI 96813

RADM Howard B. Gehring
Commander, 14th District
U.S. Coast Guard
300 Ala Moana Blvd. Rm 9116
Honolulu, HI 96850-4982

Sam Gon
Hawaii Heritage Program Coordinator
The Nature Conservancy
1116 Smith St., Suite 201
Honolulu, HI 96817

Warren Haight
Hawaii Project Management, Inc.
220 South King Street, Suite 1460
Honolulu, Hawaii 96813

Hawaii Audubon Society
212 Merchant Street, Suite 320
Honolulu, Hawaii 96813

Hawaii Nature Center
2131 Makiki Heights Drive
Honolulu, Hawaii 96822

President
Hawaiian Botanical Society
c/o Botany Department, UH Manoa
3190 Maile Way
Honolulu, Hawaii 96817

* Derral Herbst
U.S. Army Corps of Engineers
CEPOD-ED-ME, Bldg. T223
Fort Shafter, HI 96858-5440

Robert Hobdy
Division of Forestry and Wildlife
Dept. of Land & Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813

Honolulu Botanic Gardens
50 N. Vineyard
Honolulu, HI 96817

Julie G. Ishiki
Division of Forestry and Wildlife
Dept. of Land & Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813

James D. Jacobi
U.S. Fish and Wildlife Service
Hawaii Research Station
Box 44
Volcanoes, Hawaii 96718

Robert H. Johnson
RHJ Realty Service, Inc.
195 South King, 4th Floor
Honolulu, Hawaii 96813

Melvin A. Kaku
Director, Environmental Planning Division
U.S. Department of the Navy
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860-7300

Charles Lamoureux
Lyon Arboretum
University of Hawaii at Manoa
3860 Manoa Rd.
Honolulu, HI 96822-1180

Joel Lau
Hawaii Heritage Program Coordinator
The Nature Conservancy
1116 Smith St., Suite 201
Honolulu, HI 96817

Lloyd Loope
Haleakala National Park
P.O. Box 369
Makawao, Hawaii 96768

Lyon Arboretum
University of Hawaii at Manoa
3860 Manoa Rd.
Honolulu, HI 96822

Peter D. McKone
Freese and Nichols, Inc.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109-4895

Theresia McMurdo
The Estate of James Campbell
1001 Kamokila Boulevard
Kapolei, HI 96707

* Fredrick Minato, Director
Environmental Planning Division
Department of the Navy
Naval Facilities Engineering Command
Pearl Harbor, HI 96860-7300

Ed Misaki
The Nature Conservancy
P.O. Box 220
Kualapuu, HI 96757

* Clifford Morden
Dept. of Botany
University of Hawaii at Manoa
3190 Maile Way
Honolulu, HI 96822

Karl K. Motoyama, Esq.
Environmental Protection Specialist
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

Ralston Nagata
Administrator
Division of State Parks
P.O. Box 621
Honolulu, Hawaii 96809

Natural Resources Defense Council, Inc.
212 Merchant Street, Suite 203
Honolulu, Hawaii 96813

Steve Perlman
Hawaii Plant Conservation Center
National Tropical Botanical Garden
P.O. Box 340
Lawai, Hawaii 96765

Diane Ragone
Hawaii Plant Conservation Center
National Tropical Botanical Garden
P.O. Box 340
Lawai, HI 96765

Captain T.A. Rocklein
Commanding Officer
Department of the Navy
Naval Air Station
Barbers Point, HI 96862-5050

Fred C. Schmidt
Head, Documents Department
The Libraries
Colorado State University
Fort Collins, CO 80523-1879

Eric Shigaki
Environmental Engineer
Department of the Navy
Naval Air Station
Barbers Point, HI 96862-5050

Sierra Club, Hawaii Chapter
The Archade Building, Room 201
212 Merchant Street
Honolulu, Hawaii 96803

Sierra Club Legal Defense Fund, Inc.
212 Merchant Street, Suite 202
Honolulu, Hawaii 96813

Clifford W. Smith
Botany Department
University of Hawaii
3190 Maile Way
Honolulu, Hawaii 96822

S.H. Sohmer
Director
Botanical Research Institute of Texas, Inc.
509 Pecan Street
Fort Worth, Texas 76102

Wayne Sousa
Planning Division, Hawaii Division of State
Parks, Outdoor Recreation, and Historic Sites
P.O. Box 61
Honolulu, Hawaii 96809

Benjamin Stein
3671 Glendon Avenue #304
Los Angeles, CA 90034

* Tim Sutterfield
U.S. Department of Navy
Code 237, Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, HI 96860-7300

Mike Taylor
Real Estate Division
U.S. Army Corps of Engineers
Fort Schafter, Hawaii 96858

* The Honorable John Waihee
Governor, State of Hawaii
State Capitol
Honolulu, Hawaii 96813

Waimea Arboretum and Botanical Garden
59-864 Kamehameha Highway
Haleiwa, HI 96712

Keith R. Woolliams
Waimaea Arboretum and Botanical Garden
59-864 Kam. Hwy.
Haleiwa, HI 96712

* Comments Received

APPENDIX B.* Maps of exact locations of both species.

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