



Kaho'olawe Island Conveyance Commission
Consultant Report No. 6

**Biological
Database &
Reconnaissance
Survey of
Kaho'olawe
Island Including
Rare Plants,
Animals and
Natural
Communities**

By: The Nature Conservancy of Hawai'i
- Samuel Gon, III
- Gail Chun, et. al.

The Nature Conservancy of Hawaii



• 1116 SMITH STREET • SUITE 201 • HONOLULU, HAWAII • 96817 • PH (808) 537-4508 • FAX (808) 545-2019

September 22, 1992

Kaho'olawe Island Conveyance Commission
One Main Plaza, Suite 325
2200 Main Street
Wailuku, Maui, HI 96793

Dear Kaho'olawe Island Conveyance Commission:

We have enclosed one original hard copy of our final report (titled "Biological Database & Reconnaissance Survey of Kaho'olawe Island: Including Rare Plants, Animals, and Natural Communities"), which contains original maps and photos, and five xeroxed copies of the report. Also included is a disk copy of the report done in WordPerfect 5.1, with tables and appendices done in Lotus 1-2-3, version 2.01.

Also included with the final report are: 1) a notebook titled "Biological Database & Reconnaissance Survey of Kaho'olawe Island: Map Keys, Element Occurrence Records, Maps, and Sources;" and 2) five additional "blackline" copies of the USGS map of Kaho'olawe Island, including symbols designating the known locations of rare, native elements (plants, animals, and natural communities).

We hope that you will find the report useful. Please call me at 537-4508 if you have any questions. It has been a pleasure working with you.

Me ke aloha,

Gail Chun
Associate Botanist
Kaho'olawe Biological Survey Project Coordinator
Hawai'i Heritage Program

Enclosures

Bill D. Mills, Chairman
Peter D. Baldwin
Kenneth F. Brown
Zelmer W. Brown, Jr.
Robert F. Clarke
David C. Cole

Samuel A. Cook
Cerald M. Czarniec
Walter A. Dots, Jr.
Gau Fuiemua
Frank J. Hata
Stanley Hong

Kenneth Y. Kaneshiro, ex officio
Loren K. Landers
Thomas C. Leppert
Frank J. Mariani
Marguerite M. Perry
Charles J. Putsch, Jr.

C. Dudley Pratt, Jr.
H. M. Nancy Richards-
Jean E. Relfo
R. Osamu Shide
Oswald N. Stender
William H. Stricker

Edward D. Sultan, Jr.
Laura L. Thompson
Laurence Vogel
Jeffrey N. Watanabe
Rodrick T. Wilson

There are 20 files for the final report titled "Biological Database & Reconnaissance Survey of Kaho'olawe Island: Including Rare Plants, Animals, and Natural Communities." The file names are as follows:

Files on WordPerfect 5.1:

FINALRPT.TNC = Main text of the final report
APPEN_G.WP = Appendix G of the final report.
APPENDA1.TXT = Explanatory text for Appendix A1.
APPENDA2.TXT = Explanatory text for Appendix A2.

Files on Lotus 1-2-3 version 2.01:

APNA1PG1.WK1 = Appendix A1; page 1; worksheet file.
APNA1PG1.ALL = Appendix A1; page 1; format file.

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APNA2PG1.WK1 = Appendix A2; page 1; worksheet file.
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APNA2PGS.ALL = Appendix A2; pages 2 to end; format file.

APENBPG1.WK1 = Appendix B; page 1; worksheet file.
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RAREPLT2.WK1 = Table 2: Rare plant species recorded from Kaho'olawe Island; worksheet file.
RAREPLT2.ALL = Table 2: Rare plant species recorded from Kaho'olawe Island; format file.

RAREANIM.WK1 = Table 3: Rare animal species recorded from Kaho'olawe Island; worksheet file.
RAREANIM.ALL = Table 3: Rare animal species recorded from Kaho'olawe Island; format file.

Biological Database & Reconnaissance Survey
of Kaho'olawe Island

Including Rare Plants, Animals,
and Natural Communities

Prepared for:
Kaho'olawe Island Conveyance Commission
One Main Plaza, Suite 325
2200 Main Street
Wailuku, Maui, Hawai'i 96793

Prepared by:
Hawai'i Heritage Program
The Nature Conservancy of Hawai'i
Honolulu, Hawai'i

August 1992

EXECUTIVE SUMMARY

In October 1991, the Kaho'olawe Island Conveyance Commission (KICC) contracted with The Nature Conservancy's Hawai'i Heritage Program (HHP) to conduct a biological reconnaissance of the island of Kaho'olawe. This report describes the methods used and summarizes the available information on the biological resources known or reported to occur on the island. The purpose of this report is to identify existing areas deemed significant for preservation, protection, and re-vegetation efforts.

Eight native natural communities occur on the island, including two that are considered rare: a Ma'o (Hawaiian Cotton) Coastal Dry Shrubland, and a High Salinity Anchialine Pool in Lava. The cotton shrubland is located on the western coast and slopes of the island, while the anchialine pool occupies the crater known as Sailor's Hat, also on the west coast. The remaining native communities include coastal and lowland grasslands and shrublands, and two aquatic communities: intermittent streams and ephemeral pools. Because less than 10 percent of the island's area remains in native vegetation, we consider all remaining examples of native vegetation on the island significant, and have mapped their locations in this report.

Thirteen rare plant taxa have been recorded from the island. Most of these rare plants are found along the southern and eastern coasts and seacliffs. The most significant rare plant finds of the Heritage reconnaissance were located on 'Ale'ale, which is a steep-sided hill at the base of the southern seacliffs near the offshore island Pu'u Koa'e. Most important among these finds was a new species in the pea or legume family (Fabaceae). Another important find on 'Ale'ale was the largest known population of *Portulaca molokiniensis* in the Hawaiian archipelago.

Five rare animals have been recorded from Kaho'olawe, or from areas just offshore. Endangered Hawaiian monk seals and threatened green turtles have been observed at Hanakanaia (Smugglers Cove), Kuheia, Lae o Kuikui, and Hakioawa. Hawaiian monk seals have also been seen at nearby Molokini Island. The endangered Hawaiian hoary bat, Hawai'i's only native terrestrial mammal, has been recorded from Kuheia Beach and Hakioawa Gulch. In addition, the endangered Hawaiian dark-rumped petrel has been heard calling in flight near the summit of Pu'u o Moa'ulanui. All nearshore waters are important for the Hawaiian wintering population of the endangered humpback whale.

Although not rare, many other native Hawaiian animals utilize Kaho'olawe. During the HHP survey, indigenous seabirds were seen flying primarily along the southern coast of Kaho'olawe, and they were also found on Pu'u Koa'e. Both Pu'u Koa'e and the nearby

'Ale'ale support nesting populations of native seabirds such as red-tailed tropicbirds (*Phaethon rubricauda rothschildi*) and brown boobies (*Sula leucogaster plotus*). Native Hawaiian aquatic invertebrates occupy the high salinity anchialine pool at Sailor's Hat. The forested areas of Kaho'olawe, although greatly altered, may contain small isolated populations of native Hawaiian land snails and other terrestrial invertebrates. One native Hawaiian land bird, the pueo, still survives on the island.

The leading threats to native natural communities and rare plants on Kaho'olawe are invasion by aggressive weeds and fire. Predation by introduced mammals threatens the native seabird species on the island, driving them to nest on a few steep cliffs and Pu'u Koa'e, an isolated offshore islet. Threats to green turtles and Hawaiian monk seals are many, including entanglement in marine debris, ingestion of plastics, and human disturbance, especially at beaches required for their birth, basking, and resting.

ACKNOWLEDGEMENTS

Several organizations and individuals contributed information, guidance, and field assistance for the biological reconnaissance of Kaho'olawe. In particular, we wish to thank Captain M.D. Roth of the United States Navy and his staff for their assistance on this project, as well as Dr. Storrs Olson and Rowland Reeve for their assistance with the paleontological survey of avian bird remains. The Heritage staff deeply appreciates their cooperation and support.

We would also like to acknowledge the following organizations for access to their collections: the Bishop Museum and the University of Hawai'i's Botany Department and Harold H. Lyon Arboretum.

We are indebted to the many biologists, past and present, who have explored and documented the rich flora and fauna of the Hawaiian Islands. There are far too many to name, but their dedication to Hawaiian biology is deeply appreciated. Without their efforts, this report would not be possible. Special thanks are due to Dr. Stefanie Aschmann, Dr. Robert Cowie, Robert Hobdy, Dan Holmes, Steve Perlman, Craig Rowland, Mike Severns, and Kenneth Wood for assistance in updating biological information on Kaho'olawe.

We would also like to express our appreciation for the assistance of Hawai'i Heritage Program intern Mark Lewin during the compilation of this report.

Finally, we wish to thank the Kaho'olawe Island Conveyance Commission, and especially executive assistant Hardy Spoehr, for their assistance with the project and for their desire to better understand and preserve the unique natural resources of Kaho'olawe.

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INTRODUCTION

In October 1991, the Kaho'olawe Island Conveyance Commission (KICC) contracted The Nature Conservancy's Hawai'i Heritage Program (HHP) to provide biological information for the island of Kaho'olawe (Figure 1). Included in the contract are both a literature review and a reconnaissance field survey. The purposes of the project were:

1. To document the current status of native and non-native plants, animals, and ecosystems on the island, including areas not surveyed in previous studies.
2. To compare the findings of this survey with those of others.
3. To identify specific zones or areas on the island that remain dominated or particularly rich in native species.
4. To identify areas dominated by native vegetation which could be treated as special ecological areas targeted for restoration techniques that focus on native species.

This report describes the methods used and summarizes the results of the literature review and biological reconnaissance. Current and potential threats to biological resources, and management recommendations are also discussed.

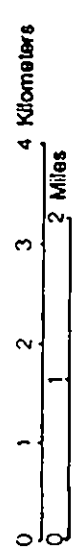
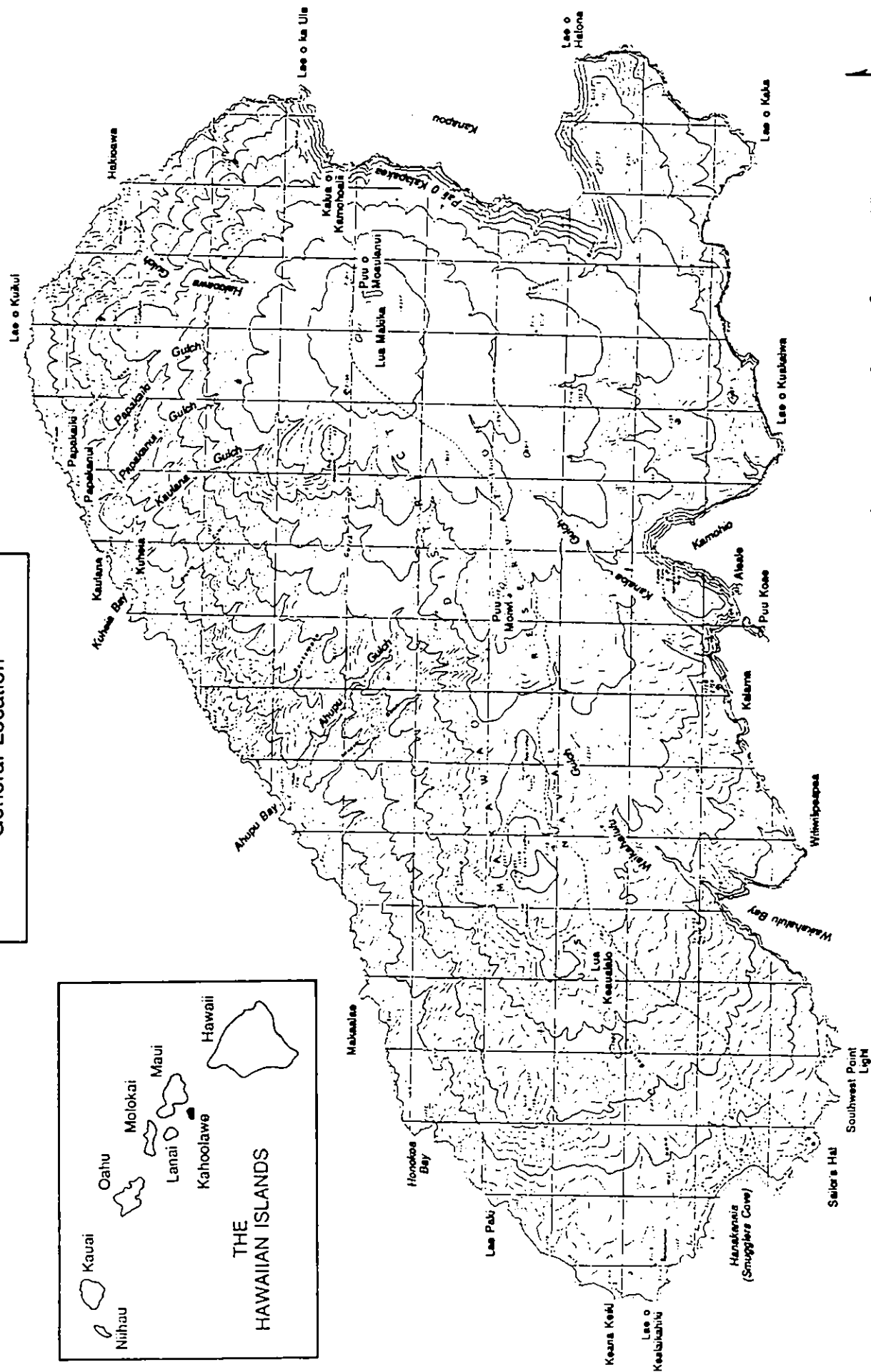
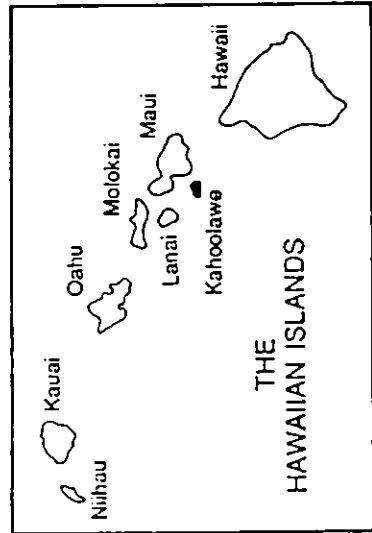
Data presented in this report are based upon an extensive body of information derived from publications, documents, museum collections, and reports from knowledgeable individuals. The HHP staff supplemented this information with a 20-day biological reconnaissance of Kaho'olawe Island conducted between February 18 and March 26, 1992. From these data, HHP developed a database on the location and condition of rare native elements (plants, animals, and natural communities) on the island.

REPORT ORGANIZATION

The Methods section of this report addresses the Heritage Program's definition of rarity for native plants, animals, and natural communities, and the methods used to collect biological information, including major sources consulted. Thereafter, the island's rare biological resources are highlighted in sections describing each of the major types of rare taxa and natural communities (together referred to as "elements" of biological diversity). Each section contains a discussion of:

- Rare elements known to occur on Kaho'olawe or in the waters adjacent to the island,

Figure 1
Island of Kahoolawe
General Location



- Distribution of these rare elements in the project area, and
- Factors currently threatening the continued survival of these rare elements.

The final two sections identify the areas of greatest biological significance and discuss management recommendations.

FOR MORE INFORMATION

This report contains the most recent information on rare biological resources of Kaho'olawe as of March 1992. If additional or updated information is needed at any time, the Hawai'i Heritage staff and database are available for consultation.

The following document can also be consulted for additional information:

How to Read Heritage Database Reports (HHP 1989). This booklet explains the methods used by HHP staff to document plant, animal, and natural community locations and other pertinent information in the database.

NOTE ON TERMINOLOGY AND HAWAIIAN DIACRITICAL MARKS

We have made a sincere effort throughout this report to minimize the use of unnecessary technical terms and HHP "jargon;" however, the use of a small number of unfamiliar biological terms is unavoidable. For example, most people are familiar with "rare species" but this term is often inappropriate. While rare plants and animals are sometimes rare species, they may also be rare subspecies or rare varieties of more common species. The term "rare taxa" is used to refer to species, subspecies, and varieties in this report. A glossary of technical terms is included at the end of the report to clarify terminology. If definitions are lacking for any unfamiliar terms or concepts contained in this report, please contact the HHP staff for clarification.

This report uses the 'u'ina (glottal stop) in Hawaiian names of plants, animals, and places. The kaha kō (macron) is not used, due to word processing limitations. Hawaiian diacritical marks are excluded from the maps because the U.S. Geological Survey (USGS) topographic maps used in this report do not include diacritical marks; however, the spelling of place names has been

corrected to match those on the place name list provided by the KICC.

SPECIAL NOTICE

According to HHP policy, the following statement must accompany all Heritage reports to assure the proper use of Heritage information:

"The Nature Conservancy's Hawai'i Heritage Program database is dependent on the research of many scientists and individuals. In most cases this information is not the result of comprehensive site-specific field surveys, and is not confirmed by the Heritage staff. Many areas in Hawai'i have never been thoroughly surveyed, and new plants and animals are still being discovered. Database information should never be regarded as final statements or substituted for on-site surveys required for environmental assessments. Data provided by the Hawai'i Heritage Program do not represent a position taken by The Nature Conservancy of Hawai'i."

If Heritage information is distributed in any way, the above statement must accompany that information.

METHODS

To describe the biological resources of Kaho'olawe, all pertinent sources of biological information for the island were consulted. From these data, Hawai'i Heritage Program staff developed a database which contains information on the location and population status of rare natural communities, plants, and animals (collectively referred to as "rare elements"). This rare element database allows for a better understanding of existing native biological resources.

The following five steps were used to gather and process existing information and information collected during the Heritage survey:

- 1) Search and review all pertinent biological literature and specimen collections on rare, endangered, or threatened elements reported from Kaho'olawe,
- 2) Interview scientists and natural resource experts with knowledge of the island,
- 3) Create a photo-mosaic of Kaho'olawe using aerial photographs to determine the general distribution of vegetation types,
- 4) Survey the island using a walk-through method along predesignated survey routes to identify major vegetation types and ecosystems and update the status of rare elements through incidental observations, and
- 5) Summarize this information in the HHP, Natural Diversity Database, including mapping of sites where rare elements were observed or have been reported to occur and updating or enhancing the computerized records of location and status information.

DEFINITION OF RARITY

The Hawai'i Heritage Program compiles and maintains statewide information only on rare and imperilled Hawaiian natural communities, plants, and animals. A natural community is considered rare and imperilled if it is known from 20 or fewer localities OR if it covers less than 2000 acres worldwide. Natural communities that are more widespread but threatened with destruction throughout their range are also considered

imperilled. The definition of a rare plant or animal varies depending on professional opinion. The Hawai'i Heritage Program defines a plant or animal taxon as rare when available records indicate that its current distribution or abundance is limited. A species is considered rare if within the last 15 years it is known from 20 or fewer locations OR if there are fewer than 3000 individuals. Other more widespread taxa that are threatened with destruction throughout their range are also considered imperilled.

After rare elements have been identified, a "Heritage global rank" is assigned by HHP to represent an element's worldwide rarity and threat of extinction. This element ranking system is used by Heritage Programs throughout the United States, Canada, and Latin America to identify communities and taxa in need of immediate protection. The global rank is based upon the following six criteria:

- Estimated number of sites
- Geographic range
- Estimated abundance
- Number of protected sites
- Threats
- Ecological fragility

In general, an "occurrence" of a rare taxon or natural community is a location from which the rare taxon or community is reported to exist. The detailed definition of an occurrence varies depending on the element type (natural community, plant, or animal). Each of the following three sections describes the element, lists the major information sources, and defines an occurrence depending on species or natural community characteristics.

NATURAL COMMUNITIES

A natural community is an assemblage of plants and animals occurring together at a site. Because of their environmental requirements, particular taxa tend to occur at specific altitudes, or on certain soil types, or under limited ranges of moisture. Additionally, some taxa require the presence of other taxa in order to persist. For example, many native birds require the nectar of 'ohi'a flowers, and many native plants require either native birds or native insects to pollinate them. These kinds of direct and indirect interactions between plants, animals, and environment form the basis for a healthy natural community.

Classification of natural communities in Hawai'i is relatively new. Useful information on the location and condition of natural communities is difficult to obtain because many field biologists focus on rare plants or animals rather than natural communities. Since 1985, ecologists at the Hawai'i Heritage Program and

elsewhere have been working together to identify and describe the many types of native and non-native communities in the Hawaiian Islands. More than 25 biologists from around the state have assisted in this effort. Known as the Hawaiian Natural Community Classification, it is an effective system for distinguishing native natural communities in the islands. A summary of the Hawaiian Natural Community Classification appears in the Manual of the Flowering Plants of Hawai'i (Wagner, Herbst, and Sohmer 1990). However, the classification will continue to change over the coming years as it is tested and refined through direct field observations.

Review of 1986 U.S. Navy aerial photographs of Kaho'olawe, interviews with biologists, and data collected from previous biological surveys of the island were used to evaluate known and potential native natural communities on the island of Kaho'olawe. These sources also helped to refine the locations and general distribution of natural communities.

For rare native natural communities, an "occurrence" is mapped when the vegetation of an area consists of at least 60 percent native plants. Stands are considered alien communities when alien plants occupy more than 40 percent of the area. These areas are mapped as alien vegetation and are not included in the natural community database.

For each native natural community reported for the island of Kaho'olawe, approximate boundaries were plotted on topographic quadrangle maps and on aerial photographs whenever available. Community descriptions and plant species lists were compiled when such information was available. Communities considered rare by HHP were located precisely and detailed computerized records (Element Occurrence Records) were completed.

RARE PLANTS

Our understanding of Hawai'i's native plants is continually being revised. Recently, the Bishop Museum sponsored the preparation of the Manual of the Flowering Plants of Hawai'i (Wagner, Herbst, and Sohmer 1990), a reevaluation of taxonomic treatments by recognized botanists. Many significant changes in taxonomy were made as the result of these revisions. Upon the advice of Hawaiian botanists, HHP has adopted the taxonomy outlined by Wagner, Herbst, and Sohmer (1990). Minor modifications are made periodically and reviewed by an advisory committee of knowledgeable botanists.

Information on rare plant locations comes from numerous sources. These include herbarium collections (the Bishop Museum and the University of Hawai'i's Botany Department and Harold H. Lyon

Arboretum), published scientific materials, unpublished reports (including environmental impact studies and government reports), and observations by field botanists. Information obtained from surveys of offshore islets is another important source (R. Hobdy, personal communication 1991). Only native Hawaiian plants are included in HHP's rare plant database. Criteria used to compile this database are:

- 1) All plant taxa listed as endangered by the U.S. Fish and Wildlife Service (USFWS) are included (USFWS 1991).
- 2) All plant taxa identified as candidates for listing by the USFWS are considered for inclusion (USFWS 1990). The final decision depends on the currently accepted taxonomy and the plant's reported abundance.
- 3) Additional native plant taxa recommended as rare by experienced botanists are considered for inclusion. Again, the final decision depends on the currently accepted taxonomy and the plant's reported abundance.

For rare plants, an "occurrence" is mapped wherever one or more individuals of a rare plant taxon are reported within a limited geographical area. For example, plants of a single taxon scattered along a cliff face, ridge top, or valley floor are considered a single occurrence. Each reported occurrence is classified as either "current" or "historic." Current occurrences are those observed in the last 15 years (1977-1992); historic occurrences are those observed prior to 1977. It is important to note that a historic sighting may simply mean that no one has recently looked for the plant at this location, or that the taxon is difficult to find due to habitat, seasonality, or small size; alternatively, a taxon may be difficult to recognize except by specialists.

Scientific names are used throughout this report because many native plants lack Hawaiian or other common names. Where available, common names for plants on Kaho'olawe are provided in individual species accounts and in Appendix A1.

RARE ANIMALS

Only native Hawaiian animal species (excluding insects), subspecies, or island populations are included in the HHP rare animal database. The following criteria are used:

- 1) All species, subspecies, or island populations listed as endangered or threatened by the USFWS (1991) or by the State of Hawai'i (DLNR 1990) are included in the list.
- 2) All species, subspecies, or island populations identified as candidates for listing by the USFWS are considered for inclusion.
- 3) Additional species, subspecies, or island populations regarded as rare by the scientific community are considered for inclusion. Final decision for inclusion is based on the animal's reported abundance.
- 4) Particular freshwater fish and invertebrates used as indicators of relatively pristine stream systems are included. These animals were chosen by a statewide streams advisory committee of aquatic biologists from the University of Hawai'i and state, federal, and other agencies.

The definition of a rare animal occurrence varies due to behavioral differences in animals. Each reported occurrence is classified as either "current" or "historic." Current occurrences are those which have been observed in the last 15 years (1977-1992); historic occurrences are those which have been observed prior to 1977. It is important to note that, like plants, a historical rare animal sighting may simply mean that no one has recently looked for the animal in a particular locale. It may also mean that the animal is difficult to find due to habitat, seasonality, or behavior. Appendix B includes a list of the scientific and common names for each species reported from Kaho'olawe.

PRELIMINARY RESEARCH

Literature and Oral History Research: In preparation for the field survey, Hawai'i Heritage Program staff researched available information on the rare native plants, animals, and natural communities known to occur on the island. A literature search of all available written sources was conducted, and experts within the scientific community were also consulted for additional information on the rare species of the island. The information collected was then incorporated into HHP's Natural Diversity Database.

Helicopter Reconnaissance: A one-day helicopter reconnaissance was conducted on December 12, 1992, to plan field strategy and to compile a draft vegetation map. Four biologists and a

representative of the Protect Kaho'olawe 'Ohana participated in this initial survey.

FIELD SURVEY

One of the primary objectives of the biological survey was to document and assess the status of native and non-native plants, animals, and ecosystems on Kaho'olawe. Zones particularly rich in native species or dominated by native vegetation were also to be identified for possible restoration. In preparation for the field work, survey routes were chosen, contingent upon the topography of the island. Fifteen routes were covered during the biological survey (Figure 2). Most of them extended for two to six miles and ran from the island's interior along a ridgetop to the coast, contoured the coastline, then returned to the interior along an adjacent ridge. Several of the survey routes were placed primarily along the coastline and cliffs to concentrate reconnaissance efforts on those areas likely to include rare species.

A group of 17 botanists, ecologists, zoologists, and other persons knowledgeable of Hawai'i's rare natural resources assisted in this extensive Heritage survey. A list of participants and their biographies are provided in Appendix F. To accomplish such an extensive survey, two 10-day visits (February 18 through 27 and March 17 through 26, 1992) were scheduled. During each survey period, a team of three to five persons, including a military Explosive Ordnance Disposal (EOD) expert, participated on a staggered field schedule.

While walking each survey route, the team recorded all native and non-native plants and animals encountered. Habitat descriptions included substrate type, slope and aspect, elevation, and prevailing moisture conditions. The ecologist on each team noted the various natural communities encountered and also recorded the community type, adjacent communities, canopy closure and height (for vegetation types), dominant and constituent species (including any rare taxa), and biological and human-related threats.

In the course of the reconnaissance survey, all plant taxa found either within native natural communities or within areas of alien-dominated vegetation were identified and recorded. All birds seen or identified by their calls were also noted. The vegetation and ground litter were searched for land snails. Furthermore, management needs were identified where appropriate. Information on non-native animals and the presence of non-native invasive plants was recorded along the survey routes. Finally, other threats were noted where recognized.

LIMITATIONS

The field surveys were conducted in February and March 1992, and took place over a period of 20 days, during what is normally the end of the wet season. However, the 1991-1992 season was unusually dry. The taxa recorded reflect the seasonal and environmental conditions existing at the time of the survey--some seasonally-dependent taxa may not have been apparent at the time of the survey. Additional surveys during wet and dry seasons may augment the results of this study. It was beyond the scope of this study to comprehensively survey for native terrestrial invertebrates, non-vascular plants, subterranean species and ecosystems, anchialine pools, and marine biota. These should be surveyed by qualified specialists.

Because of time limitations, only selected portions of the island could be surveyed. The remaining parts of the island, however, are expected to support similar kinds of plants and animals at similar elevations and habitat types. Also, more rare plants and animals may be found in additional surveys of the island.

RESULTS

HAWAIIAN NATURAL COMMUNITY CLASSIFICATION

Current conservation efforts recognize the need to identify and maintain intact natural communities as stable habitat for rare and common native plants and animals. In Hawai'i, nearly all of our natural communities are endemic to the islands, meaning they occur nowhere else in the world.

The Hawaiian natural community classification used in this report is hierarchical. There are aquatic, subterranean, and terrestrial categories of natural communities. Aquatic communities include springs, streams, lakes, and pools. Subterranean communities include lava tubes, limestone caves, and piping caves. The terrestrial community types are grouped and named according to elevation, moisture conditions, and vegetation structure. For example, among the native communities of Kaho'olawe are coastal dry shrubland, coastal dry grassland, lowland dry grassland, and coastal dry cliff. Individual community types are named more specifically for the most common or dominant plants present. For example, one coastal dry shrubland on the island of Kaho'olawe is located on coastal lava flats and is dominated by the native shrub 'ilima (*Sida fallax*). In the Hawaiian natural community classification, this community is named 'Ilima Coastal Dry Shrubland.

To date, approximately 150 native Hawaiian natural communities have been recognized and described. Of these, more than half (80 to 90) are considered rare or globally imperilled.

NATURAL COMMUNITIES OF THE ISLAND OF KAHO'OLAWA

Eight distinct native natural community types were observed during the Kaho'olawe survey (Table 1). Among them were two considered rare or imperilled: High Salinity Anchialine Pool, and Ma'o (*Gossypium tomentosum*) Coastal Dry Shrubland. The remaining native communities included two aquatic systems: Hawaiian Intermittent Stream and Hawaiian Ephemeral Pool, and four vegetation types: 'Aki'aki (*Sporobolus virginicus*) Coastal Dry Grassland, 'Ilima (*Sida fallax*) Coastal Dry Shrubland, Hawaiian Mixed Shrub Coastal Dry Cliff, and Pili (*Heteropogon contortus*) Lowland Dry Grassland. Each of these communities is described in some detail later in this report.

Native natural communities and vegetation constituted far less than 10 percent of the island, and was distributed along the coast and a few inland areas (Figure 3). In particular, coral

TABLE 1. NATIVE NATURAL COMMUNITIES OF KAHO'OLAWE ISLAND

NATURAL COMMUNITY NAME	HERITAGE GLOBAL RANK (a)	KAHO'OLAWE EXAMPLES (b)
AQUATIC		
Hawaiian Ephemeral Pool	G3?	-
Hawaiian Intermittent Stream	G4	-
High Salinity Lava Anchialine Pool *	G1	1
TERRESTRIAL		
'Aki'aki Coastal Dry Grassland	G4	-
Hawaiian Mixed Shrub Coastal Dry Cliff	G3	-
'Ilima Coastal Dry Shrubland	G3	-
Ma'o Coastal Dry Shrubland *	G1	3
Pili Lowland Dry Grassland	G3	-

Total: 8 native natural communities, 2 of which are rare.

* Rare natural community

(a) Key to the Hawai'i Heritage Program's Global Ranks:

- G1 = Critically imperilled globally (typically 5 or fewer examples worldwide)
- G2 = Imperilled globally (typically 6-20 examples worldwide)
- G3 = Restricted range (typically 21-100 examples worldwide)
- G4 = Apparently secure (typically >100 examples worldwide)

(b) Number of Kaho'olawe examples provided for rare communities only.

On Kaho'olawe, ephemeral pools were numerous in the basins of intermittent streams after winter storms. During our helicopter reconnaissance in December of 1991, many pools were seen from the air in gulch bottoms. During the ground survey in February, one such pool was observed in a nameless gulch along the west coast. Tadpole shrimps and seed shrimps were observed in a warm pool green with phytoplankton and filamentous algae. If this pool was typical, then Kaho'olawe probably supports a large number of these ephemeral pools in its many gulches. Flooded depressions such as those associated with Lua Makika and other similar features should also be inspected for ephemeral pool organisms after storm flooding.

Potential threats to ephemeral pools on Kaho'olawe include contamination or chemical modification of pool water from a variety of human sources including refuse sites and decomposing ordnance, filling of pool basins by wind-blown soil and silt, and invasion by alien aquatic insects and other invertebrates.

Hawaiian Intermittent Stream

There are many streams in the Hawaiian Islands that do not support year-long surface flow to the sea. These streams cannot support the typical complement of stream species found in streams with year-long surface flow, but are characterized by native aquatic insects and invertebrates, including those that do not require an oceanic stage. This widespread aquatic community is not currently considered rare, but the biology of intermittent streams in Hawai'i has not been well studied.

In Kaho'olawe's dry setting, all of the stream beds can be considered intermittent streams. These streams, when active, may be very important to numerous species of aquatic insects, snails, and other invertebrates. It was beyond the scope of this short survey to sample the stream beds of Kaho'olawe. An adequate sample would have to be well-timed to coincide with brief periods during the wet season in which Kaho'olawe's streams are active. As this community type becomes better understood, Kaho'olawe will probably become an important site for the study of the biology of Hawaiian intermittent streams.

High-Salinity Lava Anchialine Pool

Anchialine pools are land-locked bodies of water of varying salinity that are adjacent to the ocean (Appendix G). These pools have indirect, underground connections to the sea, and show tidal fluctuations in water level. Anchialine pool species tolerate varying salinity and include those adapted to a partially subterranean habitat offered by groundwater under the pools. Characteristic anchialine pool species include

crustaceans (shrimps, prawns, amphipods, isopods, etc.), some of which seem restricted to anchialine habitat. Hawaiian anchialine pools are often occupied by small endemic red shrimp (*Halocaridina* spp. and others) called 'opae'ula. Other species are restricted to the surface waters of the pools, and include fish, crustaceans and other invertebrates.

Globally, anchialine pools are found in a limited set of areas where fresh lava or limestone occurs adjacent to the sea. Anchialine pools are known from sites in the Indo-Pacific as well as the Caribbean. Some Hawaiian anchialine pools show extremely high invertebrate and algal diversity, among the highest in the Indo-Pacific, and perhaps the world.

There are several subtypes of Hawaiian anchialine pools, and the Kaho'olawe example is a high salinity (over 12 parts per thousand [ppt] dissolved chloride) pool in lava substrate. This pool type is considered rare, and is represented by fewer than 20 sites in the chain, with most on Hawai'i, a few on Maui, and one example each on Moloka'i and Kaho'olawe. The Kaho'olawe example was undocumented prior to this survey--an unexpected natural resource.

The Kaho'olawe anchialine pool occupies the flooded bomb crater called Sailor's Hat, on the island's west coast. Formed in June of 1965, the crater's waters show no surface connection to the sea, but water marks along its edge indicate tidal fluctuations of water level. The surface salinity of the pool was estimated to be greater than 12 ppt, and is probably higher at greater depths. The pool is about 50 meters (160 feet) in diameter, and its depth is probably greater than 15 meters (50 feet). Native animals observed included 'opae'ula shrimp (*Halocaridina rubra*), amphipods, snails, and red polychaete tube worms. An alien aquatic insect (family Corixidae) was also observed. A well-developed algal crust covered the boulders. The water was turbid with green phytoplankton (microscopic algae). The species observed form only a preliminary checklist for this pool. There are almost certainly additional species, many of which might be night-active, restricted to deeper waters, or detectable only through baited trapping.

Threats to anchialine pools include pool filling or other modifications of substrate, chemical contamination via human activities (e.g., bathing, trash disposal), introduction of alien fish or other biota, and taking of anchialine species from pools.

TERRESTRIAL COMMUNITIES

'Aki'aki Coastal Dry Grassland

Sporobolus virginicus Coastal Dry Grassland

A pantropic coastal strand community dominated by 'aki'aki (*Sporobolus virginicus*) occurs in small pockets on many sandy coastlines of all the Hawaiian Islands. This community is not currently considered rare; however, extensive 'aki'aki grasslands are limited to a few coastal dune areas where native vegetation is still relatively intact (e.g., Kahuku and Ka'ena on O'ahu, and Mo'omomi on Moloka'i).

These are among the most salt-tolerant communities and typically cover makai (ocean-facing) dune faces. Elevation ranges from sea level to about 10 meters (30 feet), and annual rainfall can vary from less than 250 millimeters (15 inches) on leeward coastlines to over 1000 millimeters (40 inches) on windward beaches. However, due to the sandy substrate and strong marine influence, rainfall seems to have little effect on the structure or composition of the 'aki'aki community.

On Kaho'olawe the 'aki'aki grasslands were simple, at times nothing but a dense cover of 'aki'aki on loose dunes of coral sand. On the mauka (inland) side of these dunes, 'aki'aki grasslands typically abut and intergrade with 'ilima (*Sida fallax*) and ma'o (*Gossypium tomentosum*) shrublands, or with the alien kiawe (*Prosopis pallida*) forest. Plants commonly found within the grassland include beach morning glory (*Ipomea pes-caprae* ssp. *brasiliensis*), nohu (*Tribulus cistoides*), and 'ohelo kai (*Lycium sandwicense*).

Though widespread in the Pacific, intact 'aki'aki grasslands are uncommon in Hawai'i. Most occurrences are heavily invaded by weeds, especially kiawe, bermuda grass (*Cynodon dactylon*), and common purslane (*Portulaca oleracea*).

Hawaiian Mixed Shrub Coastal Dry Cliff

On very steep to vertical coastal dry basalt cliffs, such as those of the northern coasts of Kaua'i, O'ahu and Moloka'i, occurs a sparse to open mixed shrubland of native coastal shrubs. Precipitation varies among the many examples of this community, from less than 1300 millimeters (50 inches) to about 2500 millimeters (100 inches) annually, but prevailing dry conditions exist due to poor soil development, steep, well-drained aspect, and exposure to sun and salt-laden winds. Dominant and constituent species vary by location, and often include rare plants, although the community itself is not currently considered rare.

An example of this community on Kaho'olawe was found on the east face of 'Ale'ale, a pinnacle-like wave-cut point near Pu'u Koa'e on the southern coast of the island. Elevation of this community varied between near sea level and about 85 meters (270 feet).

Adjacent communities were lacking due to the isolated nature of the stack, but where the Hawaiian Mixed Shrub Coastal Dry Cliff community extended to sea level, a native morning glory, *Ipomoea tuboides*, was locally dominant closest to the high tide line and seemed to occur in areas with poorer soil development. Surprisingly, the rare 'ihi (*Portulaca molokiniensis*) was a locally dominant species in the 'Ale'ale example, with over 200 individual plants present. In some sections, kawelu bunchgrass (*Eragrostis atropioides*) and kolomona (*Senna gaudichaudii*) shrubs were more abundant.

Other constituents of the mixed shrub cliff community on 'Ale'ale included 'akoko (*Chamaesyce celastroides* var. *amplectens*), *Mariscus phleoides*, 'uhaloa (*Waltheria indica*), ko'oko'olau (*Bidens mauiensis*), nehe (*Lipochaeta lavarum*), the grass *Panicum fauriei* var. *latius*, 'ilima (*Sida fallax*), and the dryland fern *Doryopteris decipiens*.

Rare constituent species of the cliffs of 'Ale'ale included two rare species of 'ihi (*Portulaca molokiniensis* and *P. villosa*), pua pilo (*Capparis sandwichiana*), and, most notably, an undetermined legume (Fabaceae) which appears to be a new taxon.

The main threat to the cliff community on 'Ale'ale is alien plants, especially species that can tolerate the dry, salty sea cliffs, such as swollen fingergrass (*Chloris barbata*), *Emilia fosbergii*, and tree tobacco (*Nicotiana glauca*). On any but the most vertical cliffs, goats can also pose a severe threat, but the vertical sides of 'Ale'ale has spared the vegetation from the heavy ungulate damage apparent elsewhere on Kaho'olawe.

'Ilima Coastal Dry Shrubland ***Sida fallax* Coastal Dry Shrubland**

Shrublands in coastal to lowland areas dominated by 'ilima (*Sida fallax*) are known from all of the main Hawaiian islands. The 'ilima coastal dry shrubland is a widespread and variable community that is not considered rare, although some examples contain rare plants.

On Kaho'olawe, patches of 'ilima shrubland typically occurred as a discontinuous band between the coast and inland plant communities. These were seen while driving the coastal road and were encountered on coastal transects. A previous survey of coastal and lowland vegetation of Kaho'olawe confirmed the presence of 'ilima shrubland. From the road, the 'ilima

shrubland appeared fairly simple, consisting of open stands of 'ilima less than one meter (from 1 to 3 feet) in stature. Other native plants found in the shrubland included ma'o (*Gossypium tomentosum*), *Abutilon incanum*, 'uhaloa (*Waltheria indica*), and pili grass (*Heteropogon contortus*). Some alien plants such as kiawe (*Prosopis pallida*), and Natal redtop (*Rhynchelytrum repens*) were observed, and in some places these and other weeds had displaced the 'ilima almost entirely. Adjacent natural communities on Kaho'olawe include: Ma'o Coastal Dry Shrubland, 'Aki'Aki Coastal Dry Grassland, Pili Lowland Dry Grassland, and alien kiawe forest. 'Ilima shrubland and pili grassland, in particular, formed a very complex mosaic, in which 'ilima was frequently codominant with pili.

It is likely that fire, and feral goats once present in the lowlands and coastal flats, have damaged the 'ilima shrubland. Invasion by alien weeds is another important threat to 'ilima shrublands on Kaho'olawe.

Ma'o Coastal Dry Shrubland ***Gossypium tomentosum* Coastal Dry Shrubland**

Only remnants of an open shrubland dominated by ma'o or Hawaiian cotton (*Gossypium tomentosum*) remain on the dry coasts and lowlands of the islands of Kaho'olawe and Lana'i (Appendix G). This community is considered rare and critically imperilled. Ma'o shrublands are found in very dry areas, receiving around 250 to 500 millimeters (10 to 20 inches) annual rainfall, on shallow, weathered clay soil, often with numerous surface rocks. Other native plants of this community may include 'ilima (*Sida* spp.), *Abutilon incanum*, 'uhaloa (*Waltheria indica*), nehe (*Lipochaeta rockii*), pili grass (*Heteropogon contortus*), and annual species of panic grasses (*Panicum* spp.).

The ma'o shrubland may formerly have extended upslope to 120 meters (500 feet) elevation, but at these higher elevations, the native vegetation has almost entirely been replaced by thickets or open woodlands of kiawe (*Prosopis pallida*) where the ground cover is dominated by alien grasses such as fingergrass (*Chloris* spp.), bristly foxtail (*Setaria verticillata*), and buffelgrass (*Cenchrus ciliaris*).

Remnants of the ma'o shrubland exist on the west coast and lowlands of Kaho'olawe. During our survey, ma'o shrubland was observed along the coast north of Hanakanaia. It was very dense, forming an almost monospecific stand surrounded by kiawe forest. Other species observed in association with ma'o shrubland on Kaho'olawe included 'ilima (*Sida fallax*), *Abutilon incanum*, and pili grass (*Heteropogon contortus*). In other areas on the west coast of the island, ma'o shrubland appeared to intergrade with adjacent 'ilima shrubland and pili grassland. An inland stand of

ma'o shrubland was visited during the helicopter reconnaissance. It occupied an opening in the prevalent kiawe-dominated woodland. In that shrubland example, 'ilima, pili and alien grasses were also present.

Threats to ma'o shrubland include fire, feral grazing animals, and displacement by aggressive alien plants, especially kiawe (*Prosopis pallida*) and buffelgrass (*Cenchrus ciliaris*). The proximity of two examples of cotton shrubland on Kaho'olawe to roads exacerbates the threat, but also provides ready access for protective management.

Pili Lowland Dry Grassland ***Heteropogon contortus* Lowland Dry Grassland**

The grass *Heteropogon contortus*, known in Hawai'i as "pili," has a widespread distribution in the dry tropics and subtropics, where it forms grasslands and savannahs in seasonal-drought regions of the world. Its worldwide status may be secure, since it is tolerant to both grazing animals and fire, but demonstrating a secure status for the community will require more research. In the Hawaiian Islands, pili grasslands are found on the main islands of Kaua'i, O'ahu, Moloka'i, Maui, Lana'i, Kaho'olawe, and Hawai'i.

Other native grasses, such as kawelu (*Eragrostis* spp.), or kakonakona (*Panicum* spp.) may sometimes be common or codominant in pili grasslands. Depending on elevation, a variety of low-growing native species can be found in pili grasslands, including 'a'ali'i (*Dodonaea viscosa*), 'ilima (*Sida* spp.), ma'o (*Gossypium tomentosum*), pa'u o Hi'iaka (*Jacquemontia ovalifolia* ssp. *sandwicensis*), and 'uhaloa (*Waltheria indica*).

On Kaho'olawe, pili grassland patches were observed on both northwest and southwest slopes, from just above sea level upslope to about 180 meters (600 feet) elevation. Scattered trees of kiawe or, rarely, wiliwili (*Erythrina sandwicensis*) occasionally occurred in the grassland, and the boundary between grassland and surrounding shrublands and forests was not always distinct. Native communities adjacent to pili grassland on Kaho'olawe include 'ilima shrubland, and ma'o shrubland. Only one rare plant species was encountered in pili grasslands on Kaho'olawe--*Vigna o-wahuensis*, a rare annual vine.

Alien plants in pili grassland on Kaho'olawe include klu (*Acacia farnesiana*), *Lantana camara*, pualele (*Emilia fosbergii*) and a variety of grasses which can displace pili in fire-prone areas. The ubiquitous alien dryland tree kiawe (*Prosopis pallida*) forms stable forests in areas that were probably pili grasslands.

Browsing ungulates such as goats, sheep, and cattle have also had an effect on pili grasslands, by removing native components and encouraging the establishment and spread of non-native species. This probably accounts for the general lack of pili grassland areas on the eastern end of the island, where historical impact from feral goats was concentrated. Fire is another potential threat to pili grasslands. Although pili regenerates well after fires, introduced grasses such as broomsedge are also fire-adapted and are rapidly increasing their range at the expense of pili grassland.

Alien-dominated Vegetation

Over 90 percent of Kaho'olawe was dominated by a combination of hardpan and barren soils, and alien vegetation such as kiawe (*Prosopis pallida*) forest, alien grasslands, and pickleweed (*Batis maritima*) flats.

Kiawe Forest: The most prevalent plant community on Kaho'olawe was an open forest or woodland of kiawe. In this forest, kiawe canopy reached up to 5 meters (20 feet), but in exposed areas, the trees were shorter. Under the kiawe canopy was a mix of alien shrubs and grasses, with a few remnant native plants. Some of the native plants encountered in the kiawe forest included: kawelu (*Eragrostis* spp.), 'ilima (*Sida* spp.), ma'oa (*Gossypium tomentosum*), pa'u o Hi'iaka (*Jacquemontia ovalifolia* ssp. *sandwicensis*), and 'uhaloa (*Waltheria indica*).

Alien Grassland: Breaks in kiawe forest cover, especially above about 150 meters (500 feet) elevation, were often occupied by alien-dominated grasslands. However, patches of alien grasslands were present from sea level up to the summit region. Some of the more abundant alien grasses included: Natal redtop (*Rhynchelytrum repens*), buffelgrass (*Cenchrus ciliaris*), fingergrass (*Chloris* spp.), bristly foxtail (*Setaria verticillata*), and *Dactyloctenium aegypticum*. Along the northwestern and southwestern slopes between sea level and about 180 meters (600 feet) elevation, alien grasses were sometimes outcompeted by the native pili (*Heteropogon contortus*), forming mosaics of native and alien-dominant grasslands.

Pickleweed Flats: Another prevalent alien-dominated vegetation type is dominated by a succulent herb, pickleweed. It formed monotypic herblands in several of the coastal mudflats associated with the mouths of intermittent streams along the west coast of the island.

RARE PLANTS OF KAHO'OLAWA

The native flora of Hawai'i consists of approximately 1300 flowering plants and ferns (Wagner, Herbst, and Sohmer 1990; Wagner and Wagner 1987). Of these, 89 percent of the flowering plants and 69 percent of the ferns are endemic (unique) to Hawai'i. Almost half of Hawai'i's native plants are believed to be rare (HHP 1992).

The Heritage biological survey resulted in several additions to the flora of Kaho'olawe, including 7 native taxa:

- Asplenium adiatum-nigrum*
- Eragrostis atropioides*
- Lepidium bidentatum* var. *o-waihiense**
- Fabaceae sp. nov.??*
- Mariscus phleoides* ssp. *phleoides*
- Senna gaudichaudii*
- Ophioglossum concinnum**

(3 of which are rare*) and 13 alien taxa (Appendix A1).

Thirteen rare plant taxa have been recorded on Kaho'olawe (photos and/or line drawings of nine rare plant taxa are included in Appendix G). Only one of the Kaho'olawe rare taxa is currently listed by the U.S. Fish and Wildlife Service as an endangered taxon. Five others are Category 1 candidates for listing as either endangered or threatened, and four are Category 2 candidates for listing (Table 2). The remaining three taxa have neither endangered status nor candidate endangered status.

Of the 13 rare plant taxa recorded from Kaho'olawe, 2 were discovered during the Heritage biological reconnaissance. These include one Category 1 plant (*Ophioglossum concinnum*), and one plant that does not have endangered or candidate endangered status (Fabaceae sp. nov.??).

The locations of rare plants recorded from Kaho'olawe are shown on Figure 4. A description of each rare plant taxon recorded from the island follows in the next section.

Caveats on the Botanical Information in this Report: This report includes information from a variety of sources including museum specimens and a large body of published and unpublished literature. The source material is sometimes subject to interpretation, and a number of doubtful records and inaccuracies may exist. For example, according to Wagner, Herbst, and Sohmer (1990), the rare plant *Exocarpos gaudichaudii* has been recorded from "all islands except Kaua'i." However, the basis for the inclusion of Kaho'olawe in the range of the species is unknown and possibly in error (J. Lau, personal communication 1992).

TABLE 2. RARE PLANT SPECIES RECORDED FROM KAHO'OLAWE ISLAND

The plants listed below are the naturally occurring rare taxa of Kaho'olawe (experimental plantings are not included in this table). This list includes taxa observed during the HHP survey (February and March 1992) as well as taxa recorded previously from other surveys.

STATUS	SCIENTIFIC NAME (a)	COMMON NAME	FEDERAL STATUS (b)	HERITAGE		SOURCE
				RANK (c)	GLOBAL	
FERNS AND FERN ALLIES						
	Ophioglossaceae					
E	Ophioglossum concinnum	Pololei	C1	G2		*

FLOWERING PLANTS

	Asteraceae					
E	Lipochaeta bryanii	Nehe	3A	GH		X
	Brassicaceae					
E	Lepidium bidentatum var. o-waihiense	'Anaunau, naunau, kunana	None	G2T2		*
	Capparaceae					
E	Capparis sandwichiiana	Pua pilo, maiapilo	C2	G2		*
	Euphorbiaceae					
E	Chamaesyce skottsbergii var. vaccinioides	'Akoko, koko, kokomalei	C2	G2T1		X
	Fabaceae					
E	Fabaceae sp. nov.	-	None	G1		*
E	Sesbania tomentosa	'Ohai	C1	G2		*
E	Vigna o-wahuensis	-	C1	G1		*
	Malvaceae					
E	Hibiscus brackenridgei ssp. brackenridgei	Ma'o hau hele	C1	G1T1		X
	Portulacaceae					
E	Portulaca molokiniensis	'Ihi	C2	G1		*
E	Portulaca villosa	'Ihi	C2	G1		*
	Rhamnaceae					
E	Gouania hillebrandii	-	LE	G1		X
	Urticaceae					
E	Neraudia sericea	Ma'aloa, ma'olua, 'olua	C1	G1		X

Status codes: E = Endemic, native only to the Hawaiian Islands

I = Indigenous, native to the Hawaiian Islands and elsewhere

Source codes: X = Recorded previously from Kaho'olawe, but not observed during the HHP survey

* = Observed during the HHP survey

Figure 4
Island of Kahoolawe
 Rare Plant and Animal Location

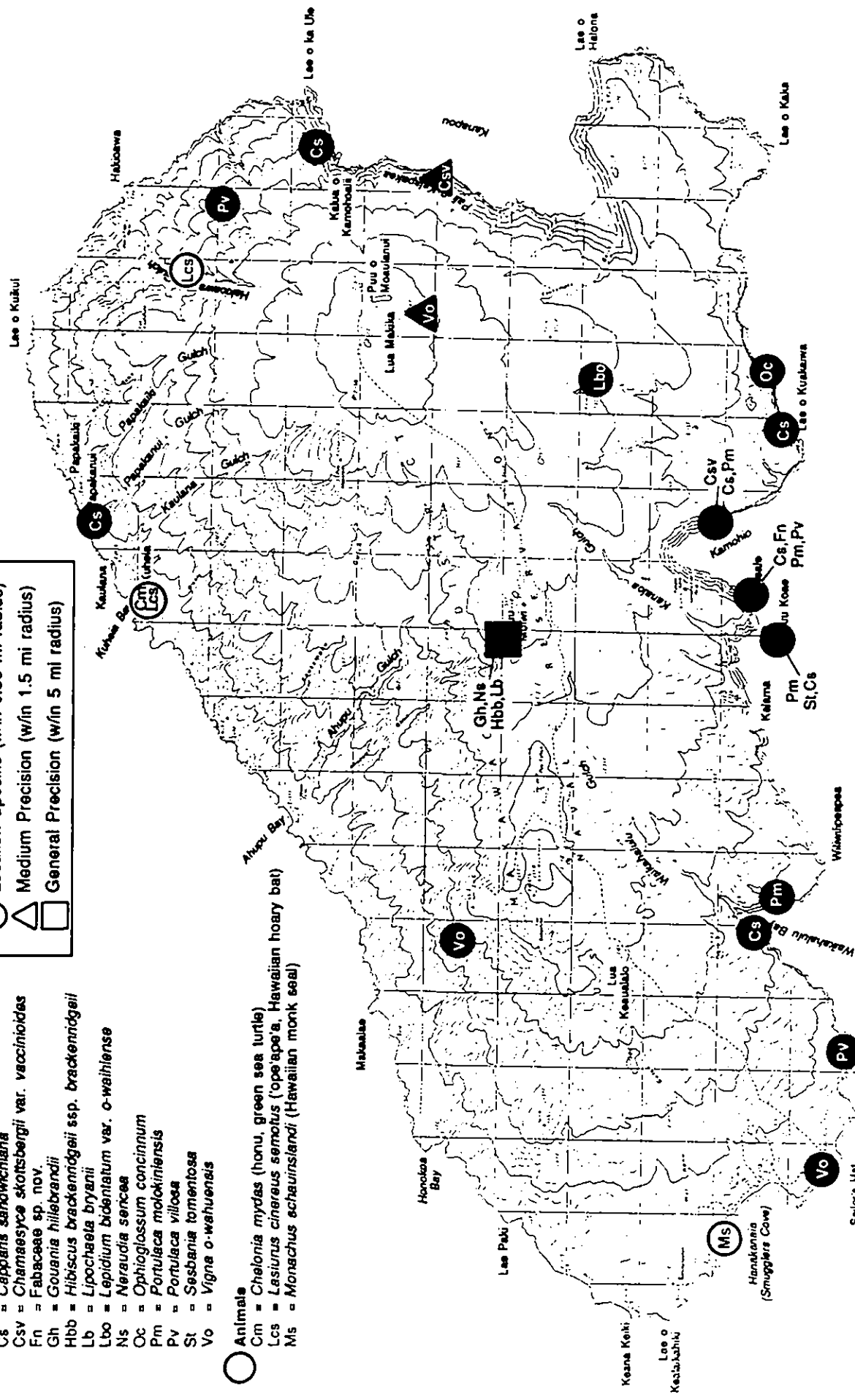
- Location Specific (w/in 0.33 mi radius)
- △ Medium Precision (w/in 1.5 mi radius)
- General Precision (w/in 5 mi radius)

Plants

- Cs = *Capparis sandwichiana*
- Csv = *Chamaesyce skottsbergii* var. *vaccinioides*
- Fn = *Fabaceae* sp. nov.
- Gh = *Gouania hillebrandii*
- Hbb = *Hibiscus brackenridgei* ssp. *brackenridgei*
- Lb = *Lipochaeta bryanii*
- Lbo = *Lepidium bidentatum* var. *o-waihiense*
- Ns = *Nerardita sericea*
- Oc = *Ophioglossum concinnum*
- Pm = *Portulaca molokiniensis*
- Pv = *Portulaca villosa*
- St = *Sesbania tomentosa*
- Vo = *Vigna o-wahuensis*

Animals

- Cm = *Chelonia mydas* (honu, green sea turtle)
- Lcs = *Lasius cinereus semotus* ('ope'ape'a, Hawaiian hoary bat)
- Ms = *Monachus echauinslandi* (Hawaiian monk seal)



Also encountered were plant ranges whose inclusion of Kaho'olawe appear to be based on specimens that were apparently misidentified. For instance, the rare *Chamaesyce celastroides* var. *stokesii* is reported in Wagner, Herbst, and Sohmer (1990) as occurring on Kaho'olawe. However, the sole specimen at the Bishop Museum herbarium identified as *Chamaesyce celastroides* var. *stokesii* is apparently a misidentified *Chamaesyce celastroides* var. *amplectens* (J. Lau, personal communication 1992). In addition, the HHP does not include beach drift material on its list of native and naturalized plants of Kaho'olawe. However, other sources (e.g., Corn et al. 1980; U.S. Department of the Navy 1979) include drift material on their lists. Notes on doubtful identifications and non-living material are made in Appendix A2.

The focus of the Heritage biological reconnaissance was to survey the native and naturalized flora of Kaho'olawe. It was not within the scope of the reconnaissance to inventory the taxa used in the various revegetation trials and other plantings.

RARE PLANT SPECIES ACCOUNTS

Federally Listed Taxa

Gouania hillebrandii Oliver

Common name: None

Federal status: Listed endangered (USFWS 1991)

Heritage global rank: G1 (HHP 1992)

Gouania hillebrandii is an erect or sprawling shrub in the buckthorn family (Rhamnaceae). It grows up to 1.8 meters (6 feet) tall and has slender branches covered with rust- or ash-colored hairs. The flowers are small and white with a strong sweet fragrance (Wagner, Herbst, and Sohmer 1990).

Gouania hillebrandii has been recorded from Moloka'i, Maui, Lana'i, and Kaho'olawe from dry to mesic shrubland and forest, from near sea level to 850 meters (2800 feet) (HHP 1992).

Gouania hillebrandii was collected from Kaho'olawe only once between 1851 and 1855 by J. Remy. It has not been reported from the island since then.

Federally Proposed Taxa

No federally proposed endangered or threatened taxa have been reported from Kaho'olawe (HHP 1992). However, the U.S. Fish and Wildlife Service is currently preparing to propose the following taxa for listing as federally endangered or threatened species:

Hibiscus brackenridgei, *Neraudia sericea*, *Ophioglossum concinnum*, *Sesbania tomentosa*, and *Vigna o-wahuensis* (J. Canfield, personal communication 1992).

Candidate Taxa

Capparis sandwichiana DC

Common name: Pua pilo, maiapilo

Federal status: Category 2 candidate (USFWS 1990)

Heritage global rank: G2 (HHP 1992)

A member of the caper family (Capparaceae), *Capparis sandwichiana* is a prostrate or upright shrub with light green, fleshy leaves, and large white flowers that turn light pink with age.

It is possible that the Hawaiian occurrences of *Capparis* are part of the widespread Pacific species *C. cordifolia*, and not a separate Hawaiian species (Wagner, Herbst, and Sohmer 1990). More taxonomic studies are needed to determine if this is an endemic or indigenous species.

The species has been recorded from all of the main Hawaiian Islands as well as Midway, Pearl and Hermes Atolls, and Laysan in the Northwestern Hawaiian Islands. Most often, this species grows in coastal areas, but sometimes it can be found inland up to 910 meters (3000 feet) in elevation (HHP 1992).

On the HHP biological reconnaissance, *Capparis sandwichiana* was seen at several locations along the southern, eastern, and northern coasts. On previous surveys it was recorded from the same general areas, as well as on Pu'u Koa'e off the southern coast of the island.

Chamaesyce skottsbergii (Sherff) Croizat & Degener var.
vaccinioides (Sherff) Koutnik

Common name: 'Akoko, koko, kokomalei

Federal status: Category 2 candidate (USFWS 1990)

Heritage global rank: G2T1 (HHP 1992)

This member of the spurge family (Euphorbiaceae) is a subshrub with elliptic to oblanceolate leaves oppositely arranged along the stem. The flowers are borne in cyathia with yellowish green to red glands. The fruit is a small green capsule borne on a recurved stalk that becomes erect just prior to dehiscence (Wagner, Herbst, and Sohmer 1990).

Chamaesyce skottsbergii is endemic to O'ahu, Moloka'i, East Maui, and Kaho'olawe. It has two varieties. The variety *vaccinioides* is endemic to Moloka'i, East Maui, and Kaho'olawe and is found

between the elevations of 20 and 580 meters (70 and 1900 feet) in dry grassland and shrubland (HHP 1992).

There are two records of this variety from Kaho'olawe. In 1913 it was collected from Kanapou Bay on the eastern coast of Kaho'olawe. In 1980 a single plant was reported from the east side of Kamohio Bay on Kaho'olawe's southern coast. This taxon was not encountered during the Heritage biological reconnaissance.

Hibiscus brackenridgei A. Gray ssp. *brackenridgei*
Common name: Ma'o hau hele
Federal status: Category 1 candidate (USFWS 1990)
Heritage global rank: G1T1 (HHP 1992)

Hibiscus brackenridgei of the mallow family (Malvaceae) is Hawai'i's state flower. The subspecies *brackenridgei* is a shrub or small tree which usually grows to a height of 3 to 5 meters (10 to 16 feet) (Wagner, Herbst, and Sohmer 1990). Its large showy flowers are bright lemon yellow and sometimes have a maroon center.

This species was collected on Kaho'olawe by J. Remy between 1851 and 1855. It has not been found in the wild on Kaho'olawe since then.

Hibiscus brackenridgei is endemic to Kaua'i, O'ahu, Moloka'i, Maui, Lana'i, Kaho'olawe, and Hawai'i. It consists of two subspecies, ssp. *brackenridgei* and ssp. *mokuleianus*. It is not certain which of the two subspecies the Kaho'olawe plant belong to, because the Remy specimens have not been recently examined by taxonomists. However, it is assumed that they represent the ssp. *brackenridgei* which has been recorded from the younger islands of Moloka'i, Maui, Lana'i, and Hawai'i (the ssp. *mokuleianus* has been recorded from the older islands of Kaua'i and O'ahu). Subspecies *brackenridgei* has been found from sea level to 760 meters (2500 feet) in elevation in dry shrublands and forests (HHP 1992).

Neraudia sericea Gaud.
Common name: Ma'aloa, ma'oloa, 'oloa
Federal status: Category 1 candidate (USFWS 1990)
Heritage global rank: G1 (HHP 1992)

Neraudia sericea of the nettle family (Urticaceae) is a 3 to 5 meter- (10 to 16-foot) tall dioecious shrub. Its branches, leaves, and petioles are covered with short hairs. The flowers, which are either staminate (male) or pistillate (female), are small and inconspicuous (Wagner, Herbst, and Sohmer 1990).

This plant has been recorded from dry to mesic forests on Moloka'i, Maui, Lana'i, and Kaho'olawe from 450 meters (1480 feet) or lower, up to 1370 meters (4500 feet) (HHP 1992).

The single known Kaho'olawe specimen of this taxon was collected by J. M. Lydgate in the 1860s. There have been no records of it on the island since then.

Ophioglossum concinnum Brack.

Common name: Pololei

Federal status: Category 1 candidate (USFWS 1990)

Heritage global rank: G2 (HHP 1992)

Ophioglossum concinnum is a fern in the adder's tongue family (Ophioglossaceae). This perennial plant is generally visible only during the wet winter season, when the underground rootstock produces fronds. The fronds are elliptic-lanceolate, ovate-elliptic, or suborbicular in shape. Each frond bears a fertile spike 1 to 1.5 centimeters (about .5 inches) long (Clausen 1938).

The species is endemic to Kaua'i, O'ahu, Moloka'i, Maui, Lana'i, Kaho'olawe, and Hawai'i. It is usually found in coastal environments, or, less frequently, at inland locations up to 430 meters (1400 feet) in elevation. It occurs in dry habitats including unconsolidated sand dunes, lithified sand dunes, and volcanic substrates (HHP 1992).

The species was observed for the first time on Kaho'olawe during the Heritage biological reconnaissance; only a single plant was seen. It was found at the top of the southern seacliffs at about 160 meters (525 feet) in elevation, 1 kilometer (0.6 mile) east of Lae o Kuakaiwa in a sparsely vegetated, gravelly area.

Portulaca molokiniensis Hobdy

Common name: 'Ihi

Federal status: Category 2 candidate (USFWS 1990)

Heritage global rank: G1 (HHP 1992)

Portulaca molokiniensis of the purslane family (Portulacaceae) is a succulent herb. It is branched at the base, with stems 2.5 to 5 decimeters tall. The leaves are broadly obovate, 40 to 45 millimeters long. The yellow flowers are borne in a head-like cluster on the end of a long leafless stalk (Wagner, Herbst, and Sohmer 1990).

Portulaca molokiniensis has been recorded from Molokini (an offshore island between Maui and Kaho'olawe), Kaho'olawe, and Lana'i (a recent find) from 10 to 230 meters (33 to 750 feet). It is known from coastal environments, except for the single known Lana'i population which is located inland (HHP 1992).

On Kaho'olawe this species has been found at three locations at the base of the seacliffs, as well as on the islet Pu'u Koa'e. The largest known population on Kaho'olawe is at 'Ale'ale, with an estimated 500 plants seen during the Heritage biological reconnaissance. The species was also reported from the east side of Waikahalulu Bay in 1980, where four plants were seen. Also in 1980, 24 to 25 plants were seen on the east side of Kamohio Bay. On the islet of Pu'u Koa'e, a state seabird sanctuary, scattered individuals were observed in 1984.

Portulaca villosa Cham.

Common name: 'Ihi

Federal status: Category 2 candidate (USFWS 1990)

Heritage global rank: G1 (HHP 1992)

Portulaca villosa is a succulent herb with stems prostrate to ascending. Its leaves are narrowly oblanceolate to linear, 5 to 25 millimeters (.2 to 1 inch) long. Its flowers are white to pink in color, with petals 8 to 10 millimeters (about .35 inches) long (Wagner, Herbst, and Sohmer 1990).

The species has been recorded from all of the main Hawaiian Islands except Ni'ihau. It has also been found on Ka'ula, and on Nihoa in the Northwestern Hawaiian Islands. It is usually found in dry open habitats, on or near the coast, but has been reported up to 490 meters (1600 feet) in elevation (HHP 1992).

Portulaca villosa has been recorded from three places on Kaho'olawe. During the Heritage biological reconnaissance it was seen along the southern coast at two locations: at 'Ale'ale, and in the U.S. Coast Guard Reservation on the southwest end of the island. At 'Ale'ale 12 plants were observed. About 40 plants were seen at the Coast Guard Reservation. Also, in 1980 on the northeastern part of the island, 50 plants were found south of Hakioawa at 290 meters (950 feet) elevation.

Sesbania tomentosa Hook. & Arnott

Common name: 'Ohai

Federal status: Category 1 candidate (USFWS 1990)

Heritage global rank: G2 (HHP 1992)

Sesbania tomentosa, a member of the pea family (Fabaceae), is a prostrate to erect shrub, or sometimes a small tree up to 6 meters (20 feet) tall. Its pinnate leaves bear 18 to 38 elliptic leaflets, often covered with silky hairs. The flowers, which grow in clusters of two to nine, can range in color from salmon to scarlet, and are rarely pure yellow. The fruits are long, narrow pods that contain 6 to 27 small dark-colored seeds (Wagner, Herbst, and Sohmer 1990).

Sesbania tomentosa has been recorded from all the major Hawaiian Islands and is also found on Necker and Nihoa in the Northwestern Hawaiian Islands. It has been found primarily in coastal environments, and less often inland as high as 853 meters (2800 feet) in elevation. It occurs in dry habitats in calcareous and volcanic substrates (HHP 1992).

Sesbania tomentosa occurs on the islet of Pu'u Koa'e, a state seabird sanctuary. The most recent observation of the species on Pu'u Koa'e was during the Heritage survey. Sixteen plants were observed from a vantage on the Kaho'olawe cliffs closest to Pu'u Koa'e, but additional plants may have been hidden from view. Two to three dozen plants were reported on the islet in 1984. The species was also collected at an unknown location on Kaho'olawe proper by C. N. Forbes in 1913. It has not been reported from the island since then.

Vigna o-wahuensis Vogel

Common name: None

Federal status: Category 1 candidate (USFWS 1990)

Heritage global rank: G1 (HHP 1992)

A member of the pea family (Fabaceae), *Vigna o-wahuensis* is a slender, twining annual or perennial herb. The leaflets, stems, and fruit pods are sparsely to moderately pubescent. The stems are usually one to four decimeters long, and the flowers are pale yellow or greenish yellow in color (Wagner, Herbst, and Sohmer 1990).

Vigna o-wahuensis is endemic to Ni'ihau, Kaua'i, O'ahu, Moloka'i, Maui, Lana'i, Kaho'olawe, and Hawai'i. The species occurs in dry to mesic grasslands and shrublands from 10 to 1370 meters (30 to 4500 feet) in elevation (HHP 1992).

Vigna o-wahuensis has been collected or reported from three areas on Kaho'olawe. In 1978, a specimen was collected approximately 150 meters (500 feet) west of Sailor's Hat (which is at the southwest end of the island, about 0.5 miles (0.8 kilometers) south of Hanakanaia). In 1982, specimens were collected on the upper part of the island between 400 and 410 meters (1300 and 1350 feet) elevation. During the Heritage biological reconnaissance of Kaho'olawe, a single plant was seen on the northwest portion of the island about halfway between Maka'alae and Lua Kealialalo at 140 meters (460 feet) in pili (*Heteropogon contortus*) grassland.

Other Taxa of Concern

Lepidium bidentatum var. *o-waihiense*
Common name: 'Anaunau, naunau, kunana
Federal status: None
Heritage global rank: G2T2 (HHP 1992)

Lepidium bidentatum var. *o-waihiense* in the mustard family (Brassicaceae) is a subshrub 15 to 60 centimeters (6 to 23 inches) tall with inconspicuous white flowers in terminal racemes (Wagner, Herbst, and Sohmer 1990).

Lepidium bidentatum is widely distributed from Hawai'i nearly throughout the south, central, and eastern Pacific islands and in New Caledonia. The Hawaiian endemic var. *o-waihiense* has been recorded from Kure, Midway, and Pearl and Hermes Atoll and Laysan in the Northwestern Hawaiian Islands, and the main Hawaiian islands of Kaua'i, O'ahu, Moloka'i, Maui, Lana'i, and Hawai'i. It has been recorded from near sea level up to 670 meters (2200 feet) elevation, in dry to mesic habitats (HHP 1992).

A single plant was seen on the HHP survey on the southwestern part of Kaho'olawe. It was found on sparsely vegetated eroded ground at 300 meters (980 feet). This taxon had not been previously recorded from the island. The plant observed possibly represents an escapee from trial plantings.

Lipochaeta bryanii Sherff
Common name: Nehe
Federal status: No longer a candidate (category 3A) (USFWS 1990)
Heritage global rank: GH (HHP 1992)

Lipochaeta bryanii is a somewhat woody perennial herb in the sunflower family (Asteraceae). It has erect stems that reach three to five decimeters (12 to 20 inches) in length and yellow flowers (Wagner, Herbst, and Sohmer 1990).

The species is known only from the type specimen collected on Kaho'olawe at an elevation of 300 meters (980 feet) amidst pili grass (*Heteropogon contortus*). It was collected in 1931 and has not been reported since.

Fabaceae sp. nov.?
Common name: None
Federal status: None
Heritage global rank: G1 (HHP 1992)

This apparently new species was discovered during the Heritage biological reconnaissance of Kaho'olawe. It is a legume in the subfamily Mimosoideae. It appears to be a native plant

representing a genus unrecorded from Hawai'i. There is also a possibility that the plant represents a completely new genus. Good flowering material needs to be collected so that its placement within the Mimosoideae can be evaluated.

There are only two known individuals of this taxon on Kaho'olawe. They are growing on 'Ale'ale, which is a steep-sided hill at the base of the seacliffs on the west side of Kamohio Bay on the southern coast of Kaho'olawe.

The plants are robust shrubs 1 meter (3.3 feet) tall and up to 2 meters (6.6 feet) across. Their leaves bear six leaflets. Each leaf has a pair of terminal pinna, and each of the pinna, furthermore, bears a terminal pair of leaflets and a single outer leaflet near the base of the pinna. The flowers are arranged in a globose head borne on a long peduncle. The fruit is a flat, dry pod that does not dehisce. Each fruit contains a single flattish seed.

RARE ANIMALS OF KAHO'OLAWE

A unique assemblage of native animals exists in Hawai'i. Most of these animals are endemic, occurring nowhere else in the world. Because of Hawai'i's isolated mid-Pacific location and relatively small size, the assemblage of native animal taxa is a result of only a few colonizations.

In the Hawaiian archipelago, geology and climate have acted together to create many different habitats. Early arriving species (such as forest birds, insects, and land snails) were able to take advantage of and adapt to these unique habitats. The resulting existing endemic species consist of one land mammal, one marine mammal, 49 birds, hundreds of land snails, and thousands of insects and other terrestrial invertebrates.

Since humans arrived, they have modified habitat and introduced numerous non-native species that have been very successful in out-competing the native species. The result has been that many of the original animal species have gone extinct, and many of the remaining endemic populations are now considered rare and in danger of extinction.

Little is known about the prehuman native Hawaiian fauna of Kaho'olawe Island because of the rapid rate at which ecological changes and extinctions took place, and because many of the changes occurred before any detailed biological explorations were undertaken. Nevertheless, the rocky cliffs, beaches, and surrounding waters of Kaho'olawe continue to provide habitat for native Hawaiian animals including seabirds, sea turtles, and marine mammals (photos of five significant animals recorded from Kaho'olawe are in Appendix G). Native Hawaiian aquatic invertebrates occupy the high salinity anchialine pool at Sailor's Hat. The forested areas of Kaho'olawe, although greatly altered, probably contain small isolated populations of native Hawaiian land snails and other native Hawaiian invertebrates. One native Hawaiian land bird, the pueo (*Asio flammeus sandwichensis*), still survives on the island. Hawai'i's only native terrestrial mammal, the rare Hawaiian hoary bat (*Lasiurus cinereus semotus*), has also been recently recorded from Kaho'olawe.

The species accounts presented below briefly describe the five rare Hawaiian animals that have been reported alive on Kaho'olawe, or from areas just offshore. Four of these animals are listed as endangered and one is listed as threatened (Table 3). Appendix B contains all animals reported on or near Kaho'olawe Island. The list includes records made during the HHP survey, land snail information from the Bishop Museum collections, and information compiled from the HHP database and the literature. Appendix B lists only records of living animals,

with the exception of the recently dead seabirds *Bulweria bulwerii* and *Puffinus pacificus chlororhynchus*. Both seabirds probably nest on Pu'u Koa'e and nearby 'Ale'ale. The dead snails recorded during the HHP survey are also included because dead specimens may indicate the existence of undiscovered snail populations on Kaho'olawe. Although it is not known whether they were collected alive or dead, snails recorded in the Bishop Museum collections are also included for the same reason. Information on archaeological snail records can be obtained in the report by Christensen (1987). Information on bird bone records is reported in Appendix C.

It is noteworthy that bones of both the nene (*Nesochen sandvicensis*) and the band-rumped storm-petrel (*Oceanodroma castro*) have been discovered on Kaho'olawe (Appendix C), although neither species has been reported alive from the island. The endemic nene is Hawai'i's state bird. The species is listed as endangered by the U.S. Fish and Wildlife Service (1991) and by the Hawai'i Department of Land and Natural Resources (1990). The indigenous band-rumped storm-petrel is listed as endangered by the Hawai'i Department of Land and Natural Resources (1990). With proper management of Kaho'olawe's natural resources (see Management Recommendations section), these birds may eventually recolonize Kaho'olawe Island.

Caveats on Animal Information: Throughout this report, the Hawai'i Heritage Program regards the pueo as a native Hawaiian land bird, and considers it to be a distinct endemic subspecies (*Asio flammeus sandwichensis*). This classification is used by others (Berger 1981; Scott et al. 1986; Pyle 1988; Hawai'i Audubon Society 1989), but is debatable (Olson and James 1982). The account by Olson (Appendix C) ranks the pueo as a post-Polynesian immigrant, not taxonomically different from mainland short-eared owls (*Asio flammeus*). Therefore, Olson does not list the pueo among Kaho'olawe's native Hawaiian land birds.

The Hawai'i Heritage Program adopts the taxonomic usage that lists the nene as *Nesochen sandvicensis* (Berger 1981; Scott et al. 1986; Pyle 1988; Hawai'i Audubon Society 1989). The account by Olson (Appendix C) uses a different classification, and places the nene in the genus *Branta*.

It was beyond the scope of the HHP survey to do a complete invertebrate inventory of Kaho'olawe. Thousands of insects and other terrestrial invertebrates inhabit the Hawaiian Islands. The native Hawaiian invertebrate fauna is poorly understood, and many of these animals have not yet been described. A comprehensive invertebrate survey would require highly specialized workers, and might be warranted for unusual ecosystems on Kaho'olawe, such as the newly discovered anchialine pool at Sailor's Hat.

RARE ANIMAL SPECIES ACCOUNTS

Federally Listed Taxa

Pterodroma phaeopygia sandwichensis

Common name: Dark-rumped (Hawaiian) petrel, 'ua'u

Federal status: Listed endangered (USFWS 1991)

Heritage global rank: G2T2 (HHP 1992)

'Ua'u formerly nested on all the main Hawaiian Islands except Ni'ihau. Now nesting colonies are restricted primarily to Haleakala Crater on Maui, with smaller numbers nesting on Kaua'i, Lana'i, Hawai'i, and Moloka'i (Pratt, Bruner, and Berrett 1987; Hawai'i Audubon Society 1989).

Little is known about 'ua'u dispersal as they are rarely seen at sea in Hawaiian waters (Pratt, Bruner, and Berrett 1987). The 'ua'u is generally seen close to the main Hawaiian Islands only during the breeding season; otherwise, it is a pelagic species. Breeding extends from March to October. It breeds in burrows or under rocks in barren areas high on mountain slopes where it lays a single white egg. Adults arrive and depart colonies at night. Adults feed on squid, fish, and crustaceans and pass food to chicks by regurgitation (Hawai'i Audubon Society 1989).

The 'ua'u is a large petrel with a short, wedge-shaped tail. Its upper parts are very dark with a white "V" at the base of the upper tail coverts. The forehead and under parts are white. The wing is white underneath with a black margin, a diagonal bar, and a broad carpal patch (Pratt, Bruner, and Berrett 1987).

Fledglings usually leave their nests during October and November. Unfortunately, they are often attracted to man-made lights while making their first flight toward the open ocean. They often become disoriented, crashing into the lights and other objects; hence, many young birds are injured or killed each year (Berger 1981). Predation by introduced rats (*Rattus* sp.) and mongooses (*Herpestes auropunctatus auropunctatus*) is also a serious threat to this endangered species (Hawai'i Audubon Society 1989).

Only 'ua'u nesting colonies are included in the Hawai'i Heritage Program's Database. Nesting colonies are not known from Kaho'olawe, but they could potentially become established, especially if feral mammals are controlled. In July 1982, 'ua'u were heard calling in flight near the summit of Pu'u o Moa'ulanui (Conant 1983). 'Ua'u were not observed during the HHP survey.

TABLE 3. RARE ANIMAL SPECIES RECORDED FROM KAHO'OLAWA ISLAND

The rare animals listed below have been recorded from visual and/or audio identification on Kaho'olawe Island, or from areas just offshore. The list includes records made during the HHP survey (February and March 1992), and information compiled from the HHP database and the literature. Only records of living animals are reported here.

STATUS	SCIENTIFIC NAME (a)	COMMON NAME	HERITAGE		SOURCE
			FEDERAL STATUS (b)	GLOBAL RANK (c)	
REPTILES					
	Cheloniidae				
I	Chelonia mydas	Honu, Green Turtle	LT	G3	x
BIRDS					
	Procellariidae				
E	Pterodroma phaeopygia sandwichensis	'Ua'u, Dark-rumped Petrel	LE	G2	x
MAMMALS					
	Vespertilionidae				
E	Lasiurus cinereus semotus	'Ope'ape'a, Hawaiian Hoary Bat	LE	G2	x
	Balaenopteridae				
I	Megaptera novaeangliae	Humpback Whale	LE	G2	*
	Phocidae				
E	Monachus schauinslandi	'Ilio holo i ka uua, Hawaiian Monk Seal	LE	G2	x

Status codes: E = Endemic, native only to the Hawaiian Islands I = Indigenous, native to the Hawaiian Islands and elsewhere (includes regular migrants and species which breed in Hawaii)

Source codes: x = Cited in the literature and/or in the HHP database * = Recorded during field survey

(a) Reptile taxonomic names are listed according to Mckeown (1978).

Bird taxonomic names are listed according to Pyle (1988).

Mammal taxonomic names are listed according to Tomich (1986).

(b) Key to Federal Status (USFWS 1991):

.E = Taxa formally listed as endangered

LT = Taxa formally listed as threatened

(c) Key to the Hawai'i Heritage Program's Global Ranks:

G2 = Species imperilled globally (typically 6-20 current occurrences).

G3 = Very rare with restricted range (typically 21-100 current occurrences).

TABLE 2. RARE PLANT SPECIES RECORDED FROM KAHO'OLAWE ISLAND (continued)

- (a) Taxonomic names of the flowering plants are listed according to Wagner, Herbst, and Sohmer (1990). Taxonomic names of the ferns and fern allies are listed according to Lamoureux (1988).
- (b) Key to Federal Status (USFWS 1990, 1991):
- LE = Taxa formally listed as endangered.
 - C1 = Category 1; candidate taxa for which the USFWS has substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened species.
 - C2 = Category 2; candidate taxa for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time. More research on vulnerability, taxonomy, and/or threat(s) are needed before they can be proposed for listing as endangered or threatened.
 - 3A = Category 3A, no longer candidates for listing; taxa for which the USFWS has persuasive evidence of extinction. If rediscovered, such taxa might acquire high priority for listing.
- None = No federal status. Recommended as rare by Hawaiian biologists and confirmed by Heritage data.
- (c) Key to the Hawai'i Heritage Program's Global Ranks:
- G1 = Species critically imperilled globally (typically 1-5 current occurrences).
 - G2 = Species imperilled globally (typically 6-20 current occurrences).
 - GH = Species known only from historical occurrences (typically no observations in past 15 years).
 - T1 = Subspecies or variety critically imperilled globally.
 - T2 = Subspecies or variety imperilled globally.

Chelonia mydas

Common name: Green turtle, honu

Federal status: Listed threatened (USFWS 1991)

Heritage global rank: G3 (HHP 1992)

Green turtles are found in tropical and subtropical waters of the Pacific and Indian Oceans. Green turtles are federally listed as threatened wherever found, except for breeding populations in Florida and on the Pacific coast of Mexico, where they are listed as endangered (USFWS 1991).

Green turtles are long-range migrants that spend most of their lives foraging and resting in nearshore habitats. The main breeding area for green turtles in Hawai'i is the U.S. Fish and Wildlife Service refuge in the Northwest Hawaiian Islands (Balazs et al. 1987). At least 90 percent of all reproduction by green turtles in the Hawaiian Islands occurs at French Frigate Shoals, and most of the remaining ten percent takes place at Laysan and Lisianski Islands and Pearl and Hermes Reef (Balazs et al. 1987). In recent years, a very small number of nests has been reported from some main islands. The total breeding population in Hawai'i is thought to be less than 1,200.

Although green turtles are thought to grow very slowly, they can reach up to 42 inches (108 centimeters) or more in shell length and weigh 250 pounds (113 kilograms) (with the largest ever, weighing 850 pounds [385 kilograms]). Each flipper has one claw. The edges of the shell are fairly smooth. The tail of males extends to the end of the hind flippers, while the tail of females rarely extends to the end of the upper shell.

Adult sea turtles return to sand beaches to lay eggs once every two to four years. Females lay eggs 3 to 7 times at 13-day intervals from July to November. Peak hatching occurs in September and October. Each clutch contains about 100 white, leathery eggs about the size of golf balls. After two months of unattended incubation, small hatchlings dig to the surface and scramble quickly to sea (Balazs 1976). Hatchlings weigh one ounce and have black upper surfaces with white borders around each flipper.

As egg-laying reptiles, sea turtles use both the ocean and land environments; both are critical to their life cycle. Undisturbed nesting beaches are required for egg laying, basking, and resting. Adults and juvenile sea turtles feed primarily in nearshore waters, while post-hatchlings forage in the open ocean (Balazs et al. 1987). Their primary food is marine plants.

Serious declines have occurred in most sea turtle populations around the world because of exploitation for their meat, shells, and use for soup stock (Balazs 1976). Though these practices persist in many areas, national and international protection

programs, such as the Endangered Species Act of the United States (USFWS 1973) and the Convention on International Trade in Endangered Species (1973), seek to protect these animals from extinction by restricting sea turtle hunting and trade.

Habitat degradation is also an international threat to sea turtle survival. In Hawai'i, the increasing use of coastal areas for housing and recreation may impact local sea turtle populations by inhibiting nesting and/or basking (Balazs et al. 1987). Numerous sea turtle deaths are attributed to entanglement in marine debris and ingestion of plastic, which is probably mistaken for food.

Only onshore nesting and basking sites are included in the HHP database. On Kaho'olawe, green turtles were seen basking at Kuheia (Figure 4) in 1990 (HHP 1992). Green turtles have also been observed feeding nearshore at Lae o Kuikui and Hakioawa. Green turtles were not seen during this survey.

Lasiurus cinereus semotus

Common name: Hawaiian hoary bat, 'ope'ape'a
Federal status: Listed endangered (USFWS 1991)
Heritage global rank: G5T2 (HHP 1992)

The Hawaiian hoary bat, or 'ope'ape'a, is Hawai'i's only endemic terrestrial mammal. Originally considered to be a distinct species, the Hawaiian hoary bat is now taxonomically classified as a subspecies of the American mainland populations of hoary bats. Nevertheless, very little information currently exists in the literature about its roosting behavior, breeding biology, home range, foraging patterns, or food supply (Kepler and Scott 1990).

Although the Hawaiian hoary bat is considered a solitary species, groups comprising 2 to 108 individuals have been described (Kramer 1971; Tomich 1986; Fujioka and Gon 1988; Kepler and Scott 1990). Observations have been reported from the islands of Hawai'i, Kaua'i, Maui, O'ahu, Moloka'i, and Kaho'olawe. Although more commonly seen in coastal and lowland forested areas, recorded sightings exist from a wide range of elevations. Bats have been reported from Haleakala Summit at an elevation of 9,055 feet (Duvall and Gassmann-Duvall 1991). The largest resident population exists on the island of Hawai'i. Breeding has been recorded on both Hawai'i and Kaua'i. Duvall and Gassmann-Duvall (1991) recently suggested that at least one resident population, if not a breeding one, exists on Maui. There have been few observations of bats on O'ahu, and only one observation has been recorded from Moloka'i. These bats were observed over open water, suggesting that the animals may have been moving through the area from other islands (Kepler and Scott 1990). It has been suggested that the Hawaiian hoary bat, like its mainland

relative, is migratory (Kramer 1971), but there is little evidence to support this. Hawaiian hoary bats appear to be much more active and conspicuous in the fall months (Kepler and Scott 1990).

Reproduction in the Hawaiian hoary bat has been virtually unaddressed by the scientific community (Kramer 1971). The small amount of data collected suggest that female bats typically produce two young in June (Kepler and Scott 1990). Kramer (1971) discusses two instances in which a female bat was found carrying two young. In one case, the combined weight of the clinging offspring was 25 percent more than the weight of the mother.

Habitat requirements of the Hawaiian hoary bat are not fully understood. Analysis by Kepler and Scott (1990) showed no preference for native vegetation. There is some evidence of bats occupying lava tubes (Fujioka and Gon 1988), but Tomich (1986) does not believe that "deep caverns are of advantage to the physiological needs of the hoary bat in Hawai'i." It appears that the bat is unselective in its choice of roosting sites (Kramer 1971; Tomich 1986) and it is quite possible that alien vegetation is not a significant threat to the species' survival. On the other hand, we do not know what changes may have occurred to the distribution of the Hawaiian hoary bat as a result of direct or indirect human interference.

On Kaho'olawe, Hawaiian hoary bats have been reported feeding at Hakioawa (Figure 4) in 1989 (HHP 1992). Bats were not observed during this survey.

Monachus schauinslandi

Common name: Hawaiian monk seal, 'ilio holo i ka uaua

Federal status: Listed endangered (USFWS 1991)

Heritage global rank: G2

The Hawaiian monk seal is found only in Hawai'i with virtually all breeding occurring in the Northwestern Hawaiian Islands. The historical record is incomplete, but indications are that the species was near extinction in 1900 from over-exploitation by sealers and whalers (Tomich 1986). Current estimates indicate a population of about 1,500 to 1,700 individuals (Gerrodette 1985; Gilmartin 1988). Sightings are rarely reported from the main Hawaiian Islands, and most of these have been from Kaua'i (Tomich 1986).

Mating of Hawaiian monk seals occurs in the water. Females give birth to a single pup on beaches adjoining a shallow water area, affording protection from sharks. Most pups are born between February and July with peak births in May. Pups are black and weigh about 25 to 30 pounds (10 to 14 kilograms) at birth. They

are weaned when about 39 days old and weigh approximately 15 to 200 pounds (7 to 90 kilograms). Adults weigh up to 500 pounds (225 kilograms); females are slightly larger than males. Adults are dark grey to brown above, and light grey to yellow underneath.

Hawaiian monk seals feed at sea, primarily at depths between 30 and 120 feet (9 to 37 meters). Their diet includes reef fish, eel, octopus, and lobster.

The Hawaiian monk seal is very sensitive to human disturbance. The species is threatened by marine debris and longline fishing activities; seals are often entangled in fishing line and other man-made objects.

Only monk seal breeding and resting (haul-out) sites are included in the HHP database. Monk seals were observed at Hanakanaia (Figure 4) in 1988 (HHP 1992). Monk seals were not observed during this survey.

Megaptera novaeangliae

Common name: Humpback whale

Federal status: Listed endangered (USFWS 1991)

Heritage global rank: G2 (HHP 1992)

The humpback whale has a worldwide distribution. It winters primarily in nearshore tropical waters, and summers in temperate and subpolar waters (Tomich 1986). Current estimates for the Hawaiian population of humpback whales range from 1000 to 3000 individuals (U.S. Department of Commerce, no date).

Humpback whales wintering in Hawai'i are found at water depths of less than 600 feet (185 meters) (U.S. Department of Commerce, no date; Shallenberger 1981; Tomich 1986). The highest density of whales are observed between February and April, primarily in the waters between Maui, Moloka'i, Lana'i, and Kaho'olawe, but also near Ni'ihau, the north coast of Kaua'i, and along the northwestern coast of the island of Hawai'i (U.S. Department of Commerce, no date). They have also been reported, although less frequently, from the waters surrounding O'ahu, the eastern and southwestern coasts of Hawai'i, and the Northwestern Hawaiian Islands.

During the HHP survey, humpback whales, both adults and calves, were observed daily in the nearshore waters surrounding Kaho'olawe. The Hawai'i Heritage Program is not currently tracking occurrences of this migratory endangered marine mammal.

Other Animal Taxa of Concern

Asio flammeus sandwichensis

Common name: Hawaiian (short-eared) owl, pueo

State status: Listed endangered on O'ahu only (DLNR 1990)

Heritage global rank: G5T3 (HHP 1992)

The Hawaiian (short-eared) owl, or pueo, is endemic to Hawai'i. The pueo occurs on all the main Hawaiian Islands, but it is most common on Kaua'i, Maui, and Hawai'i.

The pueo occurs from sea level to 8000 feet (2440 meters) in elevation in areas dominated by both native and alien vegetation, from pastures and grasslands to dry and wet forests. Short-eared owls have also been observed on some of the Northwestern Hawaiian Islands, but these individuals are probably mainland stragglers of *A. f. flammeus* (Berger 1981; Hawai'i Audubon Society 1989).

Unlike most owls, the pueo is often active at mid-day. Furthermore, it frequently soars at very high altitudes, which leads some observers to mistake the bird for the Hawaiian hawk (*Buteo solitarius*), or 'io (Berger 1981).

Pueo feed primarily on introduced rodents such as the house mouse (*Mus musculus*) and the Polynesian rat (*Rattus exulans*). Before humans introduced rodents to Hawai'i, it is possible that the pueo fed on the now extinct flightless Hawaiian rail (*Porzana sandwichensis*) and other birds (Scott et al. 1986).

Pueo build their nests on the ground, usually in grass. Three to six white eggs are laid (Hawai'i Audubon Society 1989). Little is known about the pueo's breeding biology. Nests containing young have been observed in March, May, and November. Pueo begin incubating when the first egg is laid. Subsequently, eggs usually hatch in the order they were laid, creating a marked difference in the size of the nestlings (Berger 1981).

The total number of pueo has not been estimated. Because pueo nest on the ground, the young are vulnerable to predation by feral cats and mongooses. Human-related mortalities (e.g., shooting) and other human disturbances to habitat seem to be the predominant reasons for the apparent decline of the bird (Scott et al. 1986).

Because of its endangered status, only the O'ahu population of the pueo is included in the HHP database. However, the pueo is the only remaining native Hawaiian land bird on Kaho'olawe; therefore, it is noteworthy that they occur, and that they were observed during this survey.

BIOLOGICALLY SIGNIFICANT AREAS

Rare and Native Natural Communities: The island of Kaho'olawe contains biologically significant areas for native plants, animals, and ecosystems. These areas include beaches and coastal lava flats on the west shoreline containing patches of native coastal dry grasslands, shrublands, and an anchialine pool; cliffs and steep-sided islets on the south and east shoreline bearing rare coastal plants; patches of the native pili lowland dry grassland along the northern, western, and southern slopes; and the best remaining ma'o (Hawaiian cotton) shrubland in the state, along the island's western coasts and slopes.

Particular locations of significance are: Sailor's Hat crater, which contains the only High Salinity Anchialine Pool ecosystem reported for Kaho'olawe; the beaches and coastal flats along the west shoreline, where intact native coastal grasslands and shrublands persist; the southern and eastern sea cliffs, where a variety of rare plants have escaped decades of browsing by mammals such as sheep and goats (particularly 'Ale'ale point, where a rich Hawaiian Mixed Shrub Coastal Dry Cliff Community is habitat for a potentially new plant taxon); and finally, zones along the lower portions of the northern, western, and southern slopes of the island, where patches of pili grassland are prevalent. All of these areas are depicted in Figure 3.

Furthermore, Hawaiian intermittent streams and ephemeral pools are poorly understood freshwater ecosystems present on Kaho'olawe. Intermittent streams of Kaho'olawe may provide some habitat for native stream animals, particularly insects and crustaceans. Ephemeral pools in stream beds and depressions flooded during storms support an interesting set of shrimp and other crustaceans adapted for life in a short-lived body of water.

Rare Plants: Most of the known Kaho'olawe rare plant populations are located along the island's southern and eastern seacliffs. The most significant location for rare plants on Kaho'olawe is 'Ale'ale, which is a steep-sided hill at the base of the seacliffs on the island's south coast. 'Ale'ale has been protected by its steep sides against the ingress of the feral ungulates that have so heavily affected most of Kaho'olawe. The two most significant Kaho'olawe rare plant populations are on 'Ale'ale. There, the only known population of a potentially new species in the pea family (Fabaceae) was discovered during the Heritage survey; only two plants were found. The second significant rare plant population on 'Ale'ale is that of *Portulaca molokiniensis*. The 'Ale'ale population is the largest known for this rare taxon, containing about 500 plants. The species is basically restricted to the southern coast of

Kaho'olawe, but a few are still present on the islet of Molokini between Kaho'olawe and Maui, and there is a single small population on Lana'i. Other rare plant species found on 'Ale'ale include *Portulaca villosa* and *Capparis sandwichiana*.

Other rare plants have been observed elsewhere on the southern seacliffs and coast. Some were seen during the Heritage biological reconnaissance; others were recorded within the last 20 years. These records include: scattered populations of *Capparis sandwichiana*; small populations of *Portulaca molokiniensis*; a population of *Portulaca villosa*; a population of *Vigna o-wahuensis*; a single plant of *Chamaesyce skottsbergii* var. *vaccinioides*; and a single plant of *Ophioglossum concinnum*.

On the eastern seacliffs at Kanapou Bay are populations of *Capparis sandwichiana*. *Chamaesyce skottsbergii* var. *vaccinioides* has also been collected there. On the island of Pu'u Koa'e (which is under state jurisdiction as a seabird sanctuary), *Portulaca molokiniensis*, *Sesbania tomentosa*, and *Capparis sandwichiana* have been recorded.

Rare plants have also been found at other widely scattered locations within the last two decades. These rare plants are *Vigna o-wahuensis*, *Capparis sandwichiana*, *Portulaca villosa*, and *Lepidium bidentatum* var. *o-waihiense*.

Rare and Native Animals: The most significant locations for rare and native Hawaiian animals on Kaho'olawe are beaches where threatened green turtles (*Chelonia mydas*) and endangered Hawaiian monk seals (*Monachus schauinslandi*) have been observed. These animals have recently been observed at Hanakanaia (Smugglers Cove), Kuheia, Lae o Kuikui, and Hakioawa. Hawaiian monk seals have also been seen at nearby Molokini Island.

Other areas important to native animals include Kuheia Beach and Hakioawa Gulch where the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), Hawai'i's only native terrestrial mammal, has been recorded. Also, all nearshore waters are important for the Hawaiian wintering population of endangered humpback whales (*Megaptera novaeangliae*). Although not rare, the indigenous Spinner dolphin (*Stenella longirostris*) has been sighted in large schools off of the coast, from Lae o Kuikui to Hakioawa, Lae o Kuakaiwa, and Hanakanaia.

During the HHP survey, indigenous seabirds were seen flying primarily on the southern portion of Kaho'olawe, and they were found on Pu'u Koa'e. Both Pu'u Koa'e and the nearby 'Ale'ale support nesting populations of native seabirds such as red-tailed tropicbirds (*Phaethon rubricauda rothschildi*) and brown boobies (*Sula leucogaster plotus*). Some of Kaho'olawe's coastal cliffs showed signs of recent nesting by seabirds; however, native

seabird habitat is generally limited on the majority of Kaho'olawe because of the large population of feral cats (*Felis catus*).

MANAGEMENT RECOMMENDATIONS

NATIVE/RARE NATURAL COMMUNITY MANAGEMENT

Management of Intact Natural Communities: A few areas of intact native natural communities still persist on Kaho'olawe. Examples of existing intact native natural communities or assemblages of communities should be designated as special management areas. In these special management areas, no activities detrimental to natural communities should be allowed, and steps should be taken to counteract existing threats (see Threat Management, below).

Restoration of Native Natural Communities: Most of Kaho'olawe has been seriously degraded and its original vegetation has been heavily modified or completely destroyed. Several lines of evidence can be considered in attempting to restore native vegetation on the degraded portions of the island, including historical vegetation accounts, fossil pollen records, and studies of native natural communities on other islands occupying habitats similar to those of Kaho'olawe.

Historical accounts of the vegetation of Kaho'olawe may provide clues to the nature of the original vegetation. However, one should keep in mind that by the time the first accounts were written, much of the native vegetation of Kaho'olawe had already been profoundly altered by human activities. Fossilized evidence, such as pollen deposits or charcoal deposits, may also provide some clues to the nature of the original vegetation.

Some of the other dry regions of Hawai'i have not been as severely impacted as Kaho'olawe and examples of relatively intact native dry grasslands, shrublands, and forests still exist there. One can examine these examples to gain insight into the natural communities that may have occupied similar habitats on Kaho'olawe, and to assess the potential for native revegetation of the island.

Some people may hold the opinion that native plants not historically known from Kaho'olawe should not be introduced to the island. However, others would argue that the native vegetation of Kaho'olawe has been degraded to a greater extent than all the other main islands, and, undoubtedly, many taxa that formerly occurred on the island were extirpated prior to botanical exploration. One relatively conservative approach would be to restrict native plant introductions to taxa known from lowland dry regions of Moloka'i, Maui and Lana'i. In the geologic past, these three islands and Kaho'olawe were once connected, forming a single large island; as a result, they share many of the same plant taxa.

If native Hawaiian plants are introduced to Kaho'olawe, managers should avoid using taxa closely-related to naturally occurring Kaho'olawe plants because these introductions could affect their genetic integrity through hybridization. For example, *Portulaca lutea*, which is not known from Kaho'olawe, should not be introduced to the island, as there is a potential for it to hybridize with its rare relative *Portulaca molokiniensis*. Introductions should also be screened for their potential to disrupt the existing native natural communities.

RARE TAXON MANAGEMENT

Setting Priorities for Management of Rare Taxa: Management should focus first on the taxa that are most immediately threatened with extinction on a worldwide basis. For example, it is extremely critical that resources be channeled to the presumed new species of legume (Fabaceae) that was found at 'Ale'ale on this survey since it is known only from Kaho'olawe with only two individuals in existence. Of secondary importance are plants such as *Portulaca molokiniensis*, which numbers several hundred on Kaho'olawe, with very few plants elsewhere. Other rare plants that are known from several islands besides Kaho'olawe and have additional populations and individuals should also receive attention. These include, for example, *Capparis sandwichiana*, *Lepidium bidentatum* var. *o-waihiense*, and *Ophioglossum concinnum*.

Intensive Search for Populations of Rare Taxa: Critically endangered rare taxa on Kaho'olawe should be the object of island-wide searches to locate as many of their populations as possible. This would involve intensive surveys of a given taxon's known and potential habitat on the island.

Habitat Protection: For many rare taxa, the protection and management of their habitats is sufficient to ensure their survival. Special management areas designated for the maintenance of native natural communities can serve the additional purpose of providing protected habitat for rare taxa. Additional sanctuaries could be designated to protect particular populations of critically endangered taxa not contained within the special management areas. Rare taxa within special management areas often need special attention and additional management to maintain stable populations and protect against particular threats.

Establishment of Alternate Populations: For critically endangered taxa with only one or two populations on the island, it may be desirable to establish additional populations elsewhere

on the island as a hedge against extinction. These planted populations should be established with seed or cuttings of plants from existing populations to ensure genetic purity.

Ex situ Propagation (Cultivation or Captive Propagation): Taxa on the verge of extinction should be brought into cultivation or captive propagation in case a catastrophe should extinguish the last remaining wild individuals. These cultivated or captive individuals would also serve to establish new wild populations. Care should be taken to ensure that collection of propagating material or individuals does not unduly harm wild populations.

It is extremely important that the presumed new legume species at 'Ale'ale be brought into cultivation as soon as possible as there are only two known plants of the species. These plants should be checked periodically to obtain seeds. It is also important to collect flowering specimens of this species so that its taxonomic status can be better evaluated (only fruit and dried spent flowers were collected on this biological reconnaissance). The Hawai'i Plant Conservation Center of the National Tropical Botanical Garden is currently prepared to take on responsibilities of *ex situ* rare plant propagation.

Research of Reproduction/Regeneration Limitations: Various rare Hawaiian taxa are declining for reasons unknown or not well understood. Research into a taxon's population dynamics, genetics, breeding systems, and threats may contribute to our ability to ensure the taxon's survival. On Kaho'olawe this kind of study would be pertinent for the probable new species of legume (Fabaceae sp. nov.), which is represented only by two mature plants and apparently has not regenerated for at least several decades.

REVEGETATION PROJECTS

There has been a long history of revegetation trials on Kaho'olawe, the majority aimed at controlling erosion. Although the subject of erosion control is not within the scope of this study, certain elements of revegetation efforts may affect the island's native biota and deserve consideration.

Native Plantings: Where possible, the use of material originating from Kaho'olawe's native plant populations should be used in revegetation projects in order to preserve the integrity of the Kaho'olawe gene pools. Other relevant concerns are discussed in the Native/Rare Natural Community Management section above.

Alien Plantings: It may be important to utilize existing weeds as erosion control until native vegetation becomes re-established in restoration projects. However, alien plant taxa that may potentially become weeds should not be used in revegetation. It is advisable to use only those plants that are known to be non-invasive.

THREAT MANAGEMENT: ALIEN PLANTS

Alien plants can represent serious threats to the survival of native organisms and natural communities. Some alien plants, if left uncontrolled, are capable of completely displacing the native vegetation. The most serious habitat-altering weeds already well-established on Kaho'olawe include kiawe (*Prosopis pallida*), and various alien grasses such as buffelgrass (*Cenchrus ciliaris*) and pitted beardgrass (*Bothriochloa pertusa*). While alien plants are in some places important for erosion control, in native ecosystem areas the threat to native natural resources may outweigh their erosion control value.

Weed Control: The most serious weeds should be eliminated from special management areas, or from the island if possible. However, it may be unfeasible to extirpate some of the island's worst weeds. For example, kiawe is not only a serious weed on Kaho'olawe, but also the dominant tree on the island, and island-wide removal of kiawe would undoubtedly result in a major soil erosion problem. In this and similar situations it may be more feasible to control weeds locally, e.g., around rare taxon populations or in special management areas for the maintenance of native natural communities. For example, kiawe could be cleared in the cotton shrubland areas, and all alien weeds could be manually removed from 'Ale'ale.

Prevention: Measures should be taken to prevent the introduction and establishment of invasive weeds on the island. Plants known or suspected to have the potential of becoming weeds should not be intentionally brought to the island. Also to be avoided are ornamentals or revegetation candidates whose invasiveness is unknown. Unintentional introductions should be minimized by ensuring that vehicle tires, tools, boots, and other gear brought to the island are free of seeds or soil which may contain seeds. Importantly, weeds new to the island should be eradicated when first noticed. Weeds that succeed in gaining a foothold on the island would be relatively easy and inexpensive to eliminate in the initial stages of infestation. Advanced infestations would be much more costly or even unfeasible to eradicate on an island-wide basis.

Cenchrus tribuloides is an example of an alien species in the initial stages of invasion on Kaho'olawe that should be eradicated before it spreads beyond control. *Cenchrus tribuloides* is a grass with burs bearing long spines that had not been previously reported to be naturalized anywhere in Hawai'i. Several plants were found north of the barracks at Hanakanaia, on the side of the road leading to the dump. All of the plants seen were pulled when discovered. Because this plant shows some potential of becoming a serious weed, the site should be searched during the wet seasons of the next few years to eradicate any additional plants that may germinate from dormant seeds.

THREAT MANAGEMENT: ALIEN ANIMALS

Aliens in Anchialine Pools: Alien fish and alien invertebrates are harmful to the anchialine pool biota. Any anchialine pools on the island should be guarded against the introduction and establishment of such animals.

Ungulates: Feral goats (*Capra hircus hircus*) have been responsible for much of the degradation of the island. A goat eradication program has eliminated most of them, with the exception of a few radio-collared individuals. Aside from these collared individuals there are no ungulates remaining on Kaho'olawe. Ungulates must not be allowed to reestablish populations on the island. It is almost ironic that Kaho'olawe is now the only island of the main chain that is effectively ungulate-free, and whose management can now proceed without the complication of ungulate control.

Land Snail Predators: Endemic ground-dwelling snails may still exist on Kaho'olawe. There are no indications that the introduced predatory snails *Euglandina rosea* or *Oxychilus alliarius* (both serious threats to endemic ground-dwelling snails) are present on the island. It is, therefore, important to ensure that all plantings and soil brought to the island are free of alien snails and/or their eggs. It is also important to control (if present) or exclude (if absent) other potential predators of native land snails such as rats (*Rattus* spp.) and mongooses (*Herpestes auropunctatus auropunctatus*).

Seabird Predators: Evidence of predation by feral cats (*Felis catus*) upon native seabirds was observed on this survey. It appears that cats are a major factor limiting successful nesting of seabirds on the island. The feral cat problem on Kaho'olawe was underscored by observations made during the Heritage survey of heavy predation by feral cats on approximately 90 adult

Bulwer's petrels (*Bulweria bulwerii*) and at least one adult wedge-tailed shearwater (*Puffinus pacificus chlororhynchus*) at 'Ale'ale. While island-wide eradication of cats may be impractical, establishment of protected, cat-free seabird nesting sites may be feasible and should be actively pursued. In addition, rats can also be predatory upon seabird eggs and chicks. Both the roof rat (*Rattus rattus rattus*) and the Polynesian rat (*Rattus exulans hawaiiensis*) have been reported from Kaho'olawe, although none were observed during the Heritage biological reconnaissance. The Kaho'olawe rat population and the impact of rats upon nesting seabirds on Kaho'olawe should be studied. It is noteworthy that mongooses (*Herpestes auropunctatus auropunctatus*) are not known from Kaho'olawe. By preying on bird eggs and chicks, the mongoose has played a significant role in the reduction of native Hawaiian bird populations on O'ahu, Moloka'i, Maui, and Hawai'i. Care should be taken to avoid introducing the mongoose to Kaho'olawe.

The island of Kaho'olawe is noteworthy in its lack of alien animals that on the other main islands are beyond eradication or practical control. Preventing the introduction of potential animal pests to Kaho'olawe should be a high priority.

THREAT MANAGEMENT: NON-BIOLOGICAL THREATS

Bombing: If there is any resumption of the use of the island for target practice, it should be conducted away from special management areas or sanctuaries designated for the management of native natural communities or rare native species. Also, care should be taken to prevent the ignition and spread of fires in the course of practice firing.

Furthermore, special measures should be taken to minimize disturbance to rare plant populations in the course of ordnance disposal. Care should also be taken when disposing of unexploded ordnance found in native natural communities. Whenever possible, all ordnance marked for demolition should be removed and detonated in predesignated detonation sites or defused and removed to avoid disruption of natural communities and rare plant populations.

Fires: With the elimination of the feral goats from the island, the threat of fire can be expected to increase as the island becomes progressively more vegetated. The rising fuel load will increase the potential for larger and faster-spreading fires. An island-wide fire plan should be drafted to address the anticipated growing fire threat, and to actively minimize sources of fire ignition.

MONITORING

A monitoring program should be designed and established to assess the status and population trends of rare taxa, changes in vegetation, and the effectiveness of management programs designed to protect biological resources. Likewise, monitoring should gauge the effectiveness of alien weed and alien animal control programs, as well as any natural community restoration programs. The Heritage surveys demonstrated that ridgetop surveys from the island's center to the coast are quite feasible. Some of the survey routes may be appropriate for monitoring transects.

ADDITIONAL SURVEYS

Additional surveys are needed to better understand the native biota of Kaho'olawe. The current survey provided a good baseline, and indicated several management actions that can begin immediately. However, the survey was also limited in a variety of ways:

Geographical/Habitat Coverage: Areas that have not been covered by surveys to date should be surveyed. Also, certain habitat types that are difficult to access have been insufficiently surveyed to date and should receive further attention. Such habitat types include seacliffs and talus slopes at seacliff bases.

Year-long (Wet and Dry Season) Survey: Additional surveys should be conducted throughout the year. Some annual plants are observable only during the wet winter season. Likewise, there are perennials that appear above-ground only during the wet season.

Survey for Special Groups: Various groups of organisms and natural communities that are best examined by specialists have not been adequately inventoried on Kaho'olawe. These include anchialine pools, subterranean species and ecosystems, terrestrial invertebrates, non-vascular plants (e.g., lichens, mosses, and liverworts), and marine biota.

COOPERATIVE EFFORTS AND INTEGRATED PLANNING

Cooperation With Other Concerned Agencies and Organizations: Cooperative efforts should be expanded to include other agencies and private organizations involved in the protection and recovery

of rare and endangered species and the protection and restoration of native ecosystems. These include The Nature Conservancy of Hawai'i, the National Park Service, the U.S. Fish and Wildlife Service, The U.S. Soil Conservation Service, and the State Division of Forestry and Wildlife.

Integrated Natural/Cultural Management Plan: The management of the biological resources of Kaho'olawe should be planned and coordinated in an integrated management plan with other management concerns of the island, including the preservation of the island's archaeological resources, the use of the island by visitors, and Hawaiian cultural activities on the island. Integrated planning should identify both complementary and conflicting mandates of natural and cultural resource management, and capitalize on management actions that serve both natural and cultural resource protection needs while minimizing conflicting programs.

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GLOSSARY

The following terms are often found in Hawai'i Heritage Program reports. While not all of the terms may be present in this report, the glossary is meant to provide definitions to terms that may be unfamiliar to the reader, or to clarify terms which have specific definitions in different disciplines.

'A'a: one of two general types of lava flow, distinguished by a rough, spiny clinker surface overlying a dense, sometimes massive, core. See **Pahoehoe**.

Aeolian desert: ecosystems largely lacking vegetation; usually dominated by invertebrates; where nutrient input is wind-borne from adjacent habitat. In Hawai'i, aeolian deserts occur on fresh lava flows and in alpine regions.

Alien: (same as **exotic, introduced, or non-native**) a species that is not native, i.e., one introduced accidentally or purposefully by man. In Hawai'i, these include Polynesian introductions (such as kukui, coconut, pig, rat, and jungle fowl) and many post-Cook introductions (such as guava, Christmas berry, mosquitoes, pigs, goats, cattle, deer, and sheep). See **Endemic, Indigenous, Native**.

Alluvial: made up of sand, clay, or other particles deposited by moving water, as along a river bed.

Alpine: one of five elevation zones used to classify Hawaiian natural communities. The Hawaiian alpine zone is above 3,000 m (roughly 9,000 ft) elevation and only exists on the islands of Maui and Hawai'i. See **Elevation Zones**.

Altered Stream: natural stream flow obstructed or modified by artificial barriers such as dams, diversions, or channels.

Amphidromous: species that live their entire adult lives in running freshwater habitats, but spend their larval period as marine zooplankton.

Anadromous: species that ascend rivers to spawn.

Anchialine pool: a land-locked body of water with no surface connection to the ocean, but showing measurable salinity and tidal fluctuations in water level. The pools are habitat for rare Hawaiian shrimp and endangered waterbirds.

Avian: relating to birds.

Avifauna: the birds of a specified region.

Basalt: a dark, dense volcanic rock commonly occurring in Hawaiian lava flows.

Biogenic: resulting from biological processes.

Biota: all plants and animals of a given area. A general term for living things.

Biotic: pertaining to plants and animals and characteristics related to their presence.

Canopy: the highest vegetation cover of a community. In a forest, the canopy is made up of the tallest and most numerous trees. In a shrubland, the canopy is the tallest shrub layer. Closed canopies are those where the foliage interlocks to form a continuous layer over the underlying vegetation or ground. Open canopies are those where there are gaps in the foliage, and more light may reach the lower vegetation layers or ground.

Catadromous: species that migrate downstream and into the sea to spawn.

Coastal: one of five elevation zones used to classify Hawaiian natural communities. The Hawaiian coastal zone extends from sea level to 30 m (roughly 100 ft) elevation but varies with the extent of coastal influence (e.g., waves, sea spray, and sea cliffs). See **Elevation Zones**.

Codominant: in a natural community, a condition in which two or more plant species constitute at least 50 percent of the existing vegetation cover in a given area. By Heritage definition, codominant species each must make up 25 percent or more of the total vegetation cover. See **Dominant, Natural Community**.

Continuous Perennial Stream: a stream that flows naturally to the sea year-round under normal conditions, with water always present from head of stream to ocean discharge.

CPSU: Cooperative National Park Resource Study Unit.

Crustacean: any invertebrate of the class Crustacea, including aquatic forms such as lobster, shrimp, and crabs.

Current Occurrence: See **Element Occurrence**.

Degraded: physically altered in such a way as to decrease the habitat quality for native species or invaded by alien species. A community is considered degraded if alien weeds constitute more than 40 percent of the vegetation cover.

DHHL: Department of Hawaiian Home Lands.

Diadromous: referring to aquatic animals, a life cycle in which both the ocean and freshwater habitats are involved. Three principal types of life history are considered diadromous. See **Amphidromous, Anadromous, Catadromous.**

Disjunct: not contiguous; separated by intervening land.

Diverted Stream: See **Altered Stream.**

DLNR: Hawai'i Department of Land and Natural Resources.

DOFAW: Division of Forestry and Wildlife: a division of the State Department of Land and Natural Resources (DLNR).

Dominant: in a vegetated community, the plant species contributing the most canopy cover in a given area. Dominant species may also be the most numerous in a natural community. By Heritage definition, a dominant species must make up 25 percent or more of the total vegetation cover. See **Natural Community.**

Dry: a moisture category describing habitat in areas with less than 50 inches annual rainfall, or subject to seasonal drought, or bearing generally dry prevailing soil conditions. See **Mesic, Wet.**

Ecosystem: an assemblage of animals and plants and its interaction with the environment. See **Natural Community.**

Element: a plant, animal, or natural community (i.e., collectively, the elements of natural diversity).

Element Occurrence (EO): a place where an element is found. It is a location or area which sustains or otherwise contributes to the survival of a population of a particular element. Typically, "current" occurrences are EOs that have been observed within the past 15 years.

Element Occurrence Record (EOR): the basic building block of the Heritage database. The EOR is a summary of all available information for a single element at a single location or occurrence.

Elevation Zones: broad regions defined by elevation range and used to classify natural communities (ecosystems). There are five elevation zones defined by the Hawaiian natural community classification: coastal, lowland, montane, subalpine, and alpine. Each is defined separately.

Endangered: a species officially recognized by federal or state officials to be in immediate danger of extinction due to natural or man-made factors. See **Federal Status.**

Endemic: naturally restricted to a locality. Most of Hawai'i's native plants and animals are endemic (restricted) to the Hawaiian Islands. Many are restricted to a single island, mountain range, or even gulch. See **Alien, Native, Indigenous**.

Endemism: the extent to which the species of a region are unique to that region. See **Endemic**.

Epigeal: restricted to surface waters or surface habitats. See **Hypogeal**.

Euryhaline: tolerant of a wide range of salinities.

Eutrophic: heavily loaded with nutrients and often supporting thick algal or bacterial growth.

Exotic: not native. See **Alien**.

Fauna: the animals of a specified region.

Federal Status: official U.S. Fish and Wildlife Service categories for endangered and candidate endangered taxa according to the Federal Register (USFWS 1990):

- | | | |
|--------------------------|---|---|
| Listed Endangered (LE) | = | Taxa formally listed as endangered. |
| Listed Threatened (LT) | = | Taxa formally listed as threatened. |
| Proposed Endangered (PE) | = | Taxa already proposed to be listed as endangered. |
| Proposed Threatened (PT) | = | Taxa proposed to be formally listed as threatened. |
| Category 1 (C1) | = | Candidate taxa for which the USFWS has substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened species. |
| Category 1* (C1*) | = | Same as C1, possibly extinct. |
| Category 2 (C2) | = | Candidate taxa for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time. More research on vulnerability, taxonomy, and/or threat(s) are needed before they can be proposed for listing as endangered or threatened. |
| Category 3A (3A) | = | No longer candidates for listing: taxa for which the USFWS has persuasive evidence of extinction. If rediscovered, such taxa might acquire high priority for listing. |

- Category 3B (3B) = No longer candidates for listing: names that, on the basis of current taxonomic understanding, do not represent distinct taxa. Such supposed taxa could be reevaluated in the future on the basis of new information.
- Category 3C (3C) = No longer candidates for listing: taxa that have proven to be more abundant or widespread than previously believed and/or those that are not subject to any identifiable threat. If further research or changes in habitat indicate a significant decline in any of these taxa, they may be reevaluated for possible inclusion in categories 1 or 2.
- = No federal status. Recommended as rare by Hawaiian biologists and confirmed by Heritage data.

Feral: formerly domesticated animals reverted to wild state or living in wild habitat.

Feral Ungulate Activity: detectable damage or sign of feral ungulates including: scat, browsing, trails, trampling, wallows, and rooting.

Global Rank: an indicator of rarity or imperilment of an element on a world-wide level. This ranking system is used by Heritage Programs throughout the country to establish The Nature Conservancy's protection priorities.

- G1 = Species critically imperilled globally (typically 1 to 5 current viable occurrences).
- G2 = Species imperilled globally (typically 6 to 20 current viable occurrences).
- G3 = Restricted range (typically 21 to 100 occurrences).
- G4 = Apparently secure globally, although may be rare locally (e.g., at periphery of range). (Greater than 100 occurrences.)
- G5 = Demonstrably secure globally, although may be rare locally (e.g., at periphery of range).
- G#? = Global rank tentative, insufficient data available to assign definite rank.
- GH = Species known only from historical occurrences (typically no observations in past 15 years).
- GX = Extinct.
- G1G2 = Global rank tentative, 1 to 20 current viable occurrences, insufficient data available to assign definite rank.
- T1 = Subspecies or variety critically imperilled globally.
- T2 = Subspecies or variety imperilled globally.

- TH = Subspecies or variety known only from historical occurrences.
T#? = Global rank of subspecies or variety tentative, insufficient data available to assign definite rank.

Goby, Gobiid: a member of the Gobiidae family of fishes. These are usually small bottom-dwelling fish found in both fresh and marine waters.

HHP: Hawai'i Heritage Program.

High Salinity Anchialine Pond: pools with bottom salinity of 12 parts per thousand or more dissolved chloride.

Hypogeal: utilizing underground interstices as prevalent habitat.

Imperilled: rare or threatened by extinction. In Heritage terminology, it is a plant, animal, or natural community with 20 or fewer viable occurrences, all or most of which are immediately threatened by such factors as alien invasion, direct destruction, or loss of habitat.

Indicator Species: species that require specific ecological conditions and are, therefore, used to measure the quality of the habitat. For example, certain native Hawaiian aquatic animals are indicator species of quality streams.

Indigenous: naturally occurring in a given area as well as elsewhere. Indigenous Hawaiian taxa also occur naturally outside of the Hawaiian Islands (e.g., naupaka kahakai [*Scaevola sericea*] is indigenous to Hawai'i, found in Hawai'i and throughout the South Pacific). See **Alien, Endemic, Native.**

Ined.: abbreviation for "ineditus," referring to a scientific name that has not been published, or a manuscript prepared for publication that has not yet received formal review.

Intact: maintaining at least 60 percent cover in native species.

Intermittent Stream: a stream which does not flow continuously.

Interrupted Perennial Stream:: a stream with ecologically significant perennial water flow in its upper watercourse and intermittent flow at low elevations; discharge into sea may occur occasionally during wet seasons.

Interstitial: occupying the network of small cracks and crevices in a substrate.

Introduced: See **Alien.**

Invertebrates: animals without backbones, including such groups as insects, spiders, shrimps, and snails. Some Hawaiian invertebrates are rare and endangered.

Larva (plural = **Larvae**): young or immature form of an organism which is different from the adult.

Lava Tube: a cave-like structure often formed in pahoehoe lava flows.

Lithified: having turned to stone.

Lobeliads: members of the Lobelioideae subfamily of plants in the family Campanulaceae, commonly known as lobelias. There are many lobeliad species endemic to the Hawaiian Islands.

Low Salinity Anchialine Pool: pools with bottom salinity less than 12 parts per thousand dissolved chloride.

Lowland: one of five elevation zones used to classify Hawaiian natural communities. The Hawaiian lowland zone lies above the coastal zone, up to about 1,000 m (roughly 3,000 ft) elevation. There is lowland zone on all of the main islands. See **Elevation Zones**.

MHHW: Mean Higher High Water; a term referring to tidal water levels; the average of water levels reached by the highest tides.

MLLW: Mean Lower Low Water; a term referring to tidal water levels; the average of water levels at the lowest tides.

Makai: seaward, toward the ocean.

Malacological: having to do with the branch of zoology dealing with mollusks, including snails.

Malacologist: one who studies mollusks, including snails.

Mauka: mountainward, away from the ocean.

Mesic: an area receiving 50 to 75 inches of annual rainfall, or otherwise provided with sufficient water to result in moist soil conditions. See **Wet, Dry**.

Metamorphose: to change in shape or form when going from egg to adult.

Mixohaline: brackish waters resulting from a mix of fresh and ocean water.

Mollusk: invertebrates in the phylum Mollusca. Common representatives are snails, mussels, clams, oysters, squids, and octopuses.

Monotypic Genus: a genus with only a single species.

Montane: one of five elevation zones used to classify Hawaiian natural communities. The Hawaiian montane zone lies above the lowland zone and runs from 1,000 m (roughly 3,000 ft) to 2,000 m (roughly 6,000 ft) elevation. There is a montane zone on Kaua'i, O'ahu, Moloka'i, Maui, Lana'i, and Hawai'i. See **Elevation Zones**.

Multizonal: a community typically occupying more than one broad elevation zone. For example, streams may run from montane sources to sea level. See **Elevation Zones**.

NARS: Natural Area Reserves System; state lands designated to protect Hawaiian ecosystems, native plants and animals, and other natural features in perpetuity.

Native: found naturally in an area, not introduced accidentally or purposefully by man; includes both indigenous and endemic taxa. See **Alien, Endemic, Indigenous**.

Natural Community: a natural assemblage of plants and animals that occurs within certain elevation, moisture, and habitat conditions; sometimes used loosely as another term for "ecosystem." However, "ecosystem" includes abiotic environmental factors, so that (natural community + environment) = ecosystem.

Naturalized: non-native plants with established populations in the wild.

Nocturnal: active or most apparent at night.

Non-native: See **Alien**.

OHA: Office of Hawaiian Affairs.

Occurrence: See **Element Occurrence**.

Pahoehoe: one of two general types of lava flow, distinguished by relatively smooth, sometimes glassy, or ropy surface. See **'A'a**.

Paleontology: the science of the forms of life existing in former geological periods, as represented by fossil animals and plants.

Perennial: lasting or active throughout the year, when referring to streams, including both continuous and interrupted streams with year-long water flow.

Periostracum: the external layer of most mollusk and brachiopod shells.

Petroglyphs: carvings of figures and symbols in stone, in this case referring to those of ancient Hawaiians.

Physiognomy: general descriptive term for habitat, including categories such as bog, grassland, shrubland, forest, desert, and cliff.

Postlarva: (plural - postlarvae); a developmental stage between larva and adult. See **Larva**.

ppt: parts per thousand.

Priority Weed: an alien plant with known ability to disrupt the vegetation of native ecosystems. Control of such weeds is a high priority. For example, *Clidemia hirta* is a priority weed that has displaced native understory plants in much of O'ahu's forests.

Pristine: undisturbed by humans and completely lacking alien taxa; entirely native.

Protected: legally dedicated to the perpetuation of native resources and managed to mitigate or remove threats to those resources, if necessary. Areas lacking either legal protection or management are considered incompletely protected.

Pu'u: hill or volcanic cone.

Rain Shadow: a phenomenon in which a significant mountain range intercepts prevailing winds and moisture, leaving little or no available moisture in its lee. The Waianae Mountains lie in the rain shadow of the Koolau Mountains.

Rare: imperilled or threatened by extinction due to low numbers. In Heritage terminology, a plant, animal, or natural community with 20 or fewer viable occurrences, all or most of which are immediately threatened by such factors as alien invasion, direct destruction, or loss of habitat.

Riparian: pertaining to or associated with streams.

RIS: Resource Information Summary: a compilation of data from Heritage field surveys.

Sexual dimorphism: a condition in which obvious morphological or color differences are seen between sexes.

spp.: abbreviation for more than one species.

ssp.: See **Subspecies**.

Stream Ranks: ranks linked to stream quality established by an advisory committee of aquatic biologists. There are six rank categories:

Outstanding - Due to the potentially rare status of three gobies (*Awaous stamineus*, *Lentipes concolor* and *Sicyopterus stimpsoni*) and the hihiwai (*Neritina granosa*), any stream

containing significant populations of these indicator species was considered outstanding. In addition, streams with a high diversity of native species, fewer than two noxious non-native species, and essentially unaltered basins were also considered outstanding.

Substantial - Streams with good native species diversity, at least three native species, one of which is rare, and less than two noxious non-native species.

Moderate - Streams with at least one rare native species present, but low native species diversity (less than three species).

Limited - Streams with no rare native species but at least one native species.

Without - Streams with no native species.

Unknown - Insufficient biological information available for stream.

Subalpine: one of five elevation zones used to classify Hawaiian natural communities. The Hawaiian subalpine zone lies above the montane zone and runs from 2,000 m (roughly 6,000 ft) to 3,000 m (roughly 9,000 ft) elevation. There is a subalpine zone only on the islands of Maui and Hawai'i. See **Elevation Zones**.

Subspecies: (abbreviated ssp.) a taxonomically distinguishable geographic or ecological subdivision of a species. See **Variety**.

Substation: a sampling point along a survey transect of a field survey. Substations were established every 50 m (roughly 150 ft) along transects, and observations of ungulate damage, weeds, and changes in natural communities were recorded at every substation. Substations were additional sampling points established every 150 m (roughly 450 ft) along transects.

Taxon (plural = **Taxa**): a group of plants or animals making up one of the categories or formal units in taxonomic classification. In this report a taxon can be a species, subspecies, variety, or form. This distinction is important because certain species have endemic Hawaiian subspecies and varieties that are considered rare.

Trachyte Dome: a lava extrusion of fine-grained, generally light-colored rock rich in potassium and sodium which creates soil unfavorable to the growth of many plants.

Troglobytic: cave-dwelling species, usually displaying adaptations to cave life, such as blindness and loss of pigmentation.

UH: University of Hawai'i.

Ungulate: a subdivision of hoofed mammals including pigs, goats, cattle, sheep, mouflon, and deer.

USACE: United States Army Corps of Engineers.

USFWS: United States Fish and Wildlife Service.

USGS: United States Geological Survey.

Variety: (abbreviated var.) a taxonomically distinguishable subdivision of a species or subspecies. See **Subspecies**.

Vertebrate: an animal with a backbone; native terrestrial vertebrate species in Hawai'i include fish, birds, a bat, and a seal. See **Invertebrate**.

Viable: Capable of persisting and reproducing under favorable conditions.

Weed: an undesirable plant. In native ecosystems all alien plants are weeds. See **Priority Weed**.

Wet: an area receiving more than 75 inches of annual rainfall, or situated near groundwater or surface water, such that availability of water is not a major limiting factor to plants or animals there. See **Dry, Mesic**.

Zooplankton: animals that live by floating or drifting in the ocean or in bodies of freshwater; most are small to microscopic.

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWE ISLAND

The vascular plants included on this checklist are those observed on the three most recent botanical surveys of Kaho'olawe Island: the Hawai'i Heritage Program (HHP) reconnaissance survey (February and March 1992), the Division of Forestry survey (April 21-25, 1980) by Corn et al. (1980), and the Navy survey (November 22-27, 1978) for the U.S. Department of the Navy Environmental Impact Statement (1979). Known plantings were not documented during the HHP reconnaissance survey because the scope of this project was to document the native and naturalized vegetation of Kaho'olawe. The Division of Forestry survey and the Navy EIS survey include some known plantings on their checklists, as well as plant taxa seen in beach drift material, and these are identified as such in the remarks column of Appendix A2.

In addition, the flowering plant taxa reported on Kaho'olawe by the Manual of the Flowering Plants of Hawai'i (Wagner, Herbst and Sohmer 1990) are on this checklist. In the Manual, there are reports of two taxa (*Chamaesyce celastroides* var. *stokesii* and *Eragrostis variabilis*) from Kaho'olawe that may be based upon misidentified specimens (J. Lau, personal communication 1992). Also there are fourteen taxa which are reported from Kaho'olawe in the Manual, which were not observed on any of the recent surveys, and for which no Kaho'olawe specimens were seen at the Bishop Museum herbarium (BISH) in June 1992.

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND

The taxonomy, nomenclature, and status of the flowering plants listed below are according to Wagner, Herbst, and Sohmer (1990). The ferns and fern allies follow C.H. Lamoureux (1988). Families are listed alphabetically within each of the three groups: ferns and fern allies, dicots, and monocots. Genera and species are arranged alphabetically under family. The status codes and source codes are explained below.

Status Codes: + = Rare N = Non-native I = Indigenous, native to the Hawaiian Islands and elsewhere
 E = Endemic, native only to the Hawaiian Islands

Source Codes: o = Observed on field survey * = New island record for Kaho'olawe (not recorded on 1980 or 1978 surveys, not cited in Comprehensive Checklist of Plants from Kaho'olawe (Appendix F) of Navy EIS 1979, and no specimens seen at the Bishop Museum herbarium (BISH) in June 1992) x = Reported in the Manual as occurring on Kaho'olawe (native or naturalized, unless otherwise indicated) EX = Extinct on Kaho'olawe ? = Status unknown

SOURCES

MAN-
 HHP UAL CORN NAVY
 1992 1990 1980 1979

STATUS SCIENTIFIC NAME COMMON NAME

STATUS	SCIENTIFIC NAME	COMMON NAME	MAN- HHP UAL CORN NAVY 1992 1990 1980 1979
	FERNS AND FERN ALLIES		
	Adiantaceae		
N	<i>Adiantum hispidulum</i> Sw.	Rough maidenhair	*
	Aspleniaceae		
I	<i>Asplenium adiantum-nigrum</i> L.	-	*
	Hemionitidaceae		
N	<i>Pityrogramma calomelanos</i> (L.) Link	Goldfern	o
	Nephrolepidaceae		
N	<i>Nephrolepis multiflora</i> (Roxb.) Jarrett ex Morton	Kupukupu, ni'ani'au	o
	<i>Nephrolepis</i> sp.	-	o
	Ophioglossaceae		

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

SOURCES

MAN-
HHP UAL CORN NAVY
1992 1990 1980 1979

COMMON NAME

SCIENTIFIC NAME

STATUS

STATUS	SCIENTIFIC NAME	COMMON NAME	SOURCES
+ E	<i>Ophioglossum concinnum</i> Brack.	Pololei	*
	Polypodiaceae		
N	<i>Phymatosorus scolopendria</i> (N.L. Burm.) Pic.-Ser.	Laua'e	*
	Sinopteridaceae		
E	<i>Doryopteris decipiens</i> (Hook.) J. Sm.	Kumuniu	o o o
	Thelypteridaceae		
N	<i>Christella dentata</i> (Forsk.) Brownsey & Jermy	-	o
N	<i>Christella parasitica</i> (L.) Levl.	-	*
	FLOWERING PLANTS: DICOTS		
	Aizoaceae (Fig-marigold family)		
I	<i>Sesuvium portulacastrum</i> (L.) L.	'Akulikuli, sea purslane	o x o o
	Amaranthaceae (Amaranth family)		
N	<i>Amaranthus spinosus</i> L.	Spiny amaranth, pakai kuku	x o o
N	<i>Amaranthus viridis</i> L.	Slender amaranth, pakai	x o o
E	<i>Nototrichium sandwicense</i> (A. Gray) Hillebr.	Kulu'i	x
	Anacardiaceae (Mango family)		
N	<i>Mangifera indica</i> L.	Mango	x o
	Apocynaceae (Dogbane family)		
N	<i>Catharanthus roseus</i> (L.) G. Don	Madagascar periwinkle	x
	Asclepiadaceae (Milkweed family)		
N	<i>Asclepias curassavica</i> L.	Butterfly weed, laulele	x o o
N	<i>Asclepias physocarpa</i> (E. Mey.) Schlechter	Balloon plant	o x o o
N	<i>Calotropis gigantea</i> (L.) W. T. Aiton	Crown flower, puakalaunu	o x o o

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

SOURCES

MAN-
RHP UAL CORN NAVY
1992 1990 1980 1979

SCIENTIFIC NAME

COMMON NAME

STATUS

STATUS	SCIENTIFIC NAME	COMMON NAME	SOURCES
N	<i>Nerium oleander</i> L.	Oleander	
	Asteraceae (Sunflower family)		
N	<i>Acanthospermum australe</i> (Loefl.) Kuntze	Spiny-bur, pipili	O X O
N	<i>Ageratina riparia</i> (Regel) R. King & H. Robinson	Hamakua pamakani	*
N	<i>Ageratum conyzoides</i> L.	Maile hohono	O X O O
E	<i>Artemisia australis</i> Less.	'Ahinahina, hinahina	X
N	<i>Bidens alba</i> (L.) DC var. <i>radiata</i> (Shultz-Bip.) Ballard ex Melchert	-	O X
E	<i>Bidens mauiensis</i> (A. Gray) Sherff	Ko'oko'olau, koko'olau	O X O
N	<i>Bidens pilosa</i> L.	Spanish needle, beggartick	O X O O
N	<i>Centaurea melitensis</i> L.	Star thistle, knapweed	X O
N	<i>Cirsium vulgare</i> (Savi) Ten.	Bull thistle	O X O
N	<i>Conyza bonariensis</i> (L.) Cronq.	Hairy horseweed, ilioha	O X O
N	<i>Conyza canadensis</i> (L.) Cronq. var. <i>pusilla</i> (Nutt.) Cronq.	Horseweed	O
N	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	-	*
N	<i>Emilia fosbergii</i> Nicolson	-	O X O O
N	<i>Emilia sonchifolia</i> (L.) DC	Flora's paintbrush	*
N	<i>Galinoga parviflora</i> Cav.	-	X O O
N	<i>Gnaphalium purpureum</i> L.	Purple cudweed	O X O O
N	<i>Heterotheca grandiflora</i> Nutt.	Telegraph weed	O X O
N	<i>Hypochoeris glabra</i> L.	Smooth cat's ear	O X O
N	<i>Hypochoeris radicata</i> L.	Hairy cat's ear, gosmore	O X O
N	<i>Lactuca serriola</i> L.	Prickly lettuce	*
+	<i>Lipochaeta bryanii</i> Sherff	Nehe	X
E	<i>Lipochaeta integrifolia</i> (Nutt.) A. Gray	Nehe	X
E	<i>Lipochaeta lavarum</i> (Gaud.) DC	Nehe	O X O O
E	<i>Lipochaeta rockii</i> Sherff	Nehe	O X O
E	<i>Lipochaeta succulenta</i> (Hook. & Arnott) DC	Nehe	X
N	<i>Montanoa hibiscifolia</i> Benth.	Tree daisy	*
N	<i>Pluchea indica</i> (L.) Less.	Indian fleabane	O X O
N	<i>Pluchea symphytifolia</i> (Mill.) Gillis	Sourbush	O X O O

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

SOURCES

MAN-

HHP UAL CORN NAVY
1992 1990 1980 1979

COMMON NAME

SCIENTIFIC NAME

STATUS

STATUS	SCIENTIFIC NAME	COMMON NAME	HHP	UAL	CORN NAVY	1992	1990	1980	1979
N	<i>Sigesbeckia orientalis</i> L.	Small yellow crown-beard	o	x					
N	<i>Sonchus oleraceus</i> L.	Sow thistle, pualele	o	x					
N	<i>Synedrella nodiflora</i> (L.) Gaertn.	Nodeweed	o	x					
N	<i>Tridax procumbens</i> L.	Coat buttons	o	x					
N	<i>Verbesina encelioides</i> (Cav.) Benth. & Hook.	Golden crown-beard	o	x					
N	<i>Vernonia cinerea</i> (L.) Less. var. <i>parviflora</i> (Reinw.) DC	Little ironweed	o	x					
N	<i>Xanthium strumarium</i> L. var. <i>canadense</i> (Mill.) Torr. & A. Gray	Cocklebur, kikania	o	x					
N	<i>Zinnia peruviana</i> (L.) L.	Puapihi	o	x					
?	Indet sp.	-							
	Bataceae (Saltwort family)								
N	<i>Batis maritima</i> L.	Pickleweed, 'akulikuli kai	o	x					
	Boraginaceae (Borage family)								
I	<i>Heliotropium curassavicum</i> L.	Nena, seaside heliotrope	o	x					
	Brassicaceae (Mustard family)								
N	<i>Coronopus didymus</i> (L.) Sm.	Swinecress	o	x					
+ I	<i>Lepidium bidentatum</i> Montin var. <i>o-waihiense</i> (Cham & Schlechtend.) Fosb.	'Anaunau, naunau, kunana	o						
N	<i>Lepidium oblongum</i> Small	Pepperwort, peppergrass	o	x					
N	<i>Raphanus sativus</i> L.	Wild radish		x					
N	<i>Sisymbrium altissimum</i> L.	Tumble mustard	o	x					
	Cactaceae (Cactus family)								
N	<i>Hylocereus undatus</i> (Haw.) Britton & Rose	Night-blooming cereus		x					
N	<i>Opuntia ficus-indica</i> (L.) Mill.	Prickly pear, panini	o	x					
	Cannabaceae (Hemp family)								
N	<i>Cannabis sativa</i> L. ssp. <i>indica</i> (Lam.) E. Small & Cronq.	Marijuana, pakalolo		?					
	Capparaceae (Caper family)								

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHOLAWE ISLAND (continued)

SOURCES

MAN-
HHP UAL CORN NAVY
1992 1990 1980 1979

COMMON NAME

SCIENTIFIC NAME

STATUS

+	E	Capparis sandwichiana DC	Pua pilo, maiapilo	O	X	O	O
		Caryophyllaceae (Pink family)					
N		Polycarpon tetraphyllum (L.) L.	-		X	O	O
		Casuarinaceae (She-oak family)					
N		Casuarina equisetifolia L.	Common ironwood, paina		X	O	
N		Casuarina glauca Siebold ex Spreng.	Saltmarsh ironwood, longleaf ironwood		?	O	
		Chenopodiaceae (Goosefoot family)					
N		Atriplex semibaccata R. Br.	Australian saltbush	O	X	O	O
N		Atriplex suberecta Verd.	Saltbush	*			
N		Chenopodium carinatum R. Br.	Goosefoot, pigweed		X	O	O
N		Chenopodium murale L.	Goosefoot, pigweed	O	X	O	O
N		Salsola kali L.	Russian thistle, tumbleweed	O			
		Combretaceae (Indian almond family)					
N		Terminalia catappa L.	Tropical almond, false kamani			O	O
		Convolvulaceae (Morning glory family)					
I		Cressa truxillensis Kunth	-	O	X	O	O
N?		Ipomoea cairica (L.) Sweet	Ivy-leaved morning glory, koali 'ai	O	X	O	O
I		Ipomoea indica (J. Burm.) Merr.	Koali 'awa, koali 'awahia	O	X	O	
I		Ipomoea pes-caprae (L.) R. Br. ssp. brasiliensis (L.) Ooststr.	Pohuehue, beach morning glory	O	X	O	O
E		Ipomoea tuboides Degner & Ooststr.	Koali pehu, Hawaiian moonflower		X	O	O
E		Jacquemontia ovalifolia (Choisy) H. Hallier ssp. sandwicensis	Pa'u-o-Hi'iaka	O	X	O	O

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHOLAWE ISLAND (continued)

SOURCES

MAN-
HHP UAL CORN NAVY
1992 1990 1980 1979

STATUS SCIENTIFIC NAME COMMON NAME

STATUS	SCIENTIFIC NAME	COMMON NAME	MAN- HHP UAL CORN NAVY 1992 1990 1980 1979
	(A. Gray) K. Robertson		
N?	<i>Merremia aegyptia</i> (L.) Urb.	Hairy merremia	o x o o
	Cucurbitaceae (Gourd family)		
N	<i>Citrullus lanatus</i> (Thunb.) Matsum & Nakai	Watermelon, ipu 'ai-maka	
N	<i>Cucumis dipsaceus</i> Ehrenb. ex Spach	Hedgehog gourd, teasel gourd	o x o
N	<i>Cucumis sativus</i> L.	Cucumber, ka'ukama	x o
N	<i>Momordica charantia</i> L.	Balsam pear	x
E	<i>Sicyos pachycarpus</i> Hook. & Arnott	'Anunu, kupala	o x
?	Indet sp.	-	o
	Euphorbiaceae (Spurge family)		
N	<i>Aleurites moluccana</i> (L.) Willd. (C. Forbes) Degener & I. Degener	Candlenut, kukui	
E	<i>Chamaesyce celastroides</i> (Boiss.) Croizat & Degener var. amplectens (Sherff) Degener & I. Degener	'Akoko, koko, kokomalei	o x o
+ E	<i>Chamaesyce celastroides</i> (Boiss.) Croizat & Degener var. stokesii (C. Forbes) Degener & I. Degener	'Akoko, koko, kokomalei	x
N	<i>Chamaesyce hirta</i> (L.) Millsp.	Hairy spurge, garden spurge, koko kahiki	o x o o
N	<i>Chamaesyce hypericifolia</i> (L.) Millsp.	Graceful spurge	
N	<i>Chamaesyce prostrata</i> (Aiton) Small	Prostrate spurge	o x o o
+ E	<i>Chamaesyce skottsbergii</i> (Sherff) Croizat & Degener var. vaccinioides (Sherff) Koutnik	'Akoko, koko, kokomalei	x o
N	<i>Euphorbia heterophylla</i> L.	Kaliko	x
N	<i>Ricinus communis</i> L.	Castor bean, pa'aila, koli	x o o
	Fabaceae (Pea family)		
N	<i>Acacia confusa</i> Merr.	Formosan koa	x o
N	<i>Acacia farnesiana</i> (L.) Willd.	Klu, kolu	o x o o
N	<i>Cassia</i> sp.	-	
N	<i>Chamaecrista nictitans</i> (L.) Moench ssp. patellaria (DC ex Collad.)	Partridge pea, lauki	o x o o

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHOLAWE ISLAND (continued)

SOURCES

MAN-

HHP UAL CORN NAVY
1992 1990 1980 1979

STATUS SCIENTIFIC NAME COMMON NAME

STATUS	SCIENTIFIC NAME	COMMON NAME	HHP	UAL	CORN NAVY	1992	1990	1980	1979
	H. Irwin & Barneby var. glabrata (Vogel) H. Irwin & Barneby								
N	<i>Crotalaria incana</i> L.	Rattlepod							
N	<i>Crotalaria</i> sp.	-							
N	<i>Desmanthus virgatus</i> (L.) Willd.	Slender mimosa, virgate mimosa							
N	<i>Desmodium sandwicense</i> E. Mey.	Spanish clover, pua pilipili							
N	<i>Desmodium tortuosum</i> (Sw.) DC	Florida beggarweed							
N	<i>Desmodium triflorum</i> (L.) DC	Three-flowered beggarweed							
N	<i>Desmodium</i> sp.	-							
E	<i>Erythrina sandwicensis</i> Degener	Wiliwili							
N	<i>Glycine wightii</i> (Wight & Arnott) Verde	-							
N	<i>Indigofera suffruticosa</i> Mill.	Indigo							
N	<i>Leucaena leucocephala</i> (Lam.) de Wit	Haole koa, koa haole, ekoa							
N	<i>Macroptilium atropurpureum</i> (DC) Urb.	-							
N	<i>Macroptilium lathyroides</i> (L.) Urb.	Wild bean, cow pea							
N	<i>Prosopis pallida</i> (Humb. & Bonpl. ex Willd.) Kunth	Algaroba, mesquite, kiawe							
I	<i>Senna gaudichaudii</i> (Hook. & Arnott) H. Irwin & Barneby	Uhiuhi, kolomona							
+	<i>Sesbania tomentosa</i> Hook. & Arnott	'Ohai							
N	<i>Tephrosia purpurea</i> (L.) Pers. var. <i>purpurea</i>	'Auhuhu, hola							
+	<i>Vigna o-wahuensis</i> Vogel	-							
+	<i>Fabaceae</i> sp. nov.?	-							
?	<i>Indet.</i> sp.	-							
	<i>Gentianaceae</i> (Gentian family)								
N	<i>Centaurium erythraea</i> Raf. ssp. <i>erythraea</i>	Bitter herb, European centaury							
	<i>Goodeniaceae</i> (Goodenia family)								
I	<i>Scaevola sericea</i> Vahl	Naupaka kahakai							
	<i>Lamiaceae</i> (Mint family)								
N	<i>Ocimum gratissim</i> L.	Basil							

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

SOURCES

MAN-
HHP UAL CORN NAVY
1992 1990 1980 1979

COMMON NAME

SCIENTIFIC NAME

STATUS

STATUS	SCIENTIFIC NAME	COMMON NAME	MAN- HHP UAL CORN NAVY 1992 1990 1980 1979
	Malvaceae (Mallow family)		
N	<i>Abutilon grandifolium</i> (Willd.) Sweet	Hairy abutilon, ma'o	X O
I?	<i>Abutilon incanum</i> (Link) Sweet	Hoary abutilon, ma'o	X O O
E	<i>Gossypium tomentosum</i> Nutt. ex Seem.	Ma'o	X O O
+	<i>Hibiscus brackenridgei</i> A. Gray ssp. brackenridgei	Ma'o hau hele	X
N	<i>Malva parviflora</i> L.	Cheese weed	X O O
N	<i>Malvastrum coromandelianum</i> (L.) Garcke ssp. coromandelianum	False mallow	X O O
I	<i>Sida fallax</i> Walp.	'Ilima	O X O O
N	<i>Sida rhombifolia</i> L.	-	X
N	<i>Sida spinosa</i> L.	Prickly sida	O
I?	<i>Thespesia populnea</i> (L.) Sol. ex Correa	Milo	O
	Moraceae (Mulberry family)		
N	<i>Broussonetia papyrifera</i> (L.) Venten.	Paper mulberry, wauke	X
	Myoporaceae (Myoporum family)		
I	<i>Myoporum sandwicense</i> A. Gray	Naio, bastard sandalwood	O
	Myrtaceae (Myrtle family)		
N	<i>Eucalyptus</i> sp.	Eucalyptus	O
	Nyctaginaceae (Four-o'clock family)		
N	<i>Boerhavia coccinea</i> Mill.	-	X
I	<i>Boerhavia glabrata</i> Blume	Alena	X
E	<i>Boerhavia herbstii</i> Fosb.	Alena	X O
I	<i>Boerhavia repens</i> L.	Alena	O X O? O?
	Oxalidaceae (Wood sorrel family)		
N?	<i>Oxalis corniculata</i> L.	Yellow wood sorrel, 'ihi makole	O X O O

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHOLAWE ISLAND (continued)

SOURCES

MAN-
HHP UAL CORN NAVY
1992 1990 1980 1979

COMMON NAME

SCIENTIFIC NAME

STATUS

	Papaveraceae (Poppy family)							
E	<i>Argemone glauca</i> (Nutt. ex Prain) Pope var. <i>glauca</i>		Pua kala					
	Passifloraceae (Passion flower family)							
N	<i>Passiflora edulis</i> Sims		Passion fruit, liliko'i					
	Phytolaccaceae (Pokeweed family)							
N	<i>Phytolacca dioica</i> L.		Bella sombra, ombu					
	Plumbaginaceae (Plumbago or leadwort family)							
I	<i>Plumbago zeylanica</i> L.		'Ilie'e					
	Portulacaceae (Purslane family)							
+	<i>Portulaca molokiniensis</i> Hobby		'Ihi					
N	<i>Portulaca oleracea</i> L.		Pigweed, 'ihi					
N	<i>Portulaca pilosa</i> L.		Pigweed, 'ihi					
+	<i>Portulaca villosa</i> Cham.		'Ihi					
	Primulaceae (Primrose family)							
N	<i>Anagallis arvensis</i> L.		Scarlet pimpernel					
	Rhamnaceae (Buckthorn family)							
+	<i>Gouania hillebrandii</i> Oliver		-					
	Rhizophoraceae (Mangrove family)							
N	<i>Rhizophora mangle</i> L.		American mangrove, red mangrove					
	Rubiaceae (Coffee family)							
N	<i>Coffea arabica</i> L.		Arabian coffee					
	Santalaceae (Sandalwood family)							

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

SOURCES

MAN-

HHP UAL CORN NAVY
1992 1990 1980 1979

STATUS SCIENTIFIC NAME COMMON NAME

STATUS	SCIENTIFIC NAME	COMMON NAME	MAN- HHP UAL CORN NAVY 1992 1990 1980 1979	SOURCES
+	<i>Exocarpus gaudichaudii</i> A. DC	Hulumoa, kaumahana	X	
E	<i>Santalum ellipticum</i> Gaud.	'Iliahi, sandalwood	EX?	
	Sapindaceae (Soapberry family)			
E	<i>Dodonaea viscosa</i> Jacq.	'A'ali'i	O	
	Solanaceae (Nightshade family)			
I	<i>Lycium sandwicense</i> A. Gray	'Ohelo kai, 'ae'ae	O	X O O
N	<i>Lycopersicon esculentum</i> Mill.	Tomato	?	O
N	<i>Lycopersicon pimpinellifolium</i> (Jusl.) Mill.	Currant tomato	O	? O O
N	<i>Nicotiana glauca</i> R. C. Graham	Tree tobacco	O	X O O
N	<i>Nicotiana tabacum</i> L.	Tobacco, paka	X	
I?	<i>Solanum americanum</i> Mill.	Glossy nightshade, popolo	O	X O?
N	<i>Solanum linnaeanum</i> Hepper & P. Jaeger	Apple of Sodom	O	O
	Sterculiaceae (Cacao family)			
I?	<i>Waltheria indica</i> L.	'Uhaloa, hi'aloa	O	X O O
	Tamaricaceae (Tamarix family)			
N	<i>Tamarix aphylla</i> (L.) Karst.	Athel tamarisk		O O
	Urticaceae (Nettle family)			
+	<i>Neraudia sericea</i> Gaud.	Ma'aloa, ma'oloa, 'oloa		EX
	Verbenaceae (Verbena family)			
N	<i>Lantana camara</i> L.	Lantana	O	X O O
N	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	Jamaica vervain, oi	O	X
N	<i>Verbena litoralis</i> Kunth	Ha'uoi, oi	O	X O
	Zygothylaceae (Creosote bush family)			
I	<i>Tribulus cistoides</i> L.	Nohu	O	X O O

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHOLAWE ISLAND (continued)

SOURCES

MAN-
HHP UAL CORN NAVY
1992 1990 1980 1979

COMMON NAME

SCIENTIFIC NAME

STATUS

STATUS	SCIENTIFIC NAME	COMMON NAME	HHP	UAL	CORN NAVY	1992	1990	1980	1979
	FLOWERING PLANTS: MONOCOTS								
	Agavaceae (Agave family)								
N	<i>Agave sisalana</i> Perrine	Sisal, malina							
	Areaceae (Palm family)								
N	<i>Cocos nucifera</i> L.	Coconut, niu							
	Cyperaceae (Sedge family)								
I	<i>Carex meyenii</i> Nees	-							EX
I?	<i>Eleocharis calva</i> Torr.	-							X
E	<i>Mariscus phleoides</i> Nees ex Kunth ssp. <i>phleoides</i>	-							*
	Pandanaceae (Screw pine family)								
I?	<i>Pandanus</i> sp.	Hala, screw pine							
	Poaceae (Grass family)								
N	<i>Bothriochloa pertusa</i> (L.) A. Camus	Pitted beardgrass							X
N	<i>Cenchrus ciliaris</i> L.	Buffelgrass							X
N	<i>Cenchrus tribuloides</i> L.	-							*
N	<i>Chloris barbata</i> (L.) Sw.	Swollen fingergrass, mau'u lei							
N	<i>Chloris divaricata</i> R. Br. var. <i>divaricata</i>	Stargrass							X
N	<i>Chloris truncata</i> R. Br.	-							X
N	<i>Chloris virgata</i> Sw.	Feather fingergrass							X
N	<i>Chloris</i> sp.	-							
N	<i>Coix lacryma-jobi</i> L.	Job's tears, pu'ohē'ohē							
N	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass, manienie							X
N	<i>Dactyloctenium aegyptium</i> (L.) Willd.	Beach wiregrass							X
N	<i>Dicanthium aristatum</i> (Poir.) Hubb.	Wildergrass							
N	<i>Dicanthium sericeum</i> (R. Br.) A. Camus	Australian bluestem							X
N	<i>Digitaria ciliaris</i> (Retz.) Koeler	Henry's crabgrass,							X

APPENDIX A1: VASCULAR PLANT SPECIES RECORDED FROM KAHOLAWE ISLAND (continued)

SOURCES

MAN-
HHP UAL CORN NAVY
1992 1990 1980 1979

COMMON NAME

SCIENTIFIC NAME

STATUS

STATUS	SCIENTIFIC NAME	COMMON NAME	MAN- HHP UAL CORN NAVY 1992 1990 1980 1979
		kukaepua'a	
N	<i>Digitaria insularis</i> (L.) Mez ex Ekman	Sourgrass	o x o o
N	<i>Echinochloa colona</i> (L.) Link	Jungle-rice	x o
N	<i>Eleusine indica</i> (L.) Gaertn.	Wiregrass	o
E	<i>Eragrostis atropioides</i> Hillebr.	-	o
N	<i>Eragrostis c. llanensis</i> (All.) Link	Stinkgrass	o x o o
N	<i>Eragrostis tenella</i> (L.) P. Beauv ex Roem. & Schult.	Japanese lovegrass	x o
E	<i>Eragrostis variabilis</i> (Gaud.) Steud.	Kawelu, 'emoloa	x o? o?
?	<i>Eragrostis</i> sp.	-	o o
I?	<i>Heteropogon contortus</i> (L.) P. Beauv. ex Roem. & Schult.	Pili, twisted beardgrass	o x o o
N	<i>Melinis minutiflora</i> P. Beauv.	Molasses grass	o x o
E	<i>Panicum fauriei</i> Hitchc. var. <i>fauriei</i>	-	o x o o
E	<i>Panicum fauriei</i> Hitchc. var. <i>latius</i> (St. John) Davidse	-	o x o o
N	<i>Panicum maximum</i> Jacq.	Guinea grass	o x o
E	<i>Panicum ramosius</i> Hitchc.	-	x
E	<i>Panicum torridum</i> Gaud.	Kakonakona	o x o o
E	<i>Panicum xerophilum</i> (Hillebr.) Hitchc.	Kakonakona	x o o
	<i>Panicum</i> spp.	-	o
N	<i>Pennisetum polystachion</i> (L.) Schult.	Feathery pennisetum	o?
N	<i>Rhynchelytrum repens</i> (Willd.) Hubb.	Natal redtop	o x o o
N	<i>Saccharum officinarum</i> L.	Sugar cane	o
N	<i>Setaria gracilis</i> Kunth	Yellow foxtail	*
N	<i>Setaria verticillata</i> (L.) P. Beauv.	Bristly foxtail	o x o o
I	<i>Sporobolus virginicus</i> (L.) Kunth	'Aki'aki	o x o o
N	<i>Tragus berteronianus</i> Schult.	Bur grass, berterero goatgrass	o x o o

**APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM
KAHO'OLAWA ISLAND**

The vascular plants included on this checklist are those observed on the three most recent botanical surveys of Kaho'olawe Island: the Hawai'i Heritage Program (HHP) reconnaissance survey (February and March 1992), the Division of Forestry survey (April 21-25, 1980) by Corn et al. (1980), and the Navy survey (November 22-27, 1978) for the U.S. Department of the Navy Environmental Impact Statement (1979). Known plantings were not documented during the HHP reconnaissance survey because the scope of this project was to document the native and naturalized vegetation of Kaho'olawe. The Division of Forestry survey and the Navy EIS survey include some known plantings on their checklists, as well as plant taxa seen in beach drift material, and these are identified as such in the remarks column of Appendix A2.

Since the 1980 and 1978 surveys were conducted, the Manual of the Flowering Plants of Hawai'i (Wagner, Herbst, and Sohmer 1990) has been published, and its taxonomy is the current standard. The 1980 and 1978 survey checklists follow the taxonomy of St. John's List and Summary of the Flowering Plants in the Hawaiian Islands (1973). This made it challenging to determine which species were observed on those surveys. Some of the plant names that were used for the 1980 and 1978 checklists are synonyms of taxa accepted by the Manual, and these are recorded in the remarks column. Many specimens collected on the 1980 and 1978 surveys were examined at the Bishop Museum herbarium (BISH) in June 1992, to verify their identity. Several specimens collected on these past two surveys have since been reidentified. Explanations of these changes are also noted in the remarks column.

Also included on this checklist are the flowering plant taxa reported on Kaho'olawe by the Manual of the Flowering Plants of Hawai'i (Wagner, Herbst, and Sohmer 1990). In the Manual there are reports of two taxa (*Chamaesyce celastroides* var. *stokesii* and *Eragrostis variabilis*) from Kaho'olawe that may be based upon misidentified specimens (J. Lau, personal communication 1992). In addition, there are fourteen taxa which are reported from Kaho'olawe in the Manual, which were not observed on any of the recent surveys, and for which no Kaho'olawe specimens were seen at the Bishop Museum herbarium (BISH) in June 1992. For these fourteen taxa, distributions according to the Manual appear in the Remarks column. (The taxa on this checklist are the same as those on Appendix A1).

Recorded in the remarks column are the collector and collection number for taxa collected on the HHP survey. Ken Wood and Steve Perlman of the National Tropical Botanical Garden and Joel Lau of the Nature Conservancy of Hawaii were the collectors for the Hawai'i Heritage Program.

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND

The taxonomy, nomenclature, and status of the flowering plants listed below are according to Wagner, Herbst, and Schmer (1990). The ferns and fern allies follow C.H. Lamoureaux (1988). Families are listed alphabetically within each of the three groups: ferns and fern allies, dicots, and monocots. Genera and species are arranged alphabetically under family. The status codes are explained below.

Status Codes: + = Rare N = Non-native I = Indigenous, native to the Hawaiian Islands and elsewhere
 E = Endemic, native only to the Hawaiian Islands

STATUS SCIENTIFIC NAME REMARKS

	FERNS AND FERN ALLIES	
	Adiantaceae	
N	Adiantum hispidulum Sw.	
	Aspleniaceae	
I	Asplenium adiantum-nigrum L.	
	Hemionitidaceae	
N	Pityrogramma calomelanos (L.) Link	
	Nephrolepidaceae	
N	Nephrolepis multiflora (Roxb.) Jarrett ex Morton	Nephrolepis sp. (Corn 1980): Cuddihy 427 (BISH) determined in 1981 as N. multiflora by Lamoureaux
	Nephrolepis sp.	
	Ophioglossaceae	
+ E	Ophioglossum concinnum Brack.	
	Polypodiaceae	
N	Phymatosorus scolopendria (N.L. Burm.) Pic.-Ser.	

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS

SCIENTIFIC NAME

REMARKS

	Sinopteridaceae	
E	<i>Doryopteris decipiens</i> (Hook.) J. Sm.	K.R. Wood 1727. J. Lau 3504. <i>D. decora</i> (Corn 1980, Navy 1979). Lamoureux (1988) does not list <i>D. decora</i> on Kaho'olawe. No Kaho'olawe specimens of <i>D. decora</i> were seen at BISH.
	Thelypteridaceae	
N	<i>Christella dentata</i> (Forsk.) Brownsey & Jermy	
N	<i>Christella parasitica</i> (L.) Levl.	
	FLOWERING PLANTS: DICOTS	
	Aizoaceae (Fig-marigold family)	
I	<i>Sesuvium portulacastrum</i> (L.) L.	
	Amaranthaceae (Amaranth family)	
N	<i>Amaranthus spinosus</i> L.	
N	<i>Amaranthus viridis</i> L.	
E	<i>Nototrichium sandwicense</i> (A. Gray) Hillebr.	On all main islands (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.
	Anacardiaceae (Mango family)	
N	<i>Mangifera indica</i> L.	Pits in drift material (Navy 1979). No Kaho'olawe specimens were seen at BISH.
	Apocynaceae (Dogbane family)	
N	<i>Catharanthus roseus</i> (L.) G. Don	Probably on all the main islands, but specimens were not seen from Kaua'i or Lana'i (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.
	Asclepiadaceae (Milkweed family)	
N	<i>Asclepias curassavica</i> L.	
N	<i>Asclepias physocarpa</i> (E. Mey.) Schlechter	<i>Gomphocarpus physocarpus</i> (Corn 1980, Navy 1979).
N	<i>Calotropis gigantea</i> (L.) W. T. Aiton	Escaped on Kaho'olawe (Wagner et al. 1990).
N	<i>Nerium oleander</i> L.	Forestry planting (Corn 1980).

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS	SCIENTIFIC NAME	REMARKS
	Asteraceae (Sunflower family)	
N	<i>Acanthospermum australe</i> (Loefl.) Kuntze	
N	<i>Ageratina riparia</i> (Regel) R. King & H. Robinson	
N	<i>Ageratum conyzoides</i> L.	
E	<i>Artemisia australis</i> Less.	Primarily on windward sides of all main islands (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.
N	<i>Bidens alba</i> (L.) DC var. <i>radiata</i> (Shultz-Bip.) Ballard ex Melchert	
E	<i>Bidens mauriensis</i> (A. Gray) Sherff	K.R. Wood 1721.
N	<i>Bidens pilosa</i> L.	
N	<i>Centaurea melitensis</i> L.	
N	<i>Cirsium vulgare</i> (Savi) Ten.	
N	<i>Conyza bonariensis</i> (L.) Cronq.	<i>Erigeron bonariensis</i> (Cron 1980).
N	<i>Conyza canadensis</i> (L.) Cronq. var. <i>pusilla</i> (Nutt.) Cronq.	Reported on the island in 1971 as <i>C. canadensis</i> by Whitesell.
N	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	
N	<i>Emilia fosbergii</i> Nicolson	<i>E. sonchifolia</i> (Cron 1980); Clarke & Corn 359 (BISH); <i>E. javanica</i> (Cron 1980); Clarke & Corn 360 (BISH); & <i>E. sonchifolia</i> (Navy 1979); Char 78.048 (BISH) determined as <i>E. fosbergii</i> .
N	<i>Emilia sonchifolia</i> (L.) DC	
N	<i>Galinoga parviflora</i> Cav.	
N	<i>Gnaphalium purpureum</i> L.	<i>Gnaphalium</i> sp. (Navy 1979); Char 78.015 (BISH) determined as <i>G. purpureum</i> .
N	<i>Heterotheca grandiflora</i> Nutt.	
N	<i>Hypochoeris glabra</i> L.	
N	<i>Hypochoeris radicata</i> L.	
N	<i>Lactuca serriola</i> L.	
+ E	<i>Lipochaeta bryanii</i> Sherff	
E	<i>Lipochaeta integrifolia</i> (Nutt.) A. Gray	On all main islands (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS	SCIENTIFIC NAME	REMARKS
E	<i>Lipochaeta lavarum</i> (Gaud.) DC	K.R. Wood 1719 & L. cf. lavarum by K.R. Wood 1722. <i>L. l.</i> var. <i>ovata</i> (Corn 1980). Several <i>Lipochaeta</i> sp. (Corn 1980) specimens determined as <i>L. lavarum</i> at BISH.
E	<i>Lipochaeta rockii</i> Sherff	<i>Lipochaeta</i> aff. <i>rockii</i> & <i>L. kahoolawensis</i> (Corn 1980).
E	<i>Lipochaeta succulenta</i> (Hook. & Arnott) DC	On all main islands except Lana'i (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.
N	<i>Montanoa hibiscifolia</i> Benth.	
N	<i>Pluchea indica</i> (L.) Less.	
N	<i>Pluchea symphytifolia</i> (Mill.) Gillis	<i>P. odorata</i> (Corn 1980, Navy 1979).
N	<i>Sigesbeckia orientalis</i> L.	
N	<i>Sonchus oleraceus</i> L.	
N	<i>Synedrella nodiflora</i> (L.) Gaertn.	
N	<i>Tridax procumbens</i> L.	
N	<i>Verbesina encelioides</i> (Cav.) Benth. & Hook.	
N	<i>Vernonia cinerea</i> (L.) Less. var. <i>parviflora</i> (Reinw.) DC	
N	<i>Xanthium strumarium</i> L. var. <i>canadense</i> (Mill.) Torr. & A. Gray	<i>X. saccharatum</i> (Corn 1980, Navy 1979).
N	<i>Zinnia peruviana</i> (L.) L.	<i>Z. pauciflora</i> (Corn 1980, Navy 1979).
?	Indet sp.	Indet sp. of composite (Navy 1979); Char 78.071 was not seen at BISH.
	Bataceae (Saltwort family)	
N	<i>Batis maritima</i> L.	
	Boraginaceae (Borage family)	
I	<i>Heliotropium curassavicum</i> L.	K.R. Wood 1642.
	Brassicaceae (Mustard family)	
N	<i>Coronopus didymus</i> (L.) Sm.	
+ I	<i>Lepidium bidentatum</i> Montin var. <i>o-waihiense</i> (Cham & Schlechtend.) Fosb.	Possible planting escapee (HHP 1992).

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS	SCIENTIFIC NAME	REMARKS
	Euphorbiaceae (Spurge family)	
N	<i>Aleurites moluccana</i> (L.) Willd. (C. Forbes) Degener & I. Degener	Drift material (Corn 1980, Navy 1979).
E	<i>Chamaesyce celastroides</i> (Boiss.) Croizat & Degener var. <i>amplectens</i> (Sherff) Degener & I. Degener	K.R. Wood 1728 & 1720. <i>Euphorbia celastroides</i> var. <i>waikoluensis</i> (Corn 1980).
E	<i>Chamaesyce celastroides</i> (Boiss.) Croizat & Degener var. <i>stokesii</i> (C. Forbes) Degener & I. Degener	Only Kaho'olawe specimen at BISH identified as this taxon (Hobby 606, BISH) fits the description of <i>C. c.</i> var. <i>amplectens</i> (J. Lau, personal communication 1992).
N	<i>Chamaesyce hirta</i> (L.) Millsp.	<i>Euphorbia hirta</i> (Corn 1980, Navy 1979).
N	<i>Chamaesyce hypericifolia</i> (L.) Millsp.	<i>Euphorbia glomerifera</i> (Navy 1979).
N	<i>Chamaesyce prostrata</i> (Aiton) Small	<i>Euphorbia prostrata</i> (Corn 1980, Navy 1979).
+ E	<i>Chamaesyce skottsbergii</i> (Sherff) Croizat & Degener var. <i>vaccinioides</i> (Sherff) Koutnik	<i>Euphorbia multifloris</i> var. <i>microphylla</i> (Corn 1980): Clarke & Corn 387 (BISH) determined as <i>C. s.</i> var. <i>vaccinioides</i> .
N	<i>Euphorbia heterophylla</i> L.	Documented from all main islands except Moloka'i (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.
N	<i>Ricinus communis</i> L.	
	Fabaceae (Pea family)	
N	<i>Acacia confusa</i> Merr.	Forestry planting (Corn 1980).
N	<i>Acacia farnesiana</i> (L.) Willd.	
N	<i>Cassia</i> sp.	No collection made (Navy 1979).
N	<i>Chamaecrista nictitans</i> (L.) Moench ssp. <i>patellaria</i> (DC ex Collad.) H. Irwin & Barneby var. <i>glabrata</i> (Vogel) H. Irwin & Barneby	<i>Cassia leschenaultiana</i> (Corn 1980, Navy 1979).
N	<i>Crotalaria incana</i> L.	
N	<i>Crotalaria</i> sp.	
N	<i>Desmanthus virgatus</i> (L.) Willd.	
N	<i>Desmodium sandwicense</i> E. Mey.	
N	<i>Desmodium tortuosum</i> (Sw.) DC	<i>D. uncinatum</i> (Corn 1980).
N	<i>Desmodium triflorum</i> (L.) DC	
N	<i>Desmodium</i> sp.	Possible forestry planting escapee (Navy 1979).
E	<i>Erythrina sandwicensis</i> Degener	

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS	SCIENTIFIC NAME	REMARKS
N	<i>Glycine wightii</i> (Wight & Arnott) Verde	K.R. Wood 1649. Forestry planting (Corn 1980). <i>Glycine</i> sp. (Corn 1980): Cuddihy & Clarke 415 (BISH) determined as <i>G. wightii</i> .
N	<i>Indigofera suffruticosa</i> Mill.	
N	<i>Leucaena leucocephala</i> (Lam.) de Wit	
N	<i>Macroptilium atropurpureum</i> (DC) Urb.	K.R. Wood 1741.
N	<i>Macroptilium lathyroides</i> (L.) Urb.	<i>Phaseolus lathyroides</i> (Corn 1980, Navy 1979).
N	<i>Prosopis pallida</i> (Humb. & Bonpl. ex Willd.) Kunth	<i>Prosopis pallida</i> f. <i>pallida</i> & f. <i>armata</i> (Corn 1980, Navy 1979).
I	<i>Senna gaudichaudii</i> (Hook. & Arnott) H. Irwin & Barneby	K.R. Wood 1729.
+	<i>Sesbania tomentosa</i> Hook. & Arnott	<i>Sesbania</i> sp. (Navy 1979): Higashino 8059 (BISH) determined as <i>S. tomentosa</i> .
N	<i>Tephrosia purpurea</i> (L.) Pers. var. <i>purpurea</i>	Forestry planting, possibly observed in seedling stage (Navy 1979).
+	<i>Vigna o-wahuensis</i> Vogel	Indet. sp. of legume (Navy 1979): Char 78.074 (BISH) determined as <i>V. o-wahuensis</i> .
+	Fabaceae sp. nov.?	K.R. Wood 1733. Referred to as Fabaceae sp. 1 in HHP database (HHP 1992).
?	Indet. sp.	Indet. sp. of legume (Navy 1979): Char 78.046 was not seen at BISH.
	Gentianaceae (Gentian family)	
N	<i>Centaurium erythraea</i> Raf. ssp. <i>erythraea</i>	
	Goodeniaceae (Goodenia family)	
I	<i>Scaevola sericea</i> Vahl	Forestry planting & naturally occurring (Navy 1979).
	Lamiaceae (Mint family)	
N	<i>Ocimum gratissimum</i> L.	J. Lau 3501.
	Malvaceae (Mallow family)	
N	<i>Abutilon grandifolium</i> (Willd.) Sweet	
I?	<i>Abutilon incanum</i> (Link) Sweet	
E	<i>Gossypium tomentosum</i> Nutt. ex Seem.	K.R. Wood 1643 & 1653. <i>G. sandvicense</i> (Corn 1980, Navy 1979).

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS SCIENTIFIC NAME REMARKS

I	<i>Boerhavia repens</i> L.	K.R. Wood 1738. Although <i>B. diffusa</i> (a synonym of <i>B. repens</i>) was reported by Corn (1980), no specimens of it from that survey were seen at BISH. <i>B. diffusa</i> (Navy 1979): Stemmermann s.n. was not seen at BISH.
	Oxalidaceae (Wood sorrel family)	
N?	<i>Oxalis corniculata</i> L.	Possible Polynesian introduction (Wagner 1990).
	Papaveraceae (Poppy family)	
E	<i>Argemone glauca</i> (Nutt. ex Prain) Pope var. <i>glauca</i>	K.R. Wood 1641. <i>A. glauca</i> (Corn 1980, Navy 1979).
	Passifloraceae (Passion flower family)	
N	<i>Passiflora edulis</i> Sims	Fruits in drift only (Navy 1979).
	Phytolaccaceae (Pokeweed family)	
N	<i>Phytolacca dioica</i> L.	Forestry planting (Corn 1980).
	Plumbaginaceae (Plumbago or leadwort family)	
I	<i>Plumbago zeylanica</i> L.	A specimen (Stokes s.n.) was seen at BISH.
	Portulacaceae (Purslane family)	
+	<i>Portulaca molokiniensis</i> Hobby	K.R. Wood 1732. <i>Portulaca</i> aff. <i>lutea</i> (Corn 1980): Clarke & Corn 388 (BISH) determined as <i>P. molokiniensis</i> . <i>P. lutea</i> (Navy 1979): Higashino 8061 (BISH) determined as <i>P. molokiniensis</i> . No <i>P. lutea</i> specimens from Kaho'olawe were seen at BISH.
N	<i>Portulaca oleracea</i> L.	
N	<i>Portulaca pilosa</i> L.	
+	<i>Portulaca villosa</i> Cham.	

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWE ISLAND (continued)

STATUS SCIENTIFIC NAME REMARKS

	Primulaceae (Primrose family)	
N	Anagallis arvensis L.	
	Rhamnaceae (Buckthorn family)	
+	Gouania hillebrandii Oliver	Type specimens of <i>G. cucullata</i> & <i>G. remyi</i> (Remy 587, P) from 1850's.
	Rhizophoraceae (Mangrove family)	
N	Rhizophora mangle L.	Seedling (HHP 1992, Navy 1979). Drift material (Corn 1980).
	Rubiaceae (Coffee family)	
N	Coffea arabica L.	Documented from all main islands except Ni'ihau (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.
	Santalaceae (Sandalwood family)	
E	Exocarpos gaudichaudii A. DC	On all main islands except Kaua'i (Wagner et al. 1990). This is probably an error. No Kaho'olawe specimens were seen at BISH.
E	Santalum ellipticum Gaud.	A specimen collected by Remy from the 1850's was seen at BISH.
	Sapindaceae (Soapberry family)	
E	Dodonaea viscosa Jacq.	Reported as formerly present on the island by Forbes (1913). According to Wong (1973), this taxon was also planted.
	Solanaceae (Nightshade family)	
I	Lycium sandwicense A. Gray	
N	Lycopersicon esculentum Mill.	
N	Lycopersicon pimpinellifolium (Jusl.) Mill.	
N	Nicotiana glauca R. C. Graham	
N	Nicotiana tabacum L.	On all main islands (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS	SCIENTIFIC NAME	REMARKS
	Cyperaceae (Sedge family)	
I	<i>Carex meyenii</i> Nees	Extinct on Kaho'olawe (Wagner et al. 1990). No Kaho'olawe specimens were seen at BISH.
I?	<i>Eleocharis calva</i> Torr.	<i>Eleocharis</i> sp. (Corn 1980): Cuddihy 354 (BISH) determined as <i>E. calva</i> by T. Koyama.
E	<i>Mariscus phleoides</i> Nees ex Kunth ssp. <i>phleoides</i>	K.R. Wood 1731, 1732 & 1726.
	Pandanaceae (Screw pine family)	
I?	<i>Pandanus</i> sp.	Drift material (Corn 1980, Navy 1979).
	Poaceae (Grass family)	
N	<i>Bothriochloa pertusa</i> (L.) A. Camus	<i>Andropogon pertusus</i> (Corn 1980, Navy 1979).
N	<i>Cenchrus ciliaris</i> L.	<i>Pennisetum setosum</i> (Navy 1979): Char 78.049 (BISH) determined as <i>C. ciliaris</i> . K.R. Wood 1644.
N	<i>Cenchrus tribuloides</i> L.	<i>C. inflata</i> (Corn 1980, Navy 1979).
N	<i>Chloris barbata</i> (L.) Sw.	Two of the <i>Chloris</i> sp. (Navy 1979) specimens: Char 78.016 & 78.041 (BISH) determined as <i>C.</i> <i>divaricata</i> .
N	<i>Chloris divaricata</i> R. Br. var. <i>divaricata</i>	Adventive on Kaho'olawe (Wagner et al. 1990). K.R. Wood 1739.
N	<i>Chloris truncata</i> R. Br.	Two of the 5 specimens collected on the 1978 survey (Char 78.016 & 78.041, BISH) deter- mined as <i>C. divaricata</i> . The remaining 3 spec- imens of <i>Chloris</i> were not seen at BISH.
N	<i>Chloris virgata</i> Sw.	Seeds in drift material (Navy 1979).
N	<i>Coix lacryma-jobi</i> L.	
N	<i>Cynodon dactylon</i> (L.) Pers.	
N	<i>Dactyloctenium aegyptium</i> (L.) Willd.	
N	<i>Dicanthium aristatum</i> (Poir.) Hubb.	K.R. Wood 1735. Reported from the island in 1971 as <i>Andropogon nodosus</i> by Yanamura.
N	<i>Dicanthium sericeum</i> (R. Br.) A. Camus	<i>Andropogon aristatus</i> (Corn 1980): Cuddihy & Char 370 (BISH) determined as <i>D. sericeum</i> .

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS	SCIENTIFIC NAME	REMARKS
N	<i>Digitaria ciliaris</i> (Retz.) Koeler	<i>Digitaria adscendens</i> (Corn 1980, Navy 1979) & <i>D. sanguinalis</i> (Corn 1980). All four <i>Digitaria</i> sp. (Navy 1978) determined as <i>D. ciliaris</i> at BISH.
N	<i>Digitaria insularis</i> (L.) Mez ex Ekman	<i>Trichachne insularis</i> (Corn 1980, Navy 1979).
N	<i>Echinochloa colona</i> (L.) Link	
N	<i>Eleusine indica</i> (L.) Gaertn.	
E	<i>Eragrostis atropioides</i> Hillebr.	K.R. Wood 1725. J. Lau 3505 & 3506. <i>E. variabilis</i> (Corn 1980): Cuddihy 354 (BISH) determined as <i>E. variabilis</i> is actually <i>E. atropioides</i> (J. Lau, personal communication 1992). No collection made of <i>E. variabilis</i> (Navy 1979).
N	<i>Eragrostis cilianensis</i> (All.) Link	K.R. Wood 1645.
N	<i>Eragrostis tenella</i> (L.) P. Beauv ex Roem. & Schult.	
E	<i>Eragrostis variabilis</i> (Gaud.) Steud.	On all of the main islands (Wagner et al. 1990). Cuddihy 354 (BISH) identified as <i>E. variabilis</i> fits the description of <i>E. atropioides</i> (J. Lau, personal communication 1992). No Kaho'olawe specimens of <i>E. variabilis</i> were seen at BISH.
?	<i>Eragrostis</i> sp.	
I?	<i>Heteropogon contortus</i> (L.) P. Beauv. ex Roem. & Schult.	K.R. Wood 1655.
N	<i>Melinis minutiflora</i> P. Beauv.	
E	<i>Panicum fauriei</i> Hitchc. var. <i>fauriei</i>	<i>Panicum fauriei</i> (Corn 1980). <i>Panicum</i> sp. (Navy 1979): Stenmermann & Higashino 3678 (BISH) determined as <i>P. f. var. fauriei</i> .
E	<i>Panicum fauriei</i> Hitchc. var. <i>latius</i> (St. John) Davidse	K.R. Wood 1640 & 1646. Several specimens of <i>Panicum nubigenum</i> (Corn 1980, Navy 1979) determined as <i>P. f. var. latius</i> at BISH.
N	<i>Panicum maximum</i> Jacq.	
E	<i>Panicum ramosius</i> Hitchc.	
E	<i>Panicum torridum</i> Gaud.	K.R. Wood 1730.

APPENDIX A2: REMARKS ON VASCULAR PLANT SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

REMARKS

SCIENTIFIC NAME

STATUS

E	<i>Panicum xerophilum</i> (Hillebr.) Hitchc.	<i>P. nubigenum</i> var. <i>nova</i> (Corn 1980): type specimen of <i>P. cornae</i> (BISH) determined as <i>P. xerophilum</i> . <i>Panicum</i> sp. (Navy 1979): Stemmermann 3677B (BISH) determined as <i>P. xerophilum</i> .
	<i>Panicum</i> spp.	Several specimens were collected on 1978 survey of which two (Stemmermann 3657 & 3677A, BISH) were determined as <i>Panicum fauriei</i> var. <i>latius</i> and one (Stemmermann 3677B, BISH) was determined as <i>P. xerophilum</i> .
N	<i>Pennisetum polystachion</i> (L.) Schult.	Two specimens labeled as <i>P. setosum</i> in 1978: Char 78.049 (BISH) determined as <i>Cenchrus ciliaris</i> & Stemmermann 3671 was not seen at BISH.
N	<i>Rhynchelytrum repens</i> (Willd.) Hubb.	
N	<i>Saccharum officinarum</i> L.	Drift material (Corn 1980, Navy 1979).
N	<i>Setaria gracilis</i> Kunth	
N	<i>Setaria verticillata</i> (L.) P. Beauv.	K.R. Wood 1736.
I	<i>Sporobolus virginicus</i> (L.) Kunth	K.R. Wood 1652.
N	<i>Tragus berteronianus</i> Schult.	K.R. Wood 1647.

APPENDIX B: ANIMAL SPECIES RECORDED FROM KAHO'OLAWE ISLAND

The animals listed below have been recorded from visual and/or audio identification on Kaho'olawe Island, or from areas just offshore. The list includes records made during the HHP survey (February and March 1992), land snail information from the Bishop Museum collections, and information compiled from the HHP database and the literature. Only records of live animals are reported here, with the exception of two dead seabird species recorded during the HHP survey and dead snails from the survey and Bishop Museum collections (see text, pages 36-37 for explanation). Information on archaeological snail records can be obtained in the report by Christensen (1987). Information on bird bone records is reported by Dr. S.L. Olson in Appendix C. It was beyond the scope of the HHP survey to do a complete invertebrate inventory of Kaho'olawe Island. The status codes and source codes are explained below.

Status codes: E = Endemic, native only to the Hawaiian Islands I = Indigenous, native to the Hawaiian Islands and elsewhere (includes regular migrants and species which breed in Hawaii) N = Non-native, not native to the Hawaiian Islands (introduced by humans) E? = Status unknown, possibly endemic ? = Status unknown

Source codes: x = Cited in the literature and/or in the HHP database * = Recorded during field survey c = Cited in the collection log of the Malacology Department, Bishop Museum (It is not known if the specimen was collected alive or dead) x x = Cited in literature as no longer found on Kaho'olawe x ? = Unconfirmed record cited in the literature * ? = Unconfirmed record from field survey

STATUS SCIENTIFIC NAME (a) COMMON NAME HERITAGE
 FEDERAL STATUS (b) RANK (c) SOURCE

INVERTEBRATES

?	Unidentified polychaete worms	Tube Worms		*
SNAILS				
	Achatinellidae			
E	Tornatellides kahooolavensis	Achatinellid Land Snail		c
E?	Tornatellides spp.	Achatinellid Land Snail		c
E	Tornatellina baldwini	Achatinellid Land Snail		c
I	Lamellina gracilis	Achatinellid Land Snail		c

APPENDIX B: ANIMAL SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

FEDERAL STATUS (b) RANK (c) SOURCE
 HERITAGE GLOBAL

STATUS SCIENTIFIC NAME (a) COMMON NAME

	STATUS SCIENTIFIC NAME (a)	COMMON NAME	FEDERAL STATUS (b)	RANK (c)	SOURCE	HERITAGE GLOBAL
	Amastriidae					
E	<i>Amastra morticina</i>	Amastrid Land Snail				C
E	<i>Amastra</i> sp.	Amastrid Land Snail				C
E	<i>Leptachatina subcylindracea</i>	Amastrid Land Snail				C
E	<i>Leptachatina</i> sp.	Amastrid Land Snail				C
	Bradybaenidae					
N	<i>Bradybaena similaris</i>	Bradybaenid Land Snail				*
	Endodontidae					
E?	<i>Thaumatodon</i> sp.	Endodontid Land Snail				C
	Pupillidae					
N	<i>Gastrocopta servilis</i>	Pupillid Land Snail				*
E	<i>Lyropupa kahooolavensis</i>	Pupillid Land Snail				C
E?	<i>Lyropupa</i> sp.	Pupillid Land Snail				C
E	<i>Nesopupa newcombi interrupta</i>	Pupillid Land Snail				C
E	<i>Nesopupa dispersa</i>	Pupillid Land Snail				C
E?	<i>Nesopupa</i> sp.	Pupillid Land Snail				C
	Helicarionidae					
E	<i>Philonesia guavarum</i>	Helicarionid Land Snail				C
E?	<i>Philonesia</i> sp.	Helicarionid Land Snail				C
	Helicinidae					
E?	<i>Helicina</i> sp.	Helicinid Land Snail				C
	Succineidae					
E	<i>Succinea</i> sp.	Succineid Land Snail				*
	Subulinidae					
N	<i>Opeas clavulinum hawaiiense</i>	Subulinid Land Snail				*
N	<i>Opeas javanicum</i>	Subulinid Land Snail				*
	Thiaridae					
N	Unidentified sp.	Thiarid Aquatic Snail				*
	Zonitidae					
?	<i>Striatura</i> sp. OR <i>Hawaiiia</i> sp.	Zonitid Land Snail				*

APPENDIX B: ANIMAL SPECIES RECORDED FROM KAHO'OLAWE ISLAND (continued)

STATUS SCIENTIFIC NAME (a) COMMON NAME FEDERAL STATUS (b) RANK (c) SOURCE HERITAGE GLOBAL

CRUSTACEANS		COMMON NAME	FEDERAL STATUS (b)	RANK (c)	SOURCE	HERITAGE GLOBAL
	Atyidae					
E	Halocaridina rubra	Anchialine Pool Shrimp				*
	Ligilidae					
?	Ligia sp.	No common name				*
	Triopsidae					
?	Triops sp.	Tadpole Shrimp				*
?	Unidentified ostracods	Seed Shrimp				*
?	Unidentified amphipods	No common name				*

INSECTS		COMMON NAME	FEDERAL STATUS (b)	RANK (c)	SOURCE	HERITAGE GLOBAL
	Corixidae					
N	Unidentified sp.	Water Boatmen				*

VERTEBRATES

REPTILES		COMMON NAME	FEDERAL STATUS (b)	RANK (c)	SOURCE	HERITAGE GLOBAL
	Gekkonidae					
N	Lepidodactylus lugubris	Mourning Gecko				*
N	Gehyro mutilata	Stump-toed Gecko				x
N	Hemiphilodactylus typus typus	Tree Gecko				x
N	Hemidactylus garnoti	Indo-Pacific Gecko (Fox Gecko)				x
N	Hemidactylus frenatus	House Gecko				*
	Scincidae					
N	Leiopisma metallicum	Metallic Skink				x
N	Cryptoblepharus boutoni poecilopleurus	Snake-eyed Skink				x
N	Lipinia noctua noctua	Moth Skink				x ?
N	Emoia cyanura	Azure-tailed Skink				x
	Cheloniidae					
+ I	Chelonia mydas	Honu, Green Turtle	LT	G3		x

APPENDIX B: ANIMAL SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

HERITAGE
GLOBAL
FEDERAL
STATUS (b) RANK (c) SOURCE

STATUS SCIENTIFIC NAME (a) COMMON NAME

BIRDS	STATUS	SCIENTIFIC NAME (a)	COMMON NAME	FEDERAL STATUS (b)	RANK (c)	SOURCE
		Diomedidae				
I		<i>Diomedea immutabilis</i>	Moli, Laysan Albatross			*
		Procellariidae				
+ E		<i>Pterodroma phaeopygia sandwichensis</i>	'Ua'u, Dark-rumped Petrel	LE	G2	x
I		<i>Bulweria bulwerii</i>	'Ou, Bulwer's Petrel			*
I		<i>Puffinus pacificus chlororhynchus</i>	'Ua'u kani, Wedge-tailed Shearwater			*
		Hydrobatidae				
I		<i>Oceanodroma tristrami</i>	Tristram's Storm-Petrel			x
		Phaethontidae				
I		<i>Phaethon lepturus dorothaeae</i>	Koa'e kea, White-tailed Tropicbird			*
I		<i>Phaethon rubricauda rothschildi</i>	Koa'e 'ula, Red-tailed Tropicbird			*
		Sulidae				
I		<i>Sula leucogaster plotus</i>	'A, Brown Booby			*
I		<i>Sula sula rubripes</i>	'A, Red-footed Booby			*
		Fregatidae				
I		<i>Fregata minor palmerstoni</i>	'Iwa, Great Frigatebird			*
		Ardeidae				
I		<i>Nycticorax nycticorax hoactli</i>	'Auku'u, Black-crowned Night-Heron			x
		Anatidae				
?		<i>Anas sp.</i>	Unidentified duck			x
		Phasianidae				
N		<i>Alectoris chukar</i>	Chukar			x x
N		<i>Lophura nycthemerus</i>	Silver Pheasant			x x
N		<i>Phasianus versicolor</i>	Japanese Green Pheasant			x x
N		<i>Meleagris gallopavo</i>	Wild Turkey			x x
N		<i>Callipepla gambelii</i>	Gambel's Quail			*
		Charadriidae				
I		<i>Pluvialis squatarola</i>	Black-bellied Plover			x
I		<i>Pluvialis fulva</i>	Kolea, Pacific Golden-Plover			*

APPENDIX B: ANIMAL SPECIES RECORDED FROM KAHOLAWE ISLAND (continued)

HERITAGE
GLOBAL
FEDERAL
STATUS (b) RANK (c) SOURCE

STATUS SCIENTIFIC NAME (a) COMMON NAME

	STATUS	SCIENTIFIC NAME (a)	COMMON NAME	FEDERAL STATUS (b)	RANK (c)	SOURCE
		Scolopacidae				
I		Heteroscelus incanus	'Ulili, Wandering Tattler			*
I		Arenaria interpres	'Akekeke, Ruddy Turnstone			x
I		Calidris alba	Hunakai, Sanderling			x
		Laridae				
E		Sterna fuscata oahuensis	'Ewa'ewa, Sooty Tern			x
I		Anous minutus melanogenys	Noio ('Eki'eki), Black Noddy			x
		Columbidae				
N		Columba livia	Rock Dove			*
N		Streptopelia chinensis	Spotted Dove			*
N		Geopelia striata	Zebra Dove			*
		Tytonidae				
N		Tyto alba	Barn Owl			*
		Strigidae				
E		Asio flammeus sandwichensis	Pueo, Short-eared Owl			*
		Alaudidae				
N		Alauda arvensis	Eurasian Skylark			*
		Muscicapidae				
N		Cettia diphone	Japanese Bush-Warbler			*
		Mimidae				
N		Mimus polyglottos	Northern Mockingbird			*
		Sturnidae				
N		Acridotheres tristis	Common Myna			* ?
		Zosteropidae				
N		Zosterops japonicus	Japanese White-eye			*
		Emberizidae				
N		Cardinalis cardinalis	Northern Cardinal			*
N		Paroaria coronata	Red-crested Cardinal			*
		Fringillidae				
		(subfamily: Carduelinae)				
N		Carpodacus mexicanus	House Finch			*

APPENDIX B: ANIMAL SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

HERITAGE
FEDERAL GLOBAL
STATUS (b) RANK (c) SOURCE

STATUS SCIENTIFIC NAME (a) COMMON NAME

STATUS	SCIENTIFIC NAME (a)	COMMON NAME	FEDERAL STATUS (b)	RANK (c)	SOURCE
	Passeridae				
N	Passer domesticus	House Sparrow			*
	Estrildidae				
N	Lonchura malabarica	Warbling Silverbill			*
N	Lonchura punctulata	Nutmeg Mannikin			*

MAMMALS

	Vespertilionidae				
+ E	Lasiurus cinereus semotus	'Ope'ape'a, Hawaiian Hoary Bat	LE	G2	X
	Muridae				
N	Rattus rattus rattus	Roof Rat			X
N	Rattus exulans hawaiiensis	Polynesian Rat			X
N	Mus domesticus	European House Mouse			*
	Balaenopteridae				
+ I	Megaptera novaeangliae	Humpback Whale	LE	G2	*
	Delphinidae				
I	Tursiops truncatus	Bottlenose Dolphin			X
I	Stenella longirostris	Spinner Dolphin			*
I	Pseudorca crassidens	False Killer Whale			X
I	Globicephala macrorhynchus	Short-finned Pilot Whale			X
I	Globicephala melaena	Pilot Whale			X
	Canidae				
N	Canis familiaris familiaris	Feral Dog			X X
	Felidae				
N	Felis catus	Feral Cat			*
	Phocidae				
+ E	Monachus schauinslandi	'Ilio holo i ka uaua, Hawaiian Monk Seal	LE	G2	X
	Equidae				
N	Equus caballus caballus	Horse			X X
N	Equus asinus x caballus	Mule			X X

APPENDIX B: ANIMAL SPECIES RECORDED FROM KAHO'OLAWA ISLAND (continued)

STATUS	SCIENTIFIC NAME (a)	COMMON NAME	HERITAGE		
			FEDERAL STATUS (b)	GLOBAL RANK (c)	SOURCE
	Suidae				
N	<i>Sus scrofa scrofa</i>	Pig			x x
	Bovidae				
N	<i>Bos taurus</i>	Feral Cattle			x x
N	<i>Capra hircus hircus</i>	Feral Goat			x
N	<i>Ovis aries</i>	Feral Sheep			x x

(a) Identifications of snails collected during the HHP survey were provided or confirmed by Dr. Robert Cowie, Zoology Department, Bishop Museum.

Invertebrate taxonomic names are listed alphabetically by family name.

Reptile taxonomic names are listed according to McKeown (1978).

Bird taxonomic names are listed according to Pyle (1988).

Mammal taxonomic names are listed according to Tomich (1986).

(b) Key to Federal Status (USFWS 1991):

LE = Taxa formally listed as endangered

LT = Taxa formally listed as threatened

(c) Key to the Hawai'i Heritage Program's Global Ranks:

G2 = Species imperilled globally (typically 6-20 current occurrences).

G3 = Very rare with restricted range (typically 21-100 current occurrences).

APPENDIX C

SURVEY OF KAHO'OLAWE FOR BONES OF EXTINCT BIRDS

Storrs L. Olson

Dept. of Vertebrate Zoology, National Museum of Natural History,
Smithsonian Institution, Washington, D. C. 20560

EXECUTIVE SUMMARY

No native land birds are known historically from Kaho'olawe. It is assumed that many species were exterminated through human disturbance during the prehistoric period, but this can only be proven by fossil remains. A search for fossil sites was conducted on the island, but with exceedingly poor results. Dune deposits, which are fairly well developed, were almost barren of bone. The very few caves on the island likewise produced little.

A few bird remains were recovered in previous archaeological excavations. Bones of the living storm-petrel, *Oceanodroma castro*, constitute the first record of the species for Kaho'olawe. A bone of the common myna, *Acridotheres tristis*, along with early observations, suggest natural colonization and subsequent extinction of this species on the island. The only native land bird documented for Kaho'olawe is the nene, *Branta sandvicensis*, which was fairly common in midden deposits and proves at least one prehistoric extinction. Doubtless there were many more; recommendations are made for future monitoring of potential fossil sites on the island.

INTRODUCTION

The relatively recent discovery of deposits of fossil birds on most of the main Hawaiian islands revealed that prehistoric hunting and disturbance of native ecosystems by humans had caused the extinction of the major part of the Hawaiian avifauna prior to Western contact (Olson and James 1982a,b; 1984; James et al. 1987). Almost three dozen new species of extinct fossil birds have been named from the archipelago to date, and many more are known that remain to be described (James and Olson 1991; Olson and James, 1991).

No native land birds were recorded from the island of Kaho'olawe, but from the preceding discoveries we have assumed that under natural conditions there must have been a significant native avifauna on the island prior to the arrival of man. The only way to document this, however, is by finding bones of exterminated species. For this reason, we undertook paleontological exploration of the island, with the following, unfortunately meager, results.

METHODS

Bones of extinct birds have been found in a wide variety of geological settings in the Hawaiian Islands, including: sand dunes, lava tubes, sinkholes in raised limestone reefs, crater lake deposits, and archaeological midden (Olson and James 1982b; James et al. 1987; 1991). On other oceanic islands, such as St. Helena (Olson 1975), bird bones were also found in various alluvial and loess deposits. Thus, in searching for bones on Kaho'olawe, the first step was to attempt to locate similar geological settings and then determine whether bones were present in any potentially fossiliferous sites located. Latitude and longitude of sites was determined with a Global Positioning System (GPS).

PERIOD OF INVESTIGATION

20 February 1984 (S. L. Olson, H. F. James, D. W. Steadman). We visited areas of sand dunes by helicopter.

20-26 March 1992. S. L. Olson (ornithology and paleontology), Rowland Reeve (archaeology), R. Michael Severns (malacology), and various Nature Conservancy and military personnel explored much of the island by jeep and on foot.

RESULTS

Neither in any geological report (e.g., Stearns, 1940) nor in our exploration of Kaho'olawe was there any indication of uplifted limestone with karstic features, nor were there crater lake deposits. Likewise, we found no alluvial accumulations of sediment with any paleontological potential. Erosion of the island has been so severe that had any existed previous to human arrival, they most likely would have disappeared by now. Alluvium in the bottoms of gorges is all probably of very recent origin (Spriggs 1991). For example, at the mouth of Ahupu Gulch there are banks of red alluvium along the sides of the gulch. Near the bottom of one of these banks we found a weathered cow bone under nearly a meter of sediment, suggesting that the entire deposit may postdate the introduction of cattle to the island in the 1880s.

Sand Dunes: Because dunes of calcareous sand have yielded important avian fossils on Kaua'i and Moloka'i, the few areas of sand on Kaho'olawe were given top priority for paleontological investigation. On 20 February 1984 we made a survey by private helicopter of all of the sand exposures at the western end of the island and those at Kanapou Bay. The same deposits at the western end of the island were investigated again on foot on 22 March 1992. Despite the fact that some of these sites looked potentially quite fossiliferous (especially one windblown exposure with a lot of root and stem molds of naupaka (*Scaevola* sp.) at 20° 32.04' N; 156° 41.80' W, they were essentially barren of bones both in 1984 and six years later. The absence of bones even of burrowing procellariiform birds, such as the wedge-tailed shearwater (*Puffinus pacificus chlororhynchus*) and relatives, is difficult to explain.

Another potentially fossiliferous area of sand occurs inland a few hundred meters from the coast on the west side of the principal gulch leading into Hakioawa. This is well known as the site of a heiau now being re-used by the Ohana group. It was briefly investigated on 23 March 1992, but was found to be heavily vegetated by kiawe, with little exposure of sand.

Caves and Lava Tubes: Specific searches for caves and lava tubes were made as follows: 21 March 1992--Ahupu Gulch, Ahupuiki Gulch, and the next gulch to the west. 23 March--Kaulana Gulch (entered at 20° 34.95' N; 156° 35.40' W; exited at 20° 35.24' N; 156° 35.24' W), and gulches on approach to Hakioawa. 24 March--gulches in the area from Lae o Halona Point to Lae o Kaka.

No potential sites were found except at Ahupu Gulch. Several deep crevices just NE of the mouth of the gulch were large enough to enter. A barn owl (*Tyto alba*) was in residence here and the only bones found were those derived from recent owl pellets. We also investigated a well-known large habitation cave on the west

side of the gulch a few hundred meters from the mouth (20° 34.17' N, 156° 38.02' W). This extends about 30 meters uphill (roughly westward) and ends in a pile of lava rubble. Shells and sea urchin spines testify to its former human occupancy, but there were no avian remains at the surface and little or no sediment in which they might have accumulated. The cave has little potential as a fossil site in any case, as it would not have functioned as a pitfall trap and is only barely long enough to have a dark zone. A few meters mauka of this cave and above it, about 10 to 15 meters above the bottom of the gulch, was another lava tube extending straight back into the wall of the gulch. This had a flattened oval cross-section and was just big enough to admit a person, though it opened up sufficiently within to permit one to turn around. This contained mostly bones of cats, but two bird bones (myna and storm-petrel) were also recovered.

Remnant "Soil" Hummocks: On 25 March 1992 we investigated remnant "soil" hummocks, evidently of aeolian origin, in the vicinity of Moa Ula, Moa Ula Iki, and in the upper reaches of the road to Hakioawa. Samples of this sediment were screened for shells of land snails, with negative results except as noted in the report of Severns (Severns' information was incorporated into HHP report). We found no bird bones on the exposed faces of these hummocks, but these deposits are probably one of the better potential sources for archaeological sites that may contain bird bones. For example, on the road to Hakioawa (20° 33.85' N, 156° 33.96' W), we discovered the remains of an intact firepit, the outermost edge of which had been barely exposed, that was under about 1.2 meters of this sediment and only about 0.3 to 0.4 meters above the so-called hardpan.

In another instance we found a large amount of charcoal deeply buried in a hummock near archaeological site 111 (20° 32.82' N, 156° 35.07' W). These sediments are surely equivalent to what has been termed the "Ahupu Formation" (see Spriggs 1991), although I would not be inclined to so dignify them formally. It is difficult to reconcile the above mentioned firepit with Spriggs' (1991:98) assertion that "there are no prehistoric Hawaiian sites associated with this soil [sic] formation," which he regarded as "entirely historic in origin." Because this contrasts markedly with Hommon's (1980a,b) view that "massive erosion was initiated during the period of prehistoric Hawaiian occupation" (Spriggs, 1991:108), a high priority should be given to more careful investigation, including radiocarbon dating and identification of charcoal, and of cultural and other features as they are exposed in these remnant sediment hummocks. This would be of much greater value in determining the timing and consequences of prehistoric settlement of the island than documenting the inferior cultural remains exposed by deflation everywhere on the hardpan of Kaho'olawe.

Archaeological Midden Material: We did not recover any midden material during our 1992 survey, although this remains the best potential source for bird bones on the island. However, the excavations undertaken by Hommon (1980a,b; 1983) and Rosendahl et al. (1987) yielded remains of seven species of birds (Collins 1987), as discussed below.

AVIAN REMAINS FROM KAHO'OLAWA

Dark-rumped petrel, *Pterodroma phaeopygia*. Individuals, including some juveniles, have been reported from seven archaeological sites (Collins 1987). This seabird is known historically from Kaho'olawe and may still occur there.

Bulwer's petrel, *Bulweria bulwerii*. Reported from four archaeological sites (Collins 1987). This seabird is apparently not certainly known historically from Kaho'olawe but still breeds on nearby Molokini.

Band-rumped storm-petrel, *Oceanodroma castro*. Two humeri were recovered in 1984 from the sand dunes immediately west of Smuggler's Cove, and the distal end of a humerus was found in the small lava tube in Ahupu Gulch in 1992. The status of this species in the Hawaiian Islands is unclear, but it probably still breeds on Kaua'i and Hawai'i (Banko et al. 1991). Furthermore, it was reported in the last century from Ni'ihau (Wilson and Evans 1893), and it is known from fossils from O'ahu and Moloka'i (Olson and James 1982b). The specimens mentioned here apparently constitute the first record of the species from Kaho'olawe. Because these birds are extremely recondite on their breeding grounds (no nests or eggs have ever been found in Hawai'i), it cannot necessarily be assumed that the species is extinct on Kaho'olawe, although the great number of cats on the island would certainly preclude its survival in any but the most inaccessible places.

White-tailed tropicbird, *Phaethon lepturus*. Reported from two archaeological sites (Collins 1987). This seabird still occurs on Kaho'olawe.

Nene, *Branta sandvicensis*. Reported from seven archaeological sites (Hommon 1983; Collins 1987). The nene is known historically only from Hawai'i, although fossil finds indicate that it certainly or probably occurred on all the main islands (Olson and James 1991).

Red junglefowl, *Gallus gallus*. This species is a Polynesian introduction known on Kaho'olawe from only two archaeological sites (Hommon 1983; Collins 1987).

Asiatic (Pacific) golden plover, *Pluvialis fulva*. A relatively common migrant to Kaho'olawe reported from a single archaeological site.

Short-eared owl, *Asio flammeus*. A post-Polynesian immigrant to the archipelago that has been reported historically from Kaho'olawe and from three midden sites there (Collins 1987).

Common myna, *Acridotheres tristis*. The distal two-thirds of an ulna of this species were recovered from the small lava tube in Ahupu Gulch. This species was introduced from India to the Hawaiian Islands supposedly in 1865 (Caum 1933) and is generally abundant on the main islands. Forbes (1913:8) included "minas" among the "many birds . . . observed at various times in different localities over" Kaho'olawe in 1913. Stearns (1940:125), presumably based on his own experience in 1939, likewise stated that "the common birds include mynahs" By about 1970, however, the species seems to have been missing as it was not reported by LeBarron and Walker (1971), nor was it seen in 1980 by Conant (1983), and mynas were definitely absent during our week's stay in 1992. Although the earlier reports by non-ornithologists might be questioned, the bone from Ahupu Gulch provides definite proof that *Acridotheres tristis* once occurred on the island. If the earlier populations were well established, it gives one pause to consider that the environment on Kaho'olawe may have become so degraded between 1939 and 1970 that it could not even sustain myna birds.

CONCLUSIONS

The bird bones recovered so far from Kaho'olawe tell us very little about the nature of the pre-human avifauna or environment of the island. Four of the species are seabirds that may all still occur on the island, two are human-introduced species, one is a migrant, and one a recent colonizer from the mainland that also probably still occurs on the island. Only one species, the nene or Hawaiian goose, is an endemic Hawaiian land bird that has become extinct on the island. This species was widespread in the archipelago, and had larger derivatives, possibly separate species, at least on Kaua'i, O'ahu, and Maui (Olson and James 1991). Considering that all forms of the genus were exterminated in the prehistoric period everywhere in the archipelago except Hawai'i, it is hardly surprising that these geese were extirpated from the small island of Kaho'olawe. This is at least one small indication of the level of prehistoric human disturbance with the environment of the island. The complete absence in the historic period of any flightless birds, especially rails, of any native passerines, or of any endemic form of predatory bird, is a strong indication of pervasive human intervention in the ecology of Kaho'olawe.

RECOMMENDATIONS FOR FUTURE RESEARCH

The outlook for recovering further avian remains from Kaho'olawe is pretty bleak. Nevertheless, because **any** material from the island is potentially of great informative value, I make the following recommendations:

1. Archaeological midden. This is still probably the best source of bird bones on Kaho'olawe. Further investigation, to include radiocarbon dating and charcoal identification, of cultural features found *in situ* in sediments of the so-called "Ahupu Formation" is warranted to document the timing and extent of prehistoric environmental changes. All archaeological excavations should be carefully monitored for faunal remains. All sediments from excavations should be passed through screens with mesh **no larger than 1/8 inch** (1/4 inch mesh is **not acceptable** for faunal studies unless used **over** window screen). All bird bones should be submitted as promptly as possible to a qualified expert for identification.
2. Caves and lava tubes. A register should be made of any further lava tubes or other sorts of caves discovered on the island so these can be investigated for their paleontological potential.
3. Sand dunes. Under present conditions, the sand deposits of Kaho'olawe are unlikely to produce any significant amount of bone. However, any of these sites could contain important fossils. Any kind of construction, or violent storms that move significant amounts of sand in the dune areas noted above should be carefully monitored for bird bones.

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APPENDIX D

SCOPE OF WORK

1. Perform literature search for reports of rare, endangered, or threatened plant and animal species known to occur on the island.
2. Contact experts within the scientific community for additional information on known rare, endangered, or threatened species on the island.
3. Describe and map all rare, endangered, or threatened plant and animal species found during the survey.
4. Field check, describe, and map all intact native natural communities (ecosystems) situated on the island using the Hawai'i Natural Community Classification System developed by the Hawai'i Heritage Program of The Nature Conservancy of Hawai'i.
5. Revisit known locations of rare, endangered, or threatened plant and animal species and update their current status if observed during the field survey.
6. Update the biologically significant findings in the existing Hawai'i Heritage Program computer database to allow for a standardized repository for the resource.

PRODUCTS TO BE DELIVERED

1. Final report on the findings of the literature search, interviews, previous studies, and field reconnaissance; survey methodology; the significance, distribution, and condition of the plant and animal communities, and rare, endangered, and threatened species; and a bibliography of references. Maps (8.5" x 11") included in the report will show: general project area, specific surveyed areas and survey routes, locations of rare native plants, animals, and native natural communities occurring within the study area. Appendices will include all vascular plant species and animal species observed during the survey.
2. Six copies (blackline) of USGS quad maps documenting the locations of rare species and natural communities known or observed in the study area.

3. One notebook containing:

- a. Map keys listing the rare species and natural communities located within the study area.
- b. Site-specific computer database records summarizing the available information for each rare species or natural community reported within the study area.
- c. A hard copy of the computerized database records for each location of rare plant, animal, or natural community in the study area.
- d. References for published and unpublished sources used in this report.

APPENDIX E
LIST OF PREPARERS

Hawai'i Heritage Program

Coordinator

Joannie C. Dobbs *

Science Director/Ecologist

Samuel M. Gon III

Biological Staff

Theresa A. Cabrera (Associate Biologist)

Botanical Staff

Joan M. Yoshioka (Botanist)

Joel Q.C. Lau (Botanist, Hawai'i Specialist)

Gail S. H. Chun (Associate Botanist)

Ecological Staff

William G. Garnett III (Associate Ecologist)

Zoological Staff

Luciana Honigman (Zoologist)

Daniel G. Zevin (Associate Zoologist)

Production Staff

Wendy Fulks (Science Editor)

Roy S.Y Kam (Database Manager)

Dwight H. Matsuwaki (GIS Coordinator/Cartographer)

* No longer on staff

APPENDIX F

BIOGRAPHIES OF RESEARCH TEAM

Principle Investigators:

Joannie C. Dobbs, Hawai'i Heritage Program, Coordinator

B.S. (Nutrition), Michigan State University, Michigan, 1971

Ph.D. (Comparative Nutrition), University of California,

Davis, 1983. Areas of concentration: Ornithology;

Physiology and Physiological Chemistry.

Postdoctoral fellow. (Zoology), University of the

Witwatersrand, South Africa. Area of concentration:

Population dynamics of Cape vultures.

Over 10 years of wildlife research and 5 years of consulting experience with an emphasis on avian population studies, biological surveys, toxicological identification and analyses, and oil pollution research.

Heritage Coordinator, May 1990 to February 1992; other

Heritage administrative positions since 1989.

Samuel M. Gon III, Hawai'i Heritage Program, Science

Director/Ecologist

B.A. (Zoology), University of Hawai'i, Manoa, 1978

M.A. (Zoology), University of California, Davis, 1979

Ph.D. (Animal Behavior), University of California, Davis, 1985

Areas of concentration: Ecology, Evolution, Invertebrate Biology.

Over 15 years experience in Hawaiian ecology and natural history, including surveys of mammals, forest birds, terrestrial and aquatic invertebrates, native plants, and terrestrial and aquatic natural communities. Received training in U.S. Fish and Wildlife Service (USFWS) Hawaiian forest bird identification. Published scientific articles on systematic botany, ornithology, mammalogy, entomology, invertebrate ecology and behavior, arachnology, and biodiversity.

Science Director/Ecologist since 1991, Heritage Ecologist since August 1986.

Gail S.H. Chun, Hawai'i Heritage Program, Associate Botanist

B.A. (Biology), University of Hawai'i, Manoa, 1986

M.S. (Botany), University of Hawai'i, Manoa, 1990

Areas of concentration: Phycology and Marine Ecology.

Over 6 years experience in terrestrial and marine Hawaiian plant ecology and taxonomy, including extensive field work in inshore marine ecosystems.

Heritage Botanical Research Assistant, August 1990 to October 1991.
Heritage Associate Botanist, November 1991 to present.

Archaeologist:

Rowland B. Reeve, Archaeologist
M.A. (Archaeology), Institute of Archaeology, University of London.

Mr. Reeve has been involved with and visited the island of Kaho'olawe off and on for the past ten years. Mr. Reeve has worked on archaeological projects in Europe, Central and South America, Australia, Southeast Asia, and the Pacific.

Biologist:

Theresa A. Cabrera, Hawai'i Heritage Program, Associate Biologist
B.A. (Ecology, Behavior, and Evolution), University of California, San Diego, 1988

Previous seasonal fieldwork with the Peregrine Fund, The Greater Yellowstone Ecosystem Bald Eagle Research Team, and Ano Nuevo State Reserve. Received USFWS training in Hawaiian forest bird identification.

Heritage Botanical Research Assistant, October 1990 to October 1991.

Heritage Associate Biologist, November 1991 to present.

Botanists:

Joel Q.C. Lau, Hawai'i Heritage Program, Botanist, Hawai'i Specialist
B.S. (Horticultural Science), University of Hawai'i, Manoa, 1983

Over 12 years of experience in Hawaiian botany, including field experience on all the major Hawaiian Islands, propagation of native Hawaiian plants, and significant plant specimen contributions to museum collections.

Botanist, Hawai'i Specialist since 1990, other Heritage botanical positions since 1986.

Steven P. Perlman, Hawai'i Plant Conservation Center, Field Botanist
B.S. (Botany and Horticulture), University of Hawai'i, Manoa (including graduate studies in botanical taxonomy)

Interests in native Hawaiian plants and floras of Polynesia. Has done field work in Hawai'i, Fiji, and French Polynesia.

Currently working with Hawaiian rare and endangered plants in a cooperative project with the State of Hawai'i Division of Forestry and Wildlife and the National Tropical Botanical Garden.

National Tropical Botanical Garden, Nurseryman and Field Collector, 1972-1982.

Hawai'i Heritage Program Botanical Research Assistant, 1985 to 1990.

Hawai'i Plant Conservation Center of the National Tropical Botanical Garden, Kaua'i, Field Collector, 1990 to present.

Kenneth R. Wood, Hawai'i Plant Conservation Center of the National Tropical Botanical Garden, Field Botanist
B.S. (Botany), State University of New York, Oswego, 1976

Over 9 years experience as an arborist. Has done botanical field surveying and collection throughout the state of Hawai'i. Over 5 years of experience in rare plants and seed collecting, specializing in rough terrain and cliff habitat botanical surveys.

National Tropical Botanical Garden, Head Arborist, 1983-1986.
Grove Farm, Head Arborist, 1987 to present.

National Tropical Botanical Garden, Assistant Collector, 1987 to present.

Hawai'i Plant Conservation Center of the National Tropical Botanical Garden, Field Botanist, 1989 to present.

Joan M. Yoshioka, Hawai'i Heritage Program, Botanist
B.A. (Botany), University of Hawai'i, Manoa, 1986

Over 10 years of experience in the study of Hawai'i's natural history including 5 years in the field of geology and over 3 years of extensive research on the conservation and management of natural resources (botanical, ornithological) at Hawai'i Volcanoes National Park. One and a half years experience as listing botanist with the U.S. Fish and Wildlife Service. Heritage Botanist, January 1992 to present.

Ecologists:

Stefanie G. Aschmann, U.S. Navy, Facilities Engineering Command, Soil Conservationist

B.A. (Biological Sciences), University of California, Davis

M.S. (Forest Biology), University of Washington, Seattle

Ph.D. (Agronomy), University of Maryland, College Park

Over 16 years experience in natural resources management and conservation. Dr. Aschmann has been the staff soil conservationist for the Pacific Division, Naval Facilities Engineering Command since October 1988.

William G. Garnett III, Hawai'i Heritage Program, Associate Ecologist
Training in Botany, Mycology, and Horticulture.

Over 10 years of field botany experience in Hawai'i, California, Mexico, and the Mascarene Islands, specializing in insular plant collections.
Waimea Arboretum and Botanical Gardens, Superintendent of Collections, 1985 to 1992.
Heritage Associate Ecologist, January 1992 to present.

Malacologist:

R. Michael Severns, Malacologist
B.A. (Biology), University of Hawai'i, Hilo, 1978

Over 15 years experience in studying Hawaiian land snails, Mr. Severns has done research on several snail genera. From 1979 to present, he has been conducting a systematic search on the island of Maui in an effort to record exact locations of all of Maui's *Partulina* snail colonies. Since 1982, Mr. Severns has assisted the Smithsonian Institution in locating fossil bird sites and collecting fossil snail material.

Production:

Wendy Fulks, Hawai'i Heritage and Stewardship Program, Science Editor
B.S. (Biology), Davidson College, 1986
M.S. (Zoology), University of Georgia, 1989
Areas of Concentration: Behavioral/Population Ecology, Arachnology

Three years of full-time experience editing and writing scientific material. Other work: field surveys of wood storks; field research on overwintering sparrows; field research on the behavioral ecology of spiders.
Heritage and Stewardship Program Science Editor, August 1992 to present.

Roy S.Y. Kam, Hawai'i Heritage Program, Data Manager
B.A. (Geography), University of Hawai'i, Manoa, 1988
Areas of Concentration: Environmental Geography and Planning.

Over 4 years experience in data base management including data analysis, computer programming and training, and report production.
Heritage Data Manager, May 1990 to present; other Heritage positions since 1988.

Dwight H. Matsuwaki, Hawai'i Heritage Program, Geographic Information System Coordinator/Cartographer
B.A. (Geography), University of Hawai'i, Manoa, 1990
Areas of Concentration: Cartography and Computer Science.

Over 4 years cartographic experience. Over 1 year experience in computer mapping.

Heritage Conservation Intern, May 1989 to October 1990.

Heritage Data Technician/Cartographer, October 1990 to October 1991.

Heritage GIS Coordinator/Cartographer, November 1991 to present.

Protect Kaho'olawe 'Ohana Representative:

Dan Holmes, Protect Kaho'olawe 'Ohana

Mr. Holmes has visited the island of Kaho'olawe more than 40 times since 1987. Extensive involvement with conservation efforts on Kaho'olawe has given Mr. Holmes an increasing familiarity with the island's flora and fauna as well as its cultural history. He is currently Project Manager of the Kaho'olawe Restoration Project, a conservation project of the Protect Kaho'olawe Fund.

Zoologists:

Luciana Honigman, Hawai'i Heritage Program, Zoologist

B.A. (Biology), University of California, Santa Cruz, 1985

M.S. (Marine Sciences), University of California, Santa Cruz, 1988

Areas of Concentration: Biology, Natural History, Evolution, Behavioral Ecology, and Wildlife Conservation.

Over 8 years experience in behavioral ecology, wildlife biology, and conservation.

Over 4 years experience in Hawaiian natural history, zoology, and conservation, including surveys of marine mammals, forest birds, and aquatic fauna. Received USFWS training in Hawaiian forest bird identification.

Zoologist, January 1989 to present.

Craig Rowland, U.S. Fish and Wildlife Service, Zoologist

B.A. (Zoology), University of Hawai'i, 1985

Over 7 years experience in wildlife management. Mr. Rowland is currently the Assistant Manager for the Pacific/Remote Islands National Wildlife Refuge Complex for the U.S. Fish and Wildlife Service. Mr. Rowland is also actively involved in the Wildlife Society, Hawai'i Audubon Society, and the Sierra Club, Hawai'i Chapter.

Storrs Lovejoy Olson, National Museum of Natural History,
Smithsonian Institution, Curator of Birds
B.A. Florida State University, 1966
M.S. Florida State University, 1968
Sc.D. Johns Hopkins University, 1972

Extensive fieldwork in ornithology (including paleontology) in the South Atlantic, West Indies, Panama, Bermuda, Japan and elsewhere. Conducted work on fossil birds, in conjunction with Helen F. James in Hawai'i nearly every year since 1976.

Curator of Birds, Dept. of Vertebrate Zoology, Smithsonian Institution, Washington, D. C. (1975 to present).

Daniel G. Zevin, Hawai'i Heritage Program, Associate Zoologist
B.S. (Wildlife Management), Humboldt State University,
California, 1988
Areas of Concentration: Endangered Species Management and Conservation.

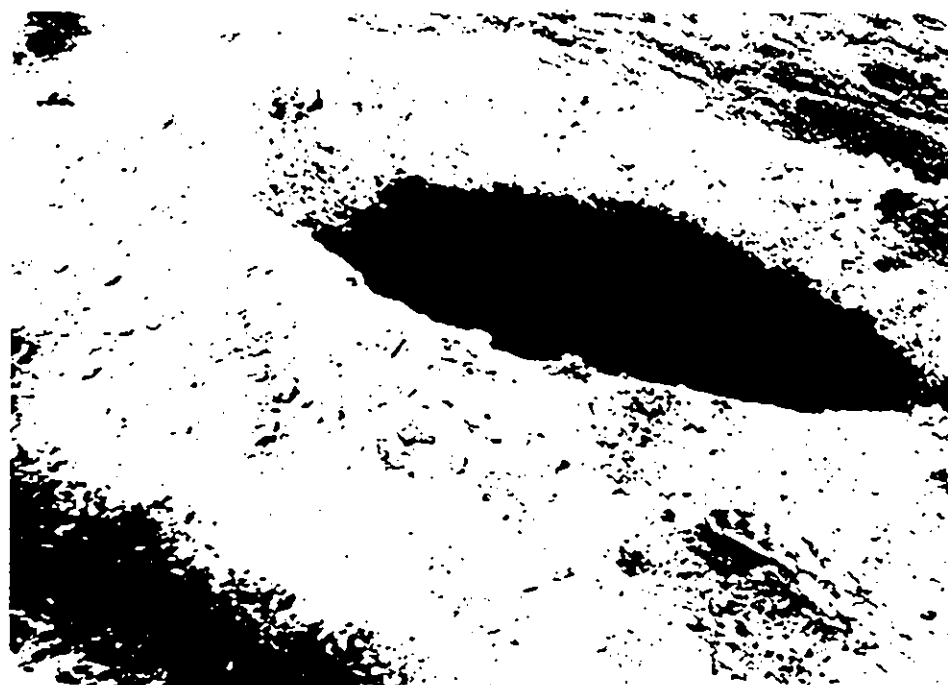
Over 8 years experience in ornithology/mammalogy and ethology, including behavioral and field work for the California Condor Recovery Plan and the Los Angeles Zoo Research Department. Received USFWS training in Hawaiian forest bird identification.

Heritage Zoological Research Assistant, July 1990 to October 1991.

Heritage Associate Zoologist, November 1991 to present.

APPENDIX G

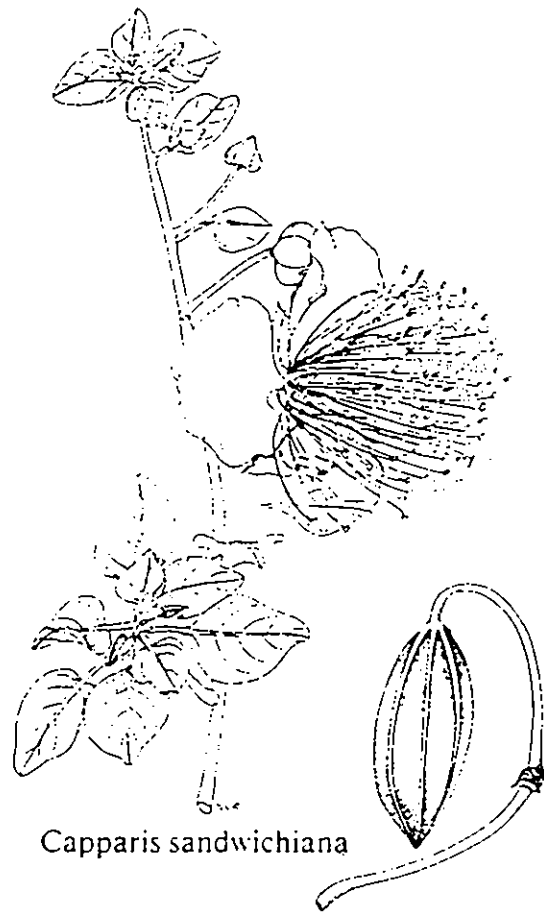
PHOTOS AND DRAWINGS OF SIGNIFICANT NATURAL COMMUNITIES, PLANTS
AND ANIMALS RECORDED FROM KAHO'OLAWA ISLAND



High Salinity Lava Anchialine Pool. Photo by Samuel Gon III.



Ha'o (Hawaiian cotton) Coastal Dry Shrubland. Photos by Gail Chan.



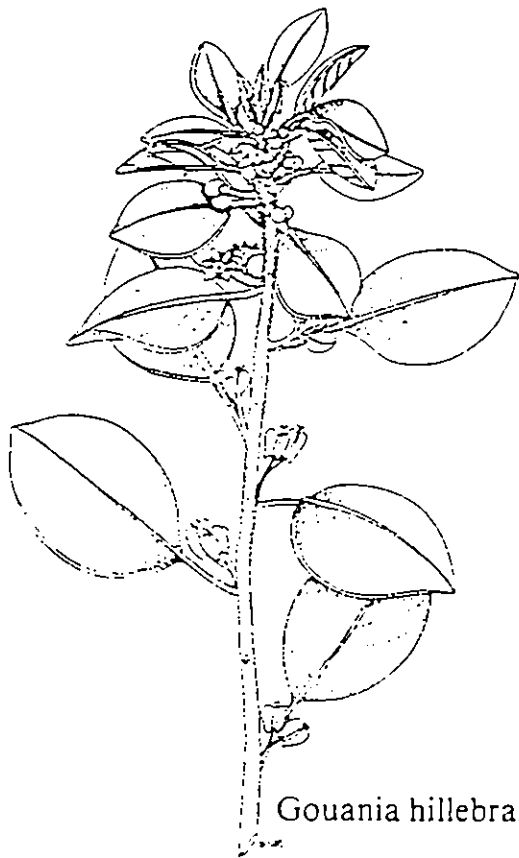
Capparis sandwichiana



Pua pilo (*Capparis sandwichiana*). Drawing reprinted from Manual of the Flowering Plants of Hawaii (Wagner, Herbst and Sohmer 1990) with permission from the Bishop Museum Press. Photo by Richard Kanayama.



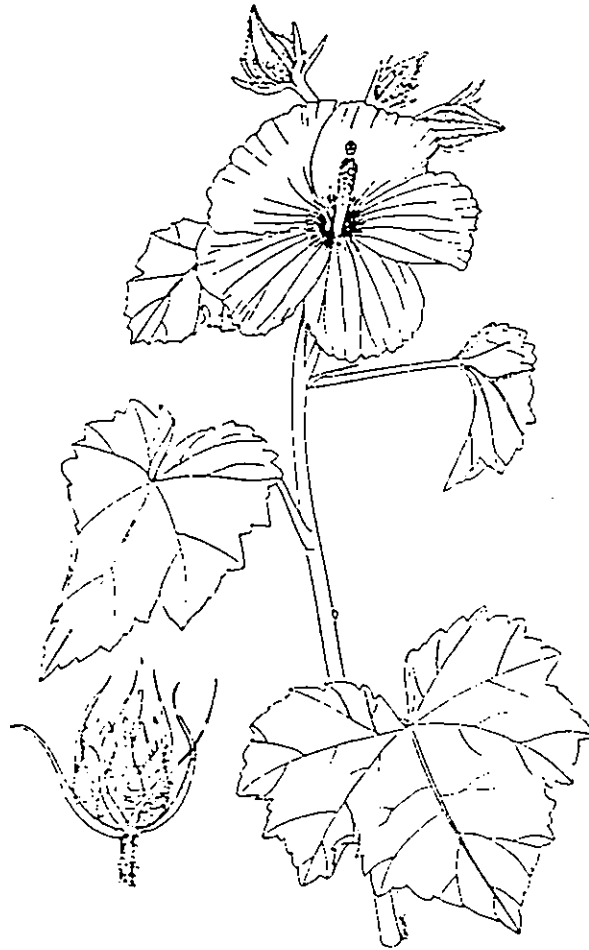
Fabaceae sp. nov.? Photos by Kenneth Wood.



Gouania hillebrandii



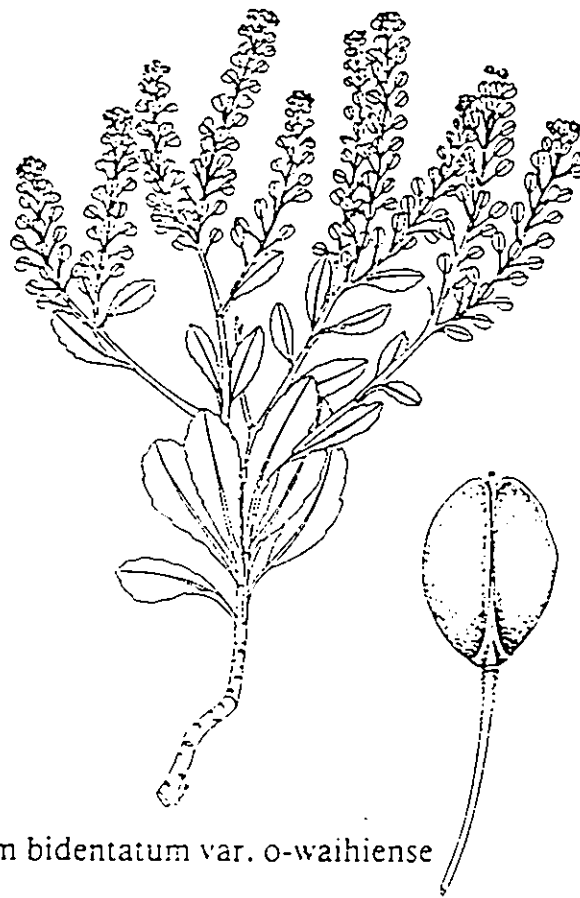
Gouania hillebrandii. Drawing reprinted from Manual of the Flowering Plants of Hawaii (Wagner, Herbst and Sohmer 1990) with permission from the Bishop Museum Press. Photo by Marie Brueggemann.



Hibiscus brackenridgei subsp. *brackenridgei*



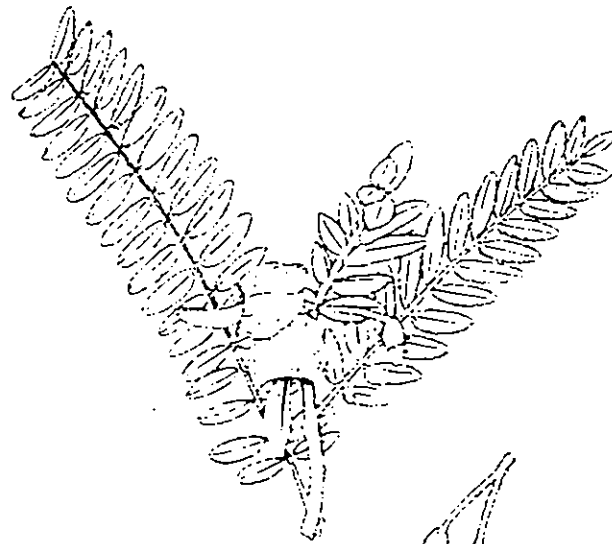
Ma'o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*).
Drawing reprinted from Manual of the Flowering Plants of Hawaii
(Wagner, Herbst and Schner 1990) with permission from the Bishop
Museum Press. Photo by Kenneth Nagata.



Lepidium bidentatum var. *o-waihiense*



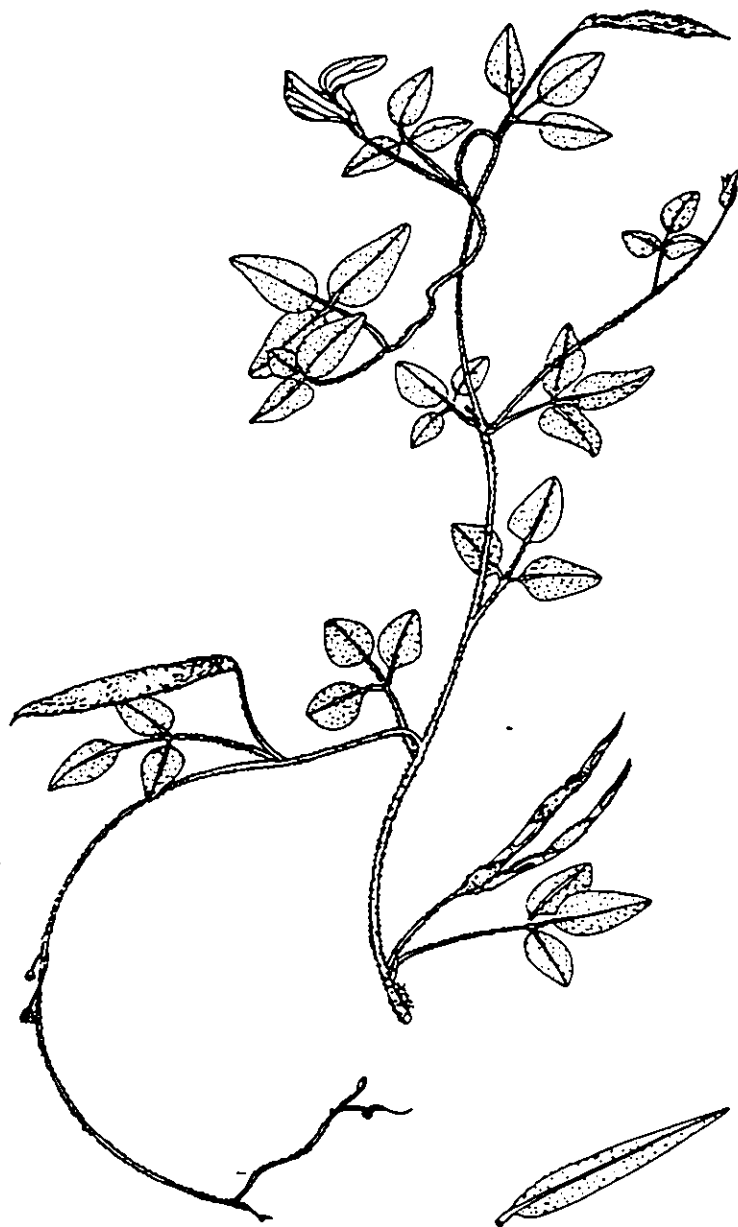
'Anaanau (*Lepidium bidentatum* var. *o-waihiense*). Drawing reprinted from Manual of the Flowering Plants of Hawaii (Wagner, Herbst and Sohmer 1990) with permission from the Bishop Museum Press. Photo by The Nature Conservancy of Hawaii.



Sesbania tomentosa



'Chai (*Sesbania tomentosa*). Drawing reprinted from Manual of the Flowering Plants of Hawaii (Wagner, Herbst and Sohmer 1990) with permission from the Bishop Museum Press. Photo by Derral Herbst.



Vigna o-wahuensis

Vigna o-wahuensis. Drawing reprinted from Manual of the Flowering Plants of Hawaii (Wagner, Herbst and Sohmer 1990) with permission from the Bishop Museum Press.



Pueo, short-eared owl, or Hawaiian owl (*Asio flammeus sandwichensis*). Photo by David Boynton.



Honu, or green turtle (*Chelonia mydas*). Photo by Stewart I. Fefer.



'Ope'ape'a, or Hawaiian hoary bat (*Lasiurus cinereus semotus*).
Photo by Jack Jeffery.



'Ilio holo i ka uaua, or Hawaiian monk seal (*Monachus schauinslandi*). Photo by Bruce Eilerts.



'Ua'u, or Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*). Photo by Robert J. Shallenberger.