
**DRAFT ENVIRONMENTAL ASSESSMENT (DEA)
FOR THE
MAUNA KEA COMPREHENSIVE MANAGEMENT PLAN (CMP)
COVER SHEET**

Proposing/Approving Agency:	University of Hawai'i
Location of the Proposed Action:	Lands leased by the University of Hawai'i from the Board of Land and Natural Resources (BLNR) on Mauna Kea, Hamakua District, Island of Hawai'i
Title of the Proposed Action:	Approval of the <i>Mauna Kea Comprehensive Management Plan</i> (CMP)
Description of the Proposed Action:	<p>The University of Hawai'i (UH) proposes to seek approval of the CMP to achieve effective management of natural and cultural resources within leased State lands located in a Conservation District (the UH Management Areas).</p> <p>The CMP provides a management framework for UH to address existing and future astronomical, recreational, commercial, scientific research and cultural activities in the UH Management Areas. It identifies measures to enhance public participation in the management process. The CMP, once approved by the BLNR, will be the guiding management plan for University decisions. All activities within the UH Management Areas will have to be consistent with the provisions of the CMP, as well as with applicable provisions of the Conservation District Use regulations and other laws and regulations.</p>
Anticipated Determination:	Based on the information contained in this DEA, UH has determined that the proposed action will not have a significant impact on the environment. Accordingly, it anticipates issuing a Finding of No Significant Impact for the proposed action.
For Further Information Contact:	Pacific Consulting Services, Inc. 720 Iwilei Road, Suite 424 Honolulu, Hawai'i 96817

EXECUTIVE SUMMARY

This Draft Environmental Assessment (DEA) has been prepared to identify and evaluate the environmental effects associated with approval and implementation of the *Mauna Kea Comprehensive Management Plan* (CMP). The CMP provides a management framework for the University of Hawai'i (UH or the University) to manage existing and future activities and uses on the State Conservation lands that the University has under lease and easement from the Board of Land and Natural Resources (BLNR).

Regulatory Authority and Processes

This DEA is being submitted by the University in accordance with requirements in Hawai'i Revised Statutes (HRS) Chapter 343 and Hawai'i Administrative Rules (HAR) Chapter 11-200.

Extensive community consultation occurred during the development of the CMP to incorporate the views and ideas of various stakeholders into that document. This included more than 150 individual and small talk story sessions, two series of public meetings in Hilo, Waimea and Kona, two presentations to the BLNR, the establishment of a CMP website, *kupuna* workshops and other outreach. This DEA is being made available to the public, as well as to appropriate governmental agencies, for review and comment in accordance with the provisions of HAR Chapter 11-200. Section 8 of this DEA provides further information for any individual or organization wishing to submit comments regarding this assessment. Depending upon the ultimate resolution of any comments that are received during the review period, the University will either issue a Finding of No Significant Impact or an Environmental Impact Statement Preparation Notice.

Location, Environment and Land Uses

The CMP will be used in managing lands leased by the University from BLNR located on Mauna Kea in the Hamakua District of Hawai'i Island and consisting of the following areas:

- **The Mauna Kea Science Reserve**, an area of 11,288 acres encompassing the summit of Mauna Kea; the Science Reserve includes the 525 acre Astronomy Precinct;
- **The Mid-Level Facilities at Hale Pōhaku**, an area of 19.3 acres on the south slope of Mauna Kea that includes the Onizuka Center for International Astronomy, the Visitor Information Station, and construction laborer camp, comprised of two old buildings and four modern cabins; and
- **A Portion of the Summit Access Road**, including the stretch between the Mid-Level Facilities and the Science Reserve, as well as a buffer around the road, totaling 723 acres.

These areas are collectively referred to as the UH Management Areas. They encompass an area rich in natural and cultural resources, and host a range of activities and uses.

Mauna Kea is a dormant volcano that rises 13,796 feet above sea level and includes a wide variety of ecosystems on its slopes. The UH Management Areas begin at approximately 9,200 feet above sea level and extend to the summit. Many unique species occur in the subalpine and alpine ecosystems of Mauna Kea, and there are several Federal and/or State protected species that may exist now, or in the future, within UH Management Areas.

Native Hawaiian traditions state that ancestral *akua* (gods, goddesses, deities) reside within the mountain summit area. These personages are embodied within the Mauna Kea landscape – they are believed to be physically manifested in earthly form as various *pu`u* (hills) and as the waters of Lake Waiau. Because these *akua* are connected to the Mauna Kea landscape in Hawaiian genealogies, and because elders and *akua* are revered and looked to for spiritual guidance in Hawaiian culture, Mauna Kea is considered a sacred place.

Mauna Kea is still a focus of many traditional and customary Native Hawaiian cultural practices and beliefs. It is a source of inspiration and object of reverence for many Hawaiians. Ongoing cultural practices involving Mauna Kea include *kūahu* (family shrine) erection, the scattering of cremation remains, *piko* deposition, traditional gathering, pilgrimage, offerings, and prayer.

Within the boundaries the UH Management Areas, two areas have been listed as Traditional Cultural Properties by the State Historic Preservation Division, and 223 historic properties have been identified, including 147 ancient shrines.

Mauna Kea's unique setting, resources and beauty make it a popular recreation and tourism destination. Approximately 270 visitors per day ascend the mountain for sightseeing, hiking and amateur astronomy. Many are brought by guided commercial tours while some visit in personal vehicles. During periods when the summit is snow covered, visitors are drawn to Mauna Kea to sled, ski, snow board, and enjoy the unique conditions. Up to 1,400 vehicles at a time have been recorded in the summit area during heavy snowfalls.

Mauna Kea is also the world's foremost location for astronomical observation and research. It is the site of 13 observatories, constructed between 1968 and 2002. The observatories contribute extensively to the advancement of science worldwide, provide valuable teaching and research resources for the University, and employs 610 local residents at the summit and at other facilities within the State.

Current Status and Proposed Action

Originally part of the DLNR Forest Reserve system, the Science Reserve was created in 1968 to allow the University to site the first observatory on the summit for use in its teaching and research programs. However, no division within DLNR has jurisdiction over the Science Reserve, nor are there any DLNR rules managing activities or access within the Science Reserve. The ready access to Mauna Kea facilitated by the construction of the Summit Access Road led to rapid growth in cultural, recreational and research activities occurring in the Science Reserve and surrounding areas. In the absence of rules controlling access or activities, a succession of plans were developed in an effort to deal with these varied, and sometimes conflicting, activities and uses.

Current responsibility for managing the natural and cultural resources on UH Management Areas is a divided among several State departments, divisions and offices. The Office of Mauna Kea Management (OMKM) was created in 2000 and charged with the day to day management of the natural, cultural, and recreational resources within the UH Management Areas.

The CMP will replace the current management plan approved by the DLNR in 1995. The overarching goal of the CMP is to provide management strategies that protect, preserve and enhance Mauna Kea's cultural and natural resources. The CMP adopts many of the controls contained in the 1995 *Revised Management Plan for the UH Management Areas on Mauna Kea*, which is the current management plan for those areas. The CMP also identifies additional Management Actions and makes specific recommendations in compliance with the Hawai'i Supreme Court's decision in *Ka Pa`akai O Ka'Aina v. Land Use Commission*, to be pursued to improve the protection afforded cultural and natural resources within the UH Management Areas. The CMP addresses current uses and activities occurring in the UH Management Areas and creates a management framework for improving resource management and protection on Mauna Kea. One of the Management Actions is that the University will seek rule-making and enforcement authority from the Hawai'i Legislature to allow it to implement components of the CMP.

Environmental Impacts of the CMP

For the following reasons, this DEA finds that the actions proposed in the CMP will not have a significant effect on the environment:

- (1) The majority of the specific measures presented in the CMP (88 of the 103 Management Actions) consist of goals, communication approaches, studies, plans and management processes. Those activities have only positive environmental effects, owing to the nature of the actions that would result from their implementation.
- (2) The remaining 15 Management Actions and some of the controls adopted from the current management plan do have some potential to affect the environment, but evaluation of their effects shows that they are minor and insignificant and include:
 - Minor, long-term visual impacts associated with the placement of new signage in relatively undeveloped landscapes.
 - Minor increases in vehicle traffic resulting from potential increases in UH staffing, resulting in minor to insignificant increases in: (1) traffic and motor vehicle air emissions, (2) solid waste generation rates, (3) domestic wastewater generation rates, (4) potable water use and (5) transient sound levels.

Measures described in this DEA will help to mitigate these potential environmental effects.

The Proposed Action is anticipated to result in positive long-term effects on cultural resources, biological resources, the visual environment and socio-economic conditions, as adoption and implementation of the CMP will provide management controls that will serve to protect, preserve and enhance the natural and cultural resources on Mauna Kea.

ACRONYMS AND ABBREVIATIONS

BLNR	Board of Land and Natural Resources
C	Centigrade
CatEx	Categorical Exclusion
CCC	Civilian Conservation Corps
CDUA	Conservation District Use Application
CFHT	Canada-France-Hawai'i Telescope
CFR	Code of Federal Regulations
CIA	Cultural Impact Assessment
CMP	Comprehensive Management Plan
CSO	Caltech Submillimeter Observatory
CWA	Clean Water Act
CZM	Coastal Zone Management
DEA	Draft Environmental Assessment
DHHL	Department of Hawaiian Home Lands
DLNR	Hawai'i Department of Land and Natural Resources
DOCARE	Division of Conservation and Resource Enforcement
DOFAW	Division of Forestry and Wildlife
DOH	Hawai'i Department of Health
e.g.	for example
EIS	Environmental Impact Statement
EISPN	Environmental Impact Statement Preparation Notice
EPA	U.S. Environmental Protection Agency
et al.	and others
F	Fahrenheit
FC	Federal Candidate for listing
FE	Federally Endangered
FEIS	Final Environmental Impact Statement
FONSI	Finding of No Significant Impact
FSOC	Federal Species of Concern
ft	foot, feet
FT	Federally Threatened
fte	Full time equivalent
FWPCA	Federal Water Pollution Control Act
gal	gallon(s)
gpd	gallons per day
ha	hectare
HAR	Hawai'i Administrative Rules
HRS	Hawai'i Revised Statutes
HSOC	Hawai'i State Species of Concern
IfA	Institute for Astronomy
IRTF	Infrared Telescope Facility
JCMT	James Clerk Maxwell Telescope
m	meter
MKMB	Mauna Kea Management Board
MKSS	Mauna Kea Support Services
mm	millimeter
NAR	Natural Area Reserve

ACRONYMS AND ABBREVIATIONS

NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NGLT	Next Generation Large Telescope
NHPA	National Historic Preservation Act
NPS	National Park Service
NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWS	National Weather Service
OCCL	Office of Conservation and Coastal Lands
OMKM	Office of Mauna Kea Management
PTA	Pōhakuloa Training Area
RCRA	Resource Conservation and Recovery Act of 1976
RDP	Research and Development Plan
SC	State Candidate for Listing
SE	State Endangered
SHPED	State Historic Preservation Division
SLIMS	State Land Information Management System
SMA	Smithsonian Submillimeter Array
ST	State Threatened
TCP	Traditional Cultural Property
TMK	Tax Map Key
TMT	Thirty Meter Telescope
UH	University of Hawai'i
UHH	University of Hawai'i at Hilo
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VIS	Visitor Information Station
VLBA	Very Long Baseline Array

TABLE OF CONTENTS

Description	Page
EXECUTIVE SUMMARY	ii
ACRONYMS AND ABBREVIATIONS	vi
1 INTRODUCTION	1-1
1.1 UH MANAGEMENT AREAS	1-1
1.1.1 Mauna Kea Science Reserve	1-1
1.1.2 Hale Pohaku	1-4
1.1.3 Summit Access Road	1-4
1.2 AUTHORITY FOR THE DRAFT ENVIRONMENTAL ASSESSMENT AND REQUIRED PERMITS	1-4
1.2.1 Chapter 343, Hawai'i Revised Statutes (HRS)	1-4
1.2.2 Required Permits for the CMP	1-4
2 PURPOSE AND NEED FOR THE COMPREHENSIVE MANAGEMENT PLAN (CMP)	2-1
2.1 HISTORICAL MANAGEMENT OF THE UH MANAGEMENT AREAS.....	2-1
2.1.1 The University of Hawai'i.....	2-1
2.1.2 1977 DLNR Mauna Kea Plan; 1980 Hale Pōhaku Complex Development Plan	2-1
2.1.3 1982 Research and Development Plan for the Mauna Kea Science Reserve; 1983 Mauna Kea Science Reserve Complex Development Plan	2-1
2.1.4 1985 Mauna Kea Management Plan	2-2
2.1.5 1995 Revised Management Plan for the UH Management Areas on Mauna Kea	2-2
2.1.6 1998 Audit of Management of Mauna Kea and the Mauna Kea Science Reserve	2-3
2.1.7 Mauna Kea Science Reserve Master Plan (2000 Master Plan)	2-3
2.1.8 2000 BLNR Transfer of Commercial Permitting Management to the University.....	2-4
2.1.9 2005 Follow-up Audit of the Management of Mauna Kea and the Mauna Kea Science Reserve	2-4
2.1.10 Outrigger Telescope Project Case	2-4
2.2 NEED FOR THE CMP.....	2-5
2.2.1 Improved Integrated Planning and Management	2-5
2.2.2 Updated Planning Guidance	2-5
2.2.3 Rule-Making Authority	2-6
2.2.4 Community Engagement.....	2-6
2.3 GOALS AND OBJECTIVES OF THE CMP	2-6
2.4 MANAGEMENT AUTHORITY	2-8
2.4.1 University of Hawai'i	2-8
2.4.2 Department of Land and Natural Resources (DLNR).....	2-10
2.5 REGULATORY OVERVIEW OF MAUNA KEA	2-12

TABLE OF CONTENTS

Description	Page
2.5.1 Federal Regulations	2-12
2.5.2 State and Locals Regulations	2-14
3 SUMMARY DESCRIPTION OF THE ACTION.....	3-1
3.1 RESOURCE MANAGEMENT APPROACH	3-1
3.1.1 Principles of Hawaiian Cultural Resource Management	3-1
3.1.2 Adaptive Management	3-2
3.1.2 Ecosystem Management.....	3-2
3.2 CMP MANAGEMENT ACTIONS.....	3-2
3.2.1 Management Action Discussions	3-6
3.2.2 Controls Adopted from the 1995 Management Plans	3-36
4 ALTERNATIVES ANALYSIS	4-1
4.1 DESCRIPTION OF THE PROPOSED ACTION.....	4-1
4.2 DESCRIPTION OF THE NO ACTION ALTERNATIVE	4-1
5 AFFECTED ENVIRONMENT	5-1
5.1 LAND USE	5-1
5.1.1 Regional Land Use.....	5-1
5.1.2 Land Uses in the UH Management Areas.....	5-7
5.2 CULTURAL RESOURCES.....	5-11
5.2.1 Summary of Consulted Source Materials.....	5-12
5.2.2 Historic Properties	5-13
5.2.3 Utilizing the Ka Pa‘Akai Analytical Framework.....	5-20
5.2.4 Hawaiian Cultural and Natural Resource Management Principles.....	5-21
5.3 BIOLOGICAL RESOURCES.....	5-39
5.3.4 Subalpine Flora and Fauna (Hale Pōhaku and Access Road).....	5-41
5.3.4 Alpine Flora and Fauna (Mauna Kea Science Reserve).....	5-42
5.4 VISUAL ENVIRONMENT	5-48
5.5 TRAFFIC	5-50
5.6 AIR QUALITY	5-50
5.7 INFRASTRUCTURE AND UTILITIES	5-52
5.7.1 Communications and Power Supply	5-52
5.7.2 Water.....	5-52
5.8 FLOOD HAZARD	5-52
5.9 GROUND AND SURFACE WATER RESOURCES.....	5-53
5.9.1 Surface Water	5-53
5.9.2 Groundwater.....	5-55
5.9.3 Water Budget Analysis	5-55
5.9.4 Water Quality.....	5-56
5.10 CLIMATE.....	5-56
5.11 GEOLOGY AND TOPOGRAPHY	5-57
5.11.1 Mauna Kea Science Reserve.....	5-60

TABLE OF CONTENTS

Description	Page
5.11.2 Hale Pōhaku.....	5-61
5.11.3 Unique Geologic Features.....	5-61
5.13 HAZARDOUS AND REGULATED MATERIALS.....	5-63
5.12.1 Hazardous Materials and Fuels.....	5-63
5.12.2 Solid Wastes	5-63
5.12.3 Wastewater	5-65
5.13 NOISE	5-66
5.14 SOCIO-ECONOMICS	5-66
6 ENVIRONMENTAL IMPACTS	6-1
6.1 INTRODUCTION.....	6-1
6.2 ACTIONS WITHOUT A POTENTIAL TO SIGNIFICANTLY AFFECT THE ENVIRONMENT.....	6-1
6.2.1 Planning and Studies	6-1
6.2.2 Communications.....	6-4
6.2.3 Management Processes and Goals	6-5
6.2.4 Recommended Management Actions with Some Potential to Affect the Environment	6-8
6.3 IMPACT LAND USE.....	6-9
6.3.1 Proposed Alternative's Effects on Land Use	6-9
6.3.2 No Action Alternative's Effect on Land	6-9
6.4 IMPACTS CULTURAL RESOURCES	6-10
6.4.1 Proposed Action	6-10
6.4.2 No Action Alternative's Effects on Cultural Resources.....	6-14
6.5 IMPACTS BIOLOGICAL RESOURCES.....	6-15
6.5.1 Proposed Action's Effect on Biological Resources.....	6-15
6.5.2 No Action Alternative's Effect on Biological Resources	6-17
6.6 IMPACTS VISUAL ON ENVIRONMENT.....	6-17
6.6.1 Proposed Action's Effect on the Visual Environment	6-17
6.6.2 No Action Alternative's Effect on the Visual Environment	6-18
6.7 IMPACTS ON TRAFFIC.....	6-18
6.7.1 Proposed Action's Effect on Traffic	6-18
6.7.2 No Action Alternative's Effect on Traffic	6-18
6.8 IMPACT ON INFRASTRUCTURE AND UTILITIES	6-18
6.8.1 Proposed Action's Effect on Infrastructure and Utilities	6-18
6.8.2 No Action Alternative's Effect on Infrastructure and Utilities	6-19
6.9 IMPACT ON FLOOD HAZARD	6-19
6.9.1 Proposed Action	6-19
6.9.2 No Action Alternative.....	6-19
6.10 IMPACTS ON GROUNDWATER AND SURFACE WATER RESOURCES	6-19
6.10.1 Proposed Action	6-19
6.10.2 No Action Alternative.....	6-19
6.11 IMPACTS ON GEOLOGY AND TOPOGRAPHY.....	6-19
6.11.1 Proposed Action	6-19
6.11.2 No Action Alternative.....	6-20

TABLE OF CONTENTS

Description	Page
6.12 IMPACTS ON CLIMATE AND AIR QUALITY	6-20
6.12.1 Proposed Action	6-20
6.12.2 No Action Alternative	6-20
6.13 IMPACTS ON HAZARDOUS MATERIALS, SOLID WASTES AND WASTEWATER ..	6-20
6.13.1 Proposed Action	6-20
6.13.2 No Action Alternative	6-21
6.14 IMPACTS ON NOISE	6-21
6.14.1 Proposed Action	6-21
6.14.2 No Action Alternative	6-21
6.15 IMPACTS ON SOCIO-ECONOMICS.....	6-21
6.15.1 Proposed Action	6-21
6.15.2 No Action Alternative	6-22
6.16.CUMULATIVE IMPACTS.....	6-22
7 ANTICIPATED DETERMINATION	7-1
7.1 PROPOSING AGENCY	7-1
7.2 APPROVING AGENCY.....	7-1
7.3 DESCRIPTION OF THE PROPOSED ACTION.....	7-1
7.4 ANTICIPATED DETERMINATION.....	7-1
7.5 REASONS SUPPORTING THE DETERMINATION.....	7-1
7.6 CONTACT INFORMATION.....	7-2
8 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED	8-1
8.1 Consultation Process	8-1
8.2 Organizations and Individuals Sent Copies of the Draft EA.....	8-7
8.3 Submission of Comments	8-9
9 REFERENCES	9-1
TABLES	
2-1 CMP Management Objectives and Component Plans with Desired Outcomes.....	2-7
3-1 Categorization of Management Actions Recommended in the CMP	3-3
5-1 Mauna Kea Telescopes (2008)	5-8
5-2 Historic Property Types in the UH Management Areas.....	5-14
5-3 List of Federal and State Threatened, Endangered, Candidate and Species of Concern found, or potentially found, at Hale Pōhaku and the Science Reserve	5-40
5-4 Hazardous Materials Used and Stored on UH Management Areas.....	5-64
5-5 Wastewater Treatment and Disposal Systems at MKSR.....	5-65
5-6 Wastewater Treatment and Disposal Systems at Hale Pōhaku	5-66
6-1 CMP Management Actions: Planning and Studies.....	6-2
6-2 CMP Management Actions: Communications-Related	6-4
6-3 CMP Management Actions: Management Processes and Goals	6-5

TABLE OF CONTENTS

Description	Page
6-4 CMP Management Actions Evaluated Individually.....	6-8
8-1 List of Parties Participating in the CMP Process	8-1
8-2 Organizations and Individuals Sent Copies of the Draft EA	8-7

FIGURES

Figure 1-1 Project Location Map.....	1-2
Figure 1-2 UH Management Areas	1-3
Figure 5-1 Existing Facilities-Astronomy Precinct.....	5-2
Figure 5-2 Existing Facilities-Hale Pōhaku	5-3
Figure 5-3 Existing Facilities-Mauna Kea Summit Access Road and Management Corridor .	5-4
Figure 5-4 Land Use	5-5
Figure 5-5 Historic Properties, Traditional Cultural Properties, and Find Spots	5-15
Figure 5-6 Examples of Shrines Identified on UH Managed Land.....	5-17
Figure 5-7 Place Names and Historic Trails	5-35
Figure 5-8 Palila Critical Habitat	5-43
Figure 5-9 Potential Extents of Fern and Lichen Habitat	5-46
Figure 5-10 Wēiku Bug Habitat.....	5-49
Figure 5-11 UH Management Area Roads and Parking Areas.....	5-51
Figure 5-12 Hydrologic Features	5-54
Figure 5-13 Topography and Geologic Features	5-59

1 INTRODUCTION

The University of Hawai'i (UH) will be seeking approval from the Board of Land and Natural Resources (BLNR) for the *Mauna Kea Comprehensive Management Plan* (CMP). Once approved by the BLNR, the CMP will be the controlling management plan for the UH Management Areas (as defined below). The goal of the CMP is to provide management strategies that protect, preserve, and enhance the natural and cultural resources on Mauna Kea that are within the UH Management Areas. The UH Management Areas are classified within the State Land Use Conservation District, and are within the Conservation District resource subzone. Because the UH Management Areas consist of lands owned by the State, and under lease or easement from the BLNR to the University, land uses within the UH Management Areas are regulated by the BLNR, and all activities must be in compliance with not only the terms of the lease or easement, but also with the laws and regulations applicable to Conservation District Lands.

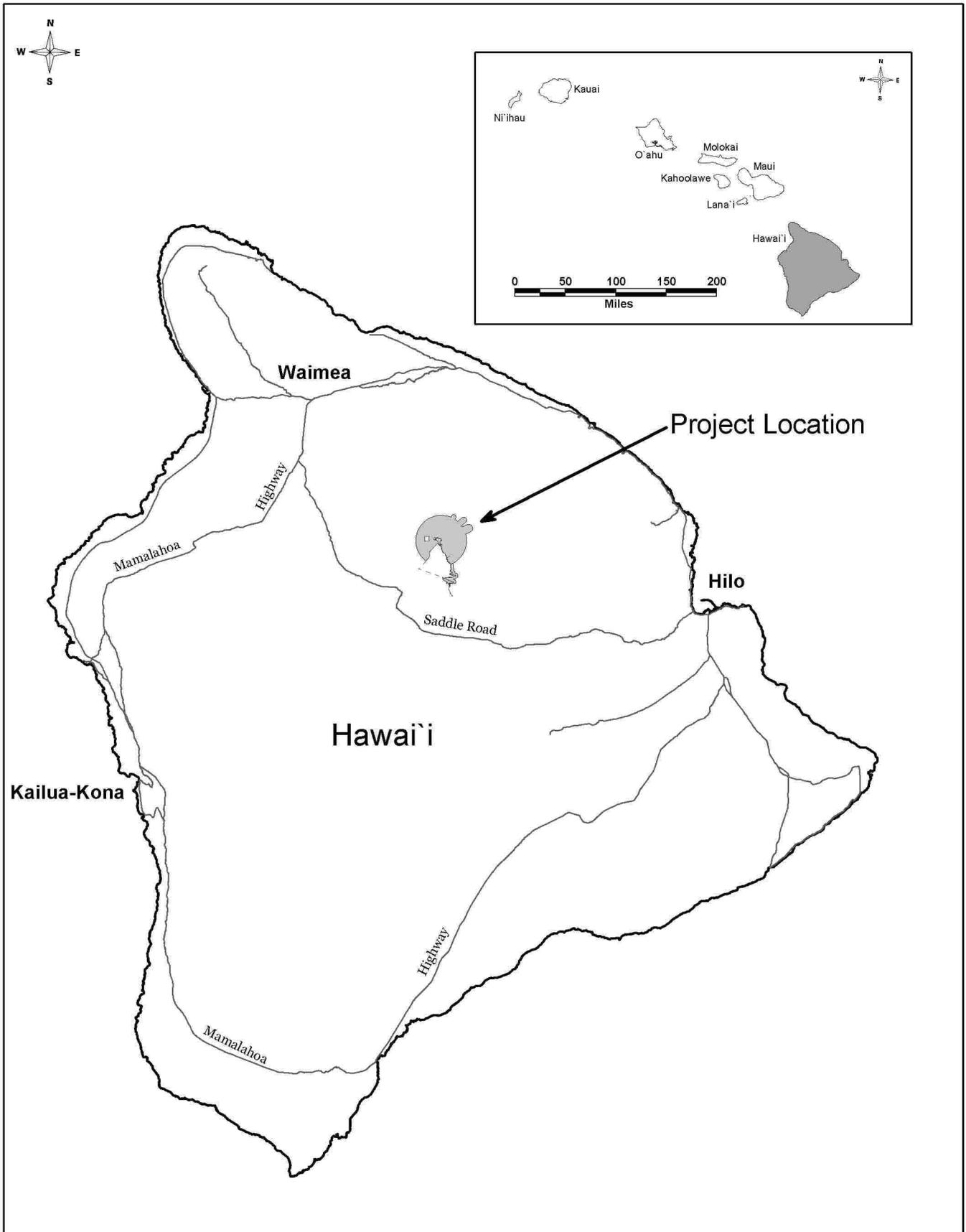
The CMP was developed in part to assist UH, and its designated management entity for the management of Mauna Kea, the Office of Mauna Kea Management (OMKM), to achieve its mission of by fulfilling management responsibilities to "achieve harmony, balance and trust in the sustainable management and stewardship of the Mauna Kea UH Science Reserve through community involvement and programs that protect, preserve and enhance the natural, cultural and recreational resources of Mauna Kea while providing a world-class center dedicated to education, research and astronomy." The CMP will require decision makers to consider multiple land uses and resource values within the UH Management Area prior to allowing any future development.

1.1 UH MANAGEMENT AREAS

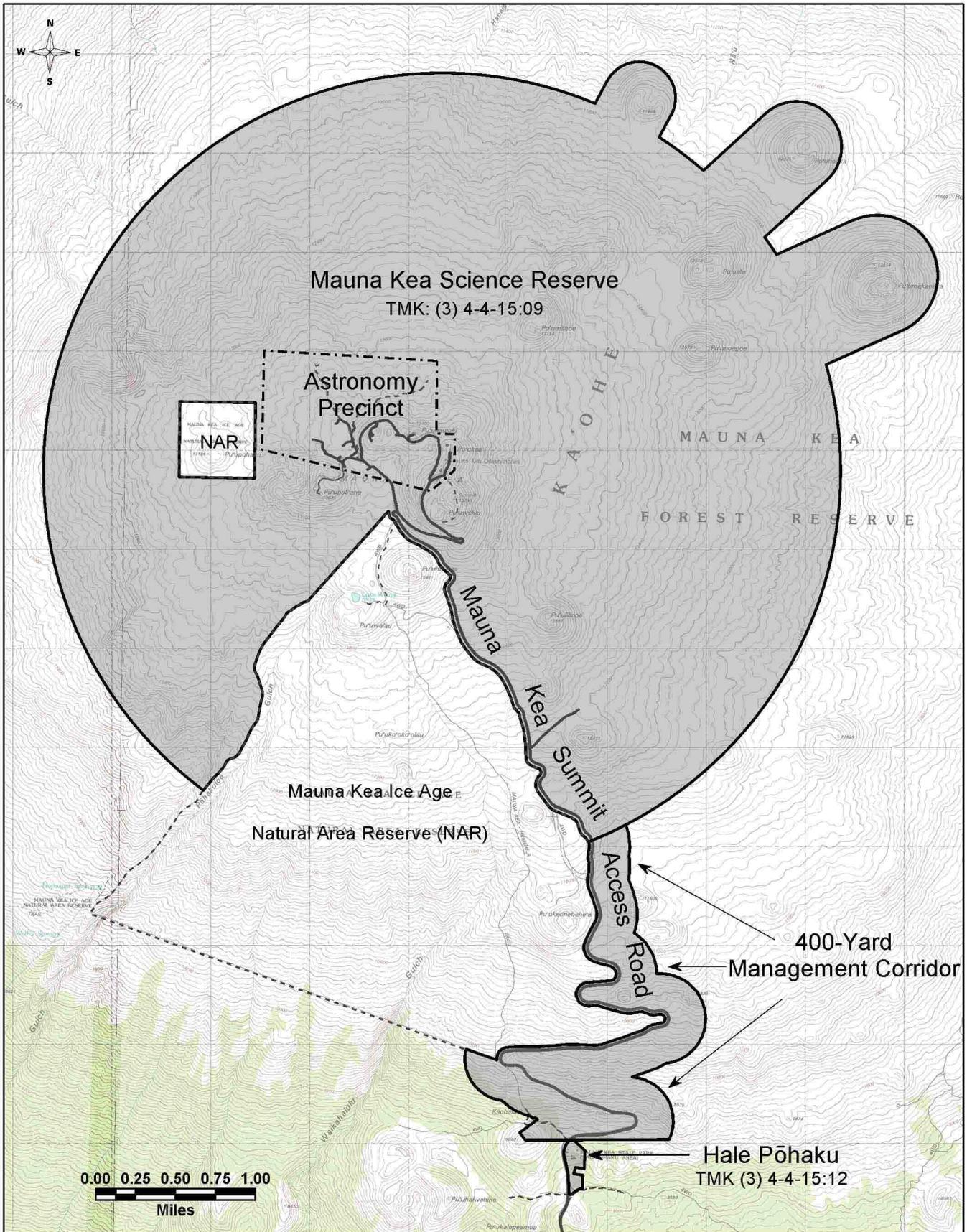
The UH Management Areas consist of three distinct sites: the Mauna Kea Science Reserve, the mid-level facilities at Hale Pōhaku, and the Summit Access Road and associated management corridor. The UH Management Areas begin at approximately 9,200 ft on Mauna Kea and extend to the Summit, at 13,796 ft. Figure 1-1 shows the project location and Figure 1-2 shows the location of the UH Management Areas.

1.1.1 Mauna Kea Science Reserve

The largest of the three areas that constitute the UH Management Areas is the Mauna Kea Science Reserve (TMK: (3) 4-4-15:09), which was established in 1968 through a 65-year lease (General Lease No. S-4191) between the BLNR and the University. Originally, the lease encompassed approximately 13,321 acres, but in 1998, 2,033 acres were withdrawn to be part of the Mauna Kea Ice Age Natural Area Reserve (NAR). The lease now covers 11,288 acres of State land, most of which is above the 11,500 foot elevation. Under the terms of the lease, the land is to be used "as a scientific complex." Under the University's 2000 Master Plan for the UH Management Areas, observatory development was to be limited to a 525-acre Astronomy Precinct within the Science Reserve. The remaining 10,763 acres of the Science Reserve are designated a Natural/Cultural Preservation Area.



Project Location Map



UH Management Areas

1.1.2 Hale Pōhaku

The mid-level facilities at Hale Pōhaku (TMK (3) 4-4-15:12) are located at approximately 9,200 ft elevation and are leased to the University under General Lease No. S-5529. The lease site contains approximately 19.3 acres located on the south slope of Mauna Kea, and houses the Onizuka Center for International Astronomy, the Visitor Information Station (VIS), and a construction laborer camp, which consists of two old buildings and four modern cabins.

1.1.3 Summit Access Road

The third area within the UH Management Areas, the Summit Access Road, extends from Hale Pōhaku to the boundary of the Mauna Kea Science Reserve, at approximately 11,500 ft. Although the Grant of Easement (No. S-4697) includes only the Summit Access Road, the *1995 Revised for the UH Management Areas on Mauna Kea* (1995 Management Plan) added a 400-yard wide corridor on either side of the road, but excluded areas within the adjacent NAR on the western side of the road. The total area of this portion of the Summit Access Road and associated corridor is approximately 723 acres.

1.2 AUTHORITY FOR THE DRAFT ENVIRONMENTAL ASSESSMENT AND REQUIRED PERMITS

The following sections describe the statutory framework for this DEA.

1.2.1 Chapter 343, Hawai'i Revised Statutes (HRS)

This draft environmental assessment (DEA) was prepared for the proposed CMP pursuant to Chapter 343, Hawai'i Revised Statutes (HRS), and the State of Hawai'i Department of Health Title 11-200 (HAR § 11-200) implementing rules for the environmental assessment process.

The University is preparing this DEA for the proposed CMP pursuant to Chapter 343, HRS because the CMP provides management strategies for UH Management Areas.

1.2.2 Required Permits for the CMP

The CMP does not propose any actions that require environmental or land use permits. The CMP will be submitted to the BLNR for approval. The CMP does not authorize any specific land uses within the UH Management Areas. All future development within the UH Management Areas will have to comply with the DLNR Administrative Rules and HRS Chapter 343, as applicable.

2 PURPOSE AND NEED FOR THE COMPREHENSIVE MANAGEMENT PLAN (CMP)

This chapter discusses the purpose of and need for the CMP. It includes a discussion of the goals and objectives of the CMP and an overview of the history of management authority for Mauna Kea.

2.1 HISTORICAL MANAGEMENT OF THE UH MANAGEMENT AREAS

The various management documents, leases, plans and permits applicable to Mauna Kea have created a complex and often confusing pattern of management responsibility, all of which could have the unintended effect of compromising the State's and the University's ability to ensure the ongoing protection of natural and cultural resources at Mauna Kea. Currently there is no mechanism for integrated or coordinated management of Mauna Kea's resources (including lands outside of the UH Management Areas). The CMP provides a mechanism for integrated and coordinated management of Mauna Kea's cultural and natural resources.

2.1.1 The University of Hawai'i

As early as 1909, the summit of Mauna Kea was recognized as a prime site for astronomical observation (Office of the Legislative Auditor 1998). In 1964, researchers from the University of Arizona conducted tests that substantiated earlier opinions that conditions for viewing were exceptional. Also in 1964, Mauna Kea lands were placed within the State's Conservation District, giving management authority to the BLNR. The University established the Institute for Astronomy (IfA) in 1967, and that same year began planning the first of the telescopes at the summit. In June 1968, the University secured a 65-year lease from BLNR for 13,321 acres (5,392 ha) at the summit of Mauna Kea and developed the Mauna Kea Science Reserve. Since 1967 the summit and the Science Reserve have been managed by the University and DLNR.

2.1.2 1977 DLNR Mauna Kea Plan; 1980 Hale Pōhaku Complex Development Plan

In 1977, after two years of planning, study and public hearings, BLNR approved *The Mauna Kea Plan* (DLNR 1977). That plan created five management areas and indicated the management objectives and permitted uses for each. Responsibility for the management and upkeep of the Science Reserve and the astronomy facilities at Hale Pōhaku was assigned to the University. Management and upkeep of the Hale Pōhaku park facilities was assigned to DLNR. Management and upkeep of the Summit Access Road from the Saddle Road to the summit was assigned to the Department of Transportation. The 1977 plan indicated that development of any mid-level facilities at Hale Pōhaku should ensure that the impacts to the surrounding *māmane-naio* forest ecosystem were minimal. The *Hale Pōhaku Mid-Elevation Facilities Master Plan: Complex Development Plan* was prepared in 1980 (Group 70 1980).

2.1.3 1982 Research and Development Plan for the Mauna Kea Science Reserve; 1983 Mauna Kea Science Reserve Complex Development Plan

In 1982 the *Research and Development Plan (RDP) for the Mauna Kea Science Reserve and Related Facilities* was approved by the UH Board of Regents (University of Hawaii Institute for

Astronomy 1981). This plan was created as a programmatic master plan for the continued development of the Science Reserve (Office of the Legislative Auditor 1998). The following year, the UH Board of Regents approved a second plan that was designed to facilitate the implementation of the specific research facilities identified in the RDP. The *Mauna Kea Science Reserve Complex Development Plan* was a plan to provide the physical planning framework to implement the RDP (Group 70 1983a). Its objective was to guide and control development, in order to preserve the scientific, physical, and environmental integrity of the mountain. Incorporated into this document was a proposal for managing resources and for monitoring and controlling visitor use. The plan stated the University would be responsible for managing and monitoring its leased areas. The *Mauna Kea Science Reserve Complex Development Plan* was amended in 1987 to address the development of the Very Long Baseline Array.

2.1.4 1985 Mauna Kea Management Plan

In 1985, BLNR approved the University's *Mauna Kea Management Plan* (also referred to as CDUA HA-1573) (University of Hawaii 1985). The plan was a revised version of the conceptual management plan contained in the 1983 *Mauna Kea Science Reserve Complex Development Plan*.

2.1.5 1995 Revised Management Plan for the UH Management Areas on Mauna Kea

In 1995 BLNR approved the *Revised Management Plan for the UH Management Areas on Mauna Kea* (DLNR 1995). The 1995 Revised Management Plan is in effect today for the UH Management Areas.

The 1995 Revised Management Plan discusses the public use activities that are permitted within the UH Management Areas. These include recreational, educational, cultural, and commercial activities. In general, recreational activities such as hiking, sightseeing, amateur astronomy, snow sports, and hunting are permitted but may be controlled or restricted. Cultural activities that do not involve physical impacts are permitted. Commercial activities that are permitted include skiing and sledding tours, hiking tours, and sight-seeing tours. Other commercial activities that are allowed but require special permission include tours of the telescope facilities, film-making and night use of the Visitor Information Station at Hale Pōhaku. Recreational use of off-road vehicles and commercial hunting tours are prohibited.

One of the major issues that the 1995 Management Plan addressed was the lack of management over commercial use. To that end, all management responsibilities, except those related directly to astronomical facilities or the Summit Access Road, were assigned to DLNR. In addition, the 1995 Management Plan incorporated management controls for permitted commercial uses. The Plan states that DLNR is responsible for issuing permits, setting and collecting fees, and enforcement for the activities of commercial operators. The University had the right to review and comment on the permits, as well as a responsibility to help monitor the activities of these operators. The University has the right to control visitor activities around the astronomy facilities, to manage access to the Science Reserve, and to restrict access under certain conditions. The University also has the right to ask other agencies to assist in visitor management when DLNR enforcement officers are not available, and to require a waiver of liability before allowing access to the upper elevations. The 1995 Management Plan outlines some of the University's commercial rights, such as the right to operate concessions within the

UH Management Areas, and the right to contract a shuttle service to take visitors to the summit for various activities.

The BLNR approved the 1995 Management Plan subject to certain conditions, such as: (i) the requirement for there to be education of Mauna Kea Observatories Support Services (MKSS) staff on the details of the Plan and instruction on reporting violations; (ii) prohibition of tampering with all historic, archaeological and cultural sites; (iii) a requirement for staff to report to the BLNR upon completion of biological and archaeological reports, to review whether any modifications to the Plan are warranted; (iv) posting of additional signage (subject to funding); and (v) that the VIS (subject to funding) should be open seven days a week.

2.1.6 1998 Audit of the Management of Mauna Kea and the Mauna Kea Science Reserve

In 1998, at the request of the legislature, the State auditor conducted an audit of the management of Mauna Kea and the Mauna Kea Science Reserve. The audit found a number of deficiencies in the management of Mauna Kea by both the University and DLNR. The audit charged that the University focused on developing astronomical facilities at the expense of protecting Mauna Kea's resources. With DLNR, the audit found inadequate monitoring and enforcement of permitting requirements, which put State resources at risk. Overall the audit found that although protection controls had been established by management plans, these controls were poorly implemented, leading to inadequate protection of cultural, historic, and natural resources (Office of the Legislative Auditor 1998).

2.1.7 Mauna Kea Science Reserve Master Plan (2000 Master Plan)

In 1998, in an effort to improve management of the Science Reserve and the facilities at Hale Pōhaku, and to assist with the planning of future development, the University created the Mauna Kea Advisory Committee. The Committee met from June 1998 through August 1999 and, with representatives from Group 70 International (consultant to the University), held a series of public meetings at various sites around the Island of Hawai'i to gather public input on a variety of matters, such as the management of Mauna Kea's resources and future development of observatories. Representatives from Group 70 also discussed with community members recommendations for a master plan.

In 2000, with consideration of the issues raised in the public meetings and the State audit, the University released the *Mauna Kea Science Reserve Master Plan* (Group 70 International 2000) (the "2000 Master Plan"). The 2000 Master Plan called for 525 acres of the summit area leased land to be designated as an "Astronomy Precinct." To help protect natural and cultural resources within the Science Reserve, and to protect the astronomy facilities from outside impacts, the 2000 Master Plan required that all astronomy facilities be confined to the Astronomy Precinct. A significant portion of the 2000 Master Plan is dedicated to what are referred to as "issues and opportunities for management." These "issues and opportunities for management" include matters related to management authority, access, natural resources, cultural resources and practices, education and research, and recreation.

The UH Board of Regents approved the 2000 Master Plan in June 2000. In the 2000 Master Plan, the University concluded that there was a need for a single entity to manage the comprehensive plan for the Science Reserve. The 2000 Master Plan calls for the management organization to be housed within the University system, and funded as an ongoing program unit

of the University of Hawai'i at Hilo (UH-Hilo). In accordance with the 2000 Master Plan, the UH-Hilo Chancellor established the OMKM on August 1, 2000. OMKM is the University office charged with ensuring compliance with, and implementation of, the 2000 Master Plan.

In addition to OMKM, the 2000 Master Plan recommended the addition of a management board and an advisory board in order to include community involvement in the management of the Science Reserve. The 2000 Master Plan recommended that the management board be "composed of members representing the major stakeholders of Mauna Kea." In fulfillment of this recommendation, the Mauna Kea Management Board (MKMB) was established. The MKMB is comprised of seven members appointed by the UH Board of Regents. Kahu Kū Mauna (Guardians of the Mountain), is appointed by the MKMB to serve as advisors to the OMKM, MKMB, and the UH Hilo Chancellor on all matters impacting the cultural integrity of Mauna Kea.

2.1.8 BLNR Transfer of Commercial Permitting Management to the University

Following the completion and adoption of the 2000 Master Plan by the UH Board of Regents, the BLNR approved the authorization of the transfer of the permitting authority with respect to commercial tour operations to the University. The UH Board of Regents formally accepted commercial permitting authority in January 2005 (UH Board of Regents 2005) and the University President delegated authority to sign permits for commercial tour activities to the UH-Hilo Chancellor in November, 2006.

2.1.9 2005 Follow-up Audit of the Management of Mauna Kea and the Mauna Kea Science Reserve

The State conducted a follow-up audit of the management of Mauna Kea in 2005. The audit recognized that the University and DLNR had implemented many of the recommendations of the 1998 audit, but found that more needed to be done (Office of the Legislative Auditor 2005). The audit praised implementation of the 2000 Master Plan – specifically the establishment of the Astronomy Precinct, the implementation of the ranger program, and increased community involvement through OMKM – but stated that management plans for the Science Reserve needed to be updated to reflect current use and management, and to provide transparency and accountability to the University (Office of the Legislative Auditor 2005).

One of the management challenges described in the audit is the University's lack of authority to establish and enforce rules. Currently, while the University is responsible for the protection of cultural and natural resources within its jurisdiction, it does not have the authority to establish and enforce administrative rules. The audit recommended that the University obtain rule-making authority and develop, implement, and monitor a comprehensive management plan for natural, cultural, and historic resources of the summit and Hale Pōhaku. It also recommended that the University implement and enforce a permit and sublease monitoring system for observatories.

2.1.10 Outrigger Telescopes Project

In 2001, the University of Hawai'i Institute for Astronomy (IfA) filed a Conservation District Use Permit application (CDUA) with the BLNR to construct and operate up to six, 1.8-meter, Outrigger Telescopes within the Astronomy Precinct at the summit area of the Science Reserve. Public hearings on the CDUA were held in 2001 and 2002. Before the public hearings concluded, several citizen groups and private individuals requested a contested case hearing on

the CDUA. The BLNR appointed a hearing officer to conduct the contested case hearing, and in June 2003, the hearing officer recommended approval of the CDUA for the Outrigger Telescopes project. In October 2004, the BLNR granted a Conservation District Use Permit, and approved a management plan for the Outrigger telescope project. (BLNR's Decision Granting Conservation District Use Permit for the Construction and Operation of Six 1.8-Meter Outrigger Telescopes Within the summit area of the Mauna Kea Science Reserve dated October 29, 2004.) The citizen groups and private individuals appealed this decision to the Circuit Court of the Third Circuit in Hilo.

The BLNR decision was overturned (*Mauna Kea Anaina Hou, et al v. Board of Land and Natural Resources*, Civ. No. 04-1-397, Decision and Order dated January 19, 2007). Judge Hara specifically concluded that the BLNR shall approve a comprehensive management plan that "covers multiple land uses within the larger overall area that UH IfA controls at the top of Mauna Kea in the Conservation District." Further, that the management plan was a "precondition to granting CDUP."

2.2 NEED FOR THE CMP

The CMP is an integrated planning tool for resource management that reflects updated guidance, supports the need for rule-making authority, and engages the community. The CMP also addresses the legal need for a comprehensive management plan per BLNR regulations and judicial guidance.

2.2.1 Improved Integrated Planning and Management

OMKM was established in 2000 as the Hawai'i Island management authority for the UH Management Areas (see Section 3.2). The CMP provides the framework for managing multiple existing and future activities, such as astronomy, recreational and commercial activities, scientific research, and cultural and religious activities. More importantly, the CMP provides a guide for protecting Mauna Kea's many unique cultural and natural resources. Once the CMP is adopted by the BLNR, it will also provide management guidelines and specific management recommendations that could be included in BLNR's CDUPs.

2.2.2 Updated Planning Guidance

Since its establishment in 2000 OMKM has operated on the basis of the *Revised Management Plan for the UH Management Areas on Mauna Kea* (1995 Management Plan) (DLNR 1995) and the *Mauna Kea Master Plan* (2000 Master Plan) (Group 70 International 2000). The 1995 Management Plan is the current BLNR approved plan for Mauna Kea. The 1995 Management Plan assigns management and enforcement responsibilities for public and commercial use and institutes commercial use and management controls for the UH Management Areas. The 2000 Master Plan, a development planning document, provides the policy framework for the responsible stewardship and use of the UH Management Areas.

The CMP reflects the current state of knowledge on cultural and natural resources and the current institutional structure to manage these resources. The CMP also provides a comprehensive vision for protection of the natural and cultural resources on Mauna Kea from impacts that may result from use of the summit area for astronomical research, recreation, and cultural activities. The need for a comprehensive management plan to ensure resource

protection was also identified in the audits of the University and their management of Mauna Kea and the Mauna Kea Science Reserve conducted by the Office of the Legislative Auditor in 1998 and 2005 (Office of the Legislative Auditor 1998, 2005).

2.2.3 Rule-Making Authority

Currently the University lacks administrative control to develop, implement and enforce rules and regulations for public activities within the UH Management Areas. This limits its ability to protect resources and bring enforcement actions. The 2005 audit conducted by the Office of the Legislative Auditor describes the lack of rule-making authority as a management challenge, lists it as the main reason protection of resources is challenging, and recommends that the University obtain administrative rule-making authority (Office of the Legislative Auditor 2005). Statutory authority for the University to implement administrative rules will protect resources and support some of the management actions identified in the CMP that require rule-making authority.

2.2.4 Community Engagement

An important component in resource management is the human community. Mauna Kea is a sacred site to the Native Hawaiian community. Mauna Kea also serves as an important astronomical site, educational facility, and recreational area. These human uses of the environment can directly conflict with the protection of cultural and natural resources. The CMP recognizes Mauna Kea's importance from both the cultural and natural standpoints while also attempting to provide for evolving astronomical use. Stakeholder cooperation in the long-term management of Mauna Kea's resources is therefore essential. To address this need, the CMP offers processes for on-going education and community consultation in the management of the UH Management Areas.

2.3 GOALS AND OBJECTIVES OF THE CMP

The goal of the CMP is to provide management strategies that protect, preserve, and enhance Mauna Kea's resources. The CMP has four primary objectives:

1. Understanding and protecting Mauna Kea's cultural and natural resources
2. Managing access, activities and uses
3. Managing the built environment
4. Managing operations.

Table 2-1 identifies 12 desired outcomes presented in the CMP that address these primary objectives.

Table 2-1. CMP Management Objectives and Component Plans with Desired Outcomes

Understanding and Protecting Mauna Kea's Cultural and Natural Resources
Native Hawaiian Culture and History Increase understanding and appreciation of Native Hawaiian history and cultural practices related to Mauna Kea to ensure that these practices are protected and respected. Identify, document the condition of, and protect historic properties in the UH Management Areas.
Natural Resources Increase understanding of the status of natural resources (biotic and abiotic), and identify threats to these resources in order to better protect and preserve unique geological features, ecosystem functions, subalpine and alpine habitats, and biological communities through adaptive management of stressors and threats.
Education and Outreach Build and maintain a constituency to engage in active and meaningful stewardship of Mauna Kea, through education and involvement of the public, to support and enhance conservation of the natural, cultural, and astronomical resources of Mauna Kea.
Astronomy Resources Astronomical resources must also be protected. The University's lease of the Summit Area provides that the scientific reserve shall be operated as a buffer zone to prevent intrusion of activities incompatible with the use of the land as a scientific complex or observatory. The lease recognizes light and dust interference as well as certain types of electronic installation as incompatible.
Managing Access, Activities and Uses
Activities and Uses To retain and enhance recreational and cultural activities, ensure regulation of commercial activities, and support scientific studies while maintaining adequate protection of resources, educating users regarding resource sensitivity, and ensuring the health and safety of those visiting or working at Mauna Kea.
Permitting and Enforcement Achieve compliance with existing and any new policies and regulations designed to manage and minimize human impacts, to preserve and protect Mauna Kea's resources.
Managing the Built Environment
Infrastructure and Maintenance Manage the built environment by implementing an Operations, Monitoring and Maintenance Plan (OMMP) containing specific maintenance strategies and protocols that will result in minimal disruptions to activities and uses, minimize impacts to the resources, and ensure that permittees remain compliant with their CDUP requirements.
Construction Guidelines Minimize adverse impacts to resources during all phases of construction, through use of innovative best management practices.
Site Recycling, Decommissioning, Demolition, and Restoration To the extent possible, reduce the area disturbed by physical structures within UH Management Areas by upgrading and reusing buildings and equipment at existing locations, decommissioning, and removing obsolete facilities, and restoring impacted sites.
Considering Future Land Use To protect cultural and natural resources in the assessment of future projects.
Managing Operations
Operations and Implementation Conduct effective operations to support management that is focused on resource protection, education, and public safety.
Monitoring, Evaluation, and Updates Determine whether management actions are achieving the goals of the CMP and provide a process for improving and updating management strategies through evaluation and revisions of the CMP.

2.4 MANAGEMENT AUTHORITY

The CMP provides a comprehensive plan for management of the UH Management Areas and clarifies the role of the University and the DLNR. Once approved by the BLNR, the CMP will be the controlling management plan for the UH Management Areas. All activities and uses within the UH Management Areas will be required to be consistent with Management Actions described in the CMP. Consistent application of the Management Actions will help achieve the CMP.

The CMP will replace the 1995 Management Plan as the overall guiding document for the UH Management Areas. At the same time, the University will continue to use the 2000 Master Plan, which will continue to serve as the University's development planning framework for the responsible stewardship and use of the UH Management Areas. In addition, the CMP provides a process through which it can be regularly updated as part of an adaptive management strategy. That process will allow the DLNR and the University to evaluate and modify management approaches over time, based on new information that may become available.

The following sub-sections describe the specific roles of the various University and DLNR offices that are involved with managing the UH Management Areas on Mauna Kea.

2.4.1 University of Hawai`i

The University has responsibility for managing the UH Management Areas. The acceptance of the 2000 Master Plan by the UH Board of Regents prompted the creation of OMKM, the MKMB, and Kahu Kū Mauna. The MKMB serves in an advisory capacity to the UH Hilo Chancellor and Kahu Kū Mauna serves in the advisory capacity, primarily to the MKMB, but also to the UH Hilo Chancellor. The MKMB has also established several advisory committees, including the MKMB Environmental Committee and the MKMB Hawaiian Cultural Committee. The IfA provides guidance and input on long term planning and future astronomical development. The University President and the UH Board of Regents have final approval authority over major projects (including astronomy development), subject to all applicable DLNR regulations.

2.4.1.1 Office of Mauna Kea Management

OMKM was established in 2000 and is responsible for the day-to-day management of the cultural and natural resources of the UH Management Areas on Mauna Kea. OMKM is within the University of Hawai`i at Hilo, and OMKM staff report directly to the Chancellor of UH Hilo. Included within OMKM's mission is the responsibility to "protect, preserve and enhance the natural, cultural, and recreational resources of Mauna Kea while providing a world-class center dedicated to education, research and astronomy," all of which requires coordination with other stakeholders, both public and private. In addition, OMKM oversees the ranger program, described below.

2.4.1.2 Mauna Kea Management Board (MKMB)

The MKMB is comprised of seven members of the community who are nominated by the UH Hilo Chancellor and approved by the UH Board of Regents. The MKMB advises the Chancellor and OMKM on the management of the UH Management Areas. The volunteer members represent a cross section of the community and serve as the community's main voice, advising

on activities, operations and land uses planned for Mauna Kea. MKMB works closely with Kahu Kū Mauna.

2.4.1.3 *Kahu Kū Mauna*

Kahu Kū Mauna (Guardians of the Mountain) is a nine-member volunteer council whose members are approved by the MKMB. Kahu Kū Mauna advises the MKMB, OMKM, and the UH Hilo Chancellor on Hawaiian cultural matters affecting the UH Management Areas on Mauna Kea. The council comprises individuals from the Native Hawaiian community. Members are selected on the basis of their awareness of Hawaiian cultural practices, traditions and significant landforms as applied to traditional and customary use of Mauna Kea, and their sensitivity to the sacredness of Mauna Kea.

2.4.1.4 *Advisory Committees*

Other committees advise OMKM and the MKMB on specific topics. They include the MKMB Environment Committee, which provides expertise on environmental issues; the Hawaiian Cultural Committee, which assists in integrating Hawaiian perspectives into OMKM's programs; the Wēkiu Bug Scientific Committee; and the Public Safety Committee. These committees are coordinated by OMKM.

2.4.1.5 *Rangers*

Shortly after its founding in the fall of 2000, OMKM established the ranger program to educate visitors, monitor for violations of the permitted uses within the UH Management Areas, and provide for the health and safety of visitors. The rangers conduct patrols by four-wheel drive vehicle to the summit four times daily. The primary purpose of these patrols is to observe and document the activities of the general public, observatory personnel, and commercial tour operators. Patrol reports are submitted to OMKM daily. Rangers perform a variety of other duties including providing emergency assistance for lost or injured people in the UH Management Areas, assisting stranded motorists, coordinating litter removal, conducting trail maintenance, and inspecting the observatories for compliance with their CDUPs. The rangers typically have diverse backgrounds, from those with cultural ties to the land, to those drawn to the mountain because of astronomy, to those looking to share their knowledge about the important natural resources of the area.

2.4.1.6 *Institute for Astronomy (IfA)*

The IfA, based at UH Mānoa, conducts state-of-the-art astronomical research. Its faculty and staff are also involved in astronomy education, and in the development and management of the observatories on Haleakala and Mauna Kea. IfA oversees the conduct and coordination of astronomical research in the Science Reserve, including long-term planning and visioning.

2.4.1.7 *Mauna Kea Observatories Oversight Committee*

The Mauna Kea Observatories Oversight Committee is composed of representatives from all of the observatories and IfA. Each observatory pays into a Research Corporation of the University of Hawaii account that is used to fund Mauna Kea Observatories Support Services (MKSS)

activities, including road maintenance, snow removal, facilities maintenance and management at Hale Pōhaku, common utilities and the VIS.

2.4.1.8 *Mauna Kea Observatories Support Services*

Mauna Kea Observatories Support Services (MKSS) operates under the direction of the observatories through the Mauna Kea Observatories Oversight Committee funds and oversees the general maintenance and logistical services to all Mauna Kea observatories and the facilities at Hale Pōhaku. MKSS also supports the ranger services, under the direction of OMKM.

2.4.2 Department of Land and Natural Resources (DLNR)

The DLNR, headed by the BLNR, manages the State's lands. The University, as lessee, does not have authority to permit new land uses within the UH Management Areas, including the construction of new observatory facilities. Several divisions within DLNR share management responsibility for Mauna Kea lands, including the Division of Aquatic Resources, the Division of Conservation and Resource Enforcement, the Division of Forestry and Wildlife, the Natural Area Reserves Commission, the Land Division, the Office of Conservation and Coastal Lands, and the State Historic Preservation Division. After the CMP is adopted, the DLNR and BLNR will retain overall authority for decisions relating to land uses within the UH Management Areas.

2.4.2.1 *Division of Aquatic Resources*

The Division of Aquatic Resources (Commission of Water Resources Management) has as its mission to manage, conserve and restore the State's unique aquatic resources and ecosystems for present and future generations. The Division sets overall water conservation, quality and use policies; defines beneficial and reasonable uses; protects ground and surface water resources, watersheds and natural stream environments; establishes criteria for water use priorities while assuring appurtenant rights and existing correlative and riparian uses and establishes procedures for regulating all uses of Hawai'i's water resources.

2.4.2.2 *Division of Conservation and Resource Enforcement*

The Division of Conservation and Resource Enforcement (DOCARE) is responsible for enforcing all laws and rules that apply to all lands managed under DLNR. This includes protecting and conserving the State's lands and natural resources, investigating complaints and violations, and monitoring all leases, permits, and licenses issued by DLNR. Pursuant to Act 226 Session Laws of Hawai'i 1981, DOCARE's enforcement officers have full police powers to execute all State laws and rules within all State lands. The division's Island of Hawai'i branch includes Mauna Kea in the East Hawai'i district.

2.4.2.3 *Division of Forestry and Wildlife*

The Division of Forestry and Wildlife (DOFAW) is charged with protecting and managing watersheds, natural resources, outdoor recreation resources, and forest product resources. It is also charged with public education and develops and manages statewide programs on forest and wildlife resources as well as natural area reserves and trail and access systems. DOFAW manages the Mauna Kea Forest Reserve. DOFAW also manages outdoor recreation programs and activities, including hunting, which occur on State-owned lands on Mauna Kea.

2.4.2.4 *Natural Area Reserves Commission*

The Natural Area Reserves (NAR) Commission is administratively attached to DLNR; its staff is in DOFAW. It establishes criteria that are used in determining whether an area is suitable for inclusion within the State reserves system. The NAR Commission also establishes policies and criteria for the management, protection, and permitted uses of the reserves system. The Statewide reserves system was established with the mandate of protecting the best remaining examples of native ecosystems and geological sites on State managed lands. There are currently 19 reserves, including the Mauna Kea Ice Age Natural Area Reserve (NAR).

2.4.2.5 *Land Division*

The Land Division is responsible for managing State-owned lands in ways that will promote the social, environmental, and economic well-being of Hawai'i's people and for ensuring that these lands are used in accordance with the goals, policies, and plans of the State. Lands that are not set aside for use by other government agencies come within the direct purview of the Land Division, as do the management and enforcement of leases, permits, executive orders, and other encumbrances for public lands. The division also investigates local land problems, maintains data for the State Land Information Management System (SLIMS), serves as custodian for all official transactions relating to public lands, and maintains a central repository of all government documents dating back to the "Great Mahele" of 1848.

2.4.2.6 *Office of Conservation and Coastal Lands*

DLNR reorganized the Land Division in 2002, creating the Office of Conservation and Coastal Lands (OCCL). The OCCL regulates and enforces land use for approximately two million acres of private and public lands that lie within the State's Conservation District, including Mauna Kea. OCCL is also responsible for processing Conservation District land use requests, developing administrative rules for the Conservation District, investigating complaints and violations, and monitoring all leases, permits and licenses issued by DLNR.

2.4.2.7 *State Historic Preservation Division*

The State Historic Preservation Division (SHPD) helps to carry out the responsibilities outlined in the National Historic Preservation Act (NHPA) and Chapter 6E, Hawai'i Revised Statutes (HRS). The goal of the NHPA is to preserve and protect historical and culturally significant properties. The SHPD is guided by the Statewide Historic Preservation Plan (2001) and the rules and regulations set forth in Chapter 6E, HRS. SHPD manages several programs to promote the use and conservation of historic properties, including those on Mauna Kea. These programs include: Statewide Inventory of Historic Properties, Burial Sites Program, Certified Local Government Program, National Main Street Program, Historic Preserves Program, Information and Education Program, Interagency Archaeological Services, and maintenance of the Hawai'i and National Register of Historic Places. SHPD also reviews proposed development projects to ensure minimal effects of change on historic and cultural assets.

2.4.2.8 *Hawai'i Island Burial Council*

The management of all human remains over 50 years old falls under the jurisdiction of SHPD. Island burial councils are administratively attached to SHPD to address concerns relating to Native Hawaiian burial sites. The Burial Council determines whether to relocate or preserve in place any previously identified Native Hawaiian burial sites. The Burial Council also works to educate landowners as to the cultural beliefs and views regarding burials encountered on their lands. Any burial protection plan or burial treatment plan for Mauna Kea must be prepared in consultation with Hawai'i Island Burial Council.

2.5 REGULATORY OVERVIEW OF MAUNA KEA

Land use management, environmental review, and natural and cultural resource management on Mauna Kea are regulated by various Federal, State and local statutes and regulations. The triggering and implementation of these regulations varies based on the specific action or actions being proposed. The following is a summary of some of the regulations that are applicable to the UH Management Areas.

2.5.1 Federal Regulations

Federal environmental standards apply to the UH Management Areas. Certain federal permits and regulatory programs are triggered when a federal action is initiated in the area. The proposed CMP is not a federal action.

2.5.1.1 *Clean Air Act of 1970, as Amended (42 U.S.C. 7401 et seq.)*

The Clean Air Act (CAA) governs the nation's air quality. The CAA prohibits new and existing sources of air pollution from emitting pollution that exceeds ambient air quality levels designed to protect public health and welfare. New sources are subject to more stringent control technology and permitting requirements. Hazardous air pollution and visibility impairment are also addressed by the CAA.

2.5.1.2 *Clean Water Act of 1977, as Amended (PL 95-217, Title 33 U.S.C. 1251 et seq.)*

The Clean Water Act (CWA) is the major federal legislation concerning improvement of the nation's water resources. The Act was amended in 1987 to strengthen enforcement mechanisms and to regulate stormwater runoff. The Act provides for the development of municipal and industrial wastewater treatment standards and a permitting system to control wastewater discharges to surface waters.

2.5.1.3 *Coastal Zone Management Act of 1972 (16 USC §145 et seq.)*

The Coastal Zone Management Act of 1972, as amended, requires that, to the maximum extent practicable, federal actions affecting any land or water use or coastal zone natural resource be implemented consistent with the enforceable policies of an approved State management program. The Act authorizes states to administer approved coastal nonpoint pollution

programs. Advance concurrence from the state coastal commission is required prior to taking an action affecting the use of land, water, or natural resources of the coastal zone.

2.5.1.4 *Endangered Species Act (16 USC §1531 et seq.)*

The Endangered Species Act is implemented by 50 CFR 402 and 50 CFR 17. This Act requires all federal agencies to carry out programs to conserve federally listed endangered and threatened plants and wildlife and the habitat on which they depend. Development and implementation of these programs must be carried out with the consultation and assistance of the Departments of the Interior and Commerce. A biological assessment may be required to determine whether formal consultation with the US Fish and Wildlife Service (USFWS) is necessary, and it may also serve as a basis for a USFWS biological opinion. USFWS also maintains a listing of candidate species and species of concern. Section 4.2.2 details federally-listed species found or potentially found on the UH Management Areas.

2.5.1.5 *National Environmental Policy Act (42 USC §4321 et seq.)*

The National Environmental Policy Act (NEPA) requires consideration of environmental concerns during project planning and execution of federally funded projects. The Act requires federal agencies to prepare an environmental assessment or environmental impact statement for actions that have the potential to significantly affect the quality of the human environment, including both natural and cultural resources. NEPA is implemented by regulations issued by the Council on Environmental Quality (40 CFR 1500). A NEPA analysis can have one or more of several outcomes: a determination of categorical exclusion (CatEx) where an action can be categorically excluded from further environmental analysis; the preparation of an Environmental Assessment (EA) if the action cannot be categorically excluded or is not a “major federal action”; the EA can result in a “finding of no significant impact” (FONSI), or in the decision to conduct an Environmental Impact Statement (EIS) study because the action has been found to be a major federal action through the NEPA analysis.

2.5.1.6 *National Registry of Natural Landmarks (Program 15.9100 § 62.2)*

The National Registry of Natural Landmarks is administered by the National Park Service, under the Department of the Interior. The landmarks registered under this program are not intended for acquisition by the federal government, but rather, voluntary maintenance and preservation is encouraged. This designation is given to sites thought to best exemplify the geological and ecological history of the United States. The program goal is that acknowledgment of these areas may increase public appreciation for the natural heritage of the United States. Mauna Kea was designated a natural landmark in November 1972 (NPS 1994).

2.5.1.7 *National Historic Preservation Act, Section 106 (16 USC §470f)*

The National Historic Preservation Act (NHPA) was created to support efforts to identify and protect sites, buildings, and objects that have historic, architectural, archeological, or cultural significance. The purpose is to ensure that the historical and cultural foundations of the nation are preserved. This act specifies that there should exist a National Register of Historic Places (NRHP), an Advisory Council on Historic Preservation, individual State Historic Preservation Offices and a review process for assessing potential impacts to sites as described in Section 106 of the NHPA. The NRHP designation is used to identify areas and properties that have

been granted certain protections with regard to planning and development and deemed worthy of preservation, whether by private, State, or Federal agencies.²

Projects within the UH Management Areas that are carried out with federal funding (e.g., from the National Science Foundation or National Aeronautics and Space Administration) that may impact a site that is listed or eligible for listing on the NRHP are covered by Section 106. In addition, any activities that require a federal permit, license, or approval (e.g., a permit or approval from the USFWS under the Endangered Species Act) also fall under Section 106. If it is determined that there would be an adverse effect, the agency conducting the project is required to seek ways to avoid, minimize, or mitigate that effect, as well as to consider alternative plans. Section 106 dictates that the views of the public should be solicited and considered throughout the process. The Advisory Council on Historic Preservation has made it possible to combine the NEPA and Section 106 processes, and the implementing regulations for Section 106 encourage this approach to project planning. While the statute broadly defines the requirements of Section 106, the implementing regulations, at 36 CFR Part 800, describe the process by which historic properties are identified and handled during an undertaking.

2.5.1.8 Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act of 1976 (RCRA) governs the management of solid wastes, including hazardous wastes, throughout the U.S. It establishes permitting, reporting and performance requirements for hazardous waste generators, transporters, and treatment, storage and disposal facilities. RCRA creates a 'cradle to grave' management system designed to ensure proper management of discarded hazardous materials. Within the UH Management Areas of Mauna Kea, RCRA effects the manner in which facilities which generate hazardous wastes must manage and dispose of those materials. The U.S. Environmental Protection Agency has delegated responsibility for administering most aspects of RCRA in Hawai'i to the Hawai'i Department of Health (DOH).

2.5.2 State and Local Regulations

Various State and County laws and regulations regulate land use management in Hawai'i. The following is a discussion of some of the State and County regulations applicable to the UH Management Areas.

2.5.2.1 Land Use

The following summarizes State and local land use regulations in Hawai'i.

HRS 183C, Conservation District

The intent of HRS Chapter 183C is to conserve, protect, and preserve important natural resources of the State through appropriate management and use to promote their long-term sustainability and the public health, safety and welfare.

² The Adze Quarry, located in the Mauna Kea Ice Age NAR, was listed on the NRHP in 1962. This site contains religious shrines, rock shelters and petroglyphs and is thought to be the largest ancient quarry

HRS Chapter 205, State Land Use Law.

The State Land Use Law establishes an overall framework for land use management whereby all lands in the State of Hawai'i are classified into one of four major land use districts: Urban, Rural, Agricultural and Conservation. Conservation District lands are comprised primarily of lands in existing forest and water reserve zones, and include areas necessary for protecting watersheds and water sources, scenic and historic areas, park, wilderness, open space, recreational areas, and habitats of endemic plants, fish and wildlife. Land uses within the Conservation Districts are administered by the BLNR and governed by its rules.

HRS Chapter 205-A, Hawai'i's Coastal Zone Management Program

The objective of the state coastal zone management (CZM) program is to use an integrated approach to determine the policies and procedures that regulate State and County actions dealing with land and water uses and activities. Because in Hawai'i there is no point of land more than 30 miles from the ocean, the CZM program is designed as an overall resource management policy and encompasses the entire-State. The objectives and policies of the CZM require consideration of ecological, cultural, historical, aesthetic, recreational, scenic and open space values, and coastal hazards, as well as economic development. HRS Chapter 205A requires all agencies to ensure that their rules comply with the objectives and policies of HRS Chapter 205A.

HRS Chapter 226, Hawai'i State Planning Act

The purpose of the Hawai'i State Planning Act is to define the topics and priorities that should be considered in planning for the future development of the State. It is intended to improve coordination among different agencies, to provide for the wise use of resources and to guide development. The Act sets forth the State's goals and objectives with regard to the development of policies and plans for economic development, population growth, education, crime, housing, and resource management.

HAR Title 13, Administrative Rules of the Department of Land and Natural Resources

HAR Title 13 defines the rules of practice and procedure for the lands that fall under the jurisdiction of DLNR. In addition, each division within DLNR has its own mission statement and rules. Several of these divisions have rules that are applicable to the management of Mauna Kea.

HAR Title 13, Chapter 5, Conservation District

Title 13, Chapter 5, Hawai'i Administrative Rules (HAR) regulate land use in the State's Conservation District for the purpose of conserving, protecting, and preserving the important natural resources of the State through appropriate management and use, to promote their long-term sustainability and the public health, safety and welfare. The Administrative Rules established five subzones within the Conservation District: protective, limited, resource, general, and special. For each subzone, the chapter describes the objective of the level of protection and identifies permitted uses along with the procedures necessary to obtain permission to engage in that use. Each use is assigned to one of four categories. The first category does not require a

permit from the DLNR or BLNR. The second category requires a site plan, to be approved by the DLNR. The third category requires a DLNR permit. The fourth category requires a BLNR permit, and, where specified, an accompanying management plan.

The UH Management Areas are in the resource subzone. The objective of this subzone is to develop areas using management that ensures that the natural resources of those areas are sustained. To that end, many of the identified uses in this subzone fall under the third or fourth categories of land use and require, at minimum, a permit from the DLNR or BLNR. Some examples of activities that require a permit are data collection that involves incidental ground disturbance (e.g., rain gauges), erosion control, noxious weed removal that results in ground disturbance, the demolition of existing structures and removal of more than five trees larger than 6" in diameter. Astronomy facilities require both a permit and an approved management plan.

Hawai'i County General Plan

The 2005 Hawai'i County General Plan establishes the long-range goals and policies that guide development and appropriate uses of land for the County of Hawai'i.

The purposes of the General Plan are to:

- Guide the pattern of future development based on long-term goals;
- Identify the visions, values, and priorities important to the people of the County;
- Provide the framework for regulatory decisions, capital improvement priorities, acquisition strategies, and other pertinent government programs within the County organization and coordinated with State and Federal programs.
- Improve the physical environment of the County as a setting for human activities; to make it more functional, beautiful, healthful, interesting, and efficient.
- Promote and safeguard the public interest and the interest of the County as a whole.
- Facilitate the democratic determination of community policies concerning the utilization of its natural, man-made, and human resources.
- Effect political and technical coordination in community improvement and development.
- Inject long-range considerations into the determination of short-range actions and implementation.

The General Plan recognizes the importance of Mauna Kea and the facilities managed by the University.

The summit area of Mauna Kea has the worldwide distinction as the best international center for observational astronomy. Mauna Kea currently accommodates twelve of the world's most state-of-the-art telescope facilities. The newest telescope is the \$300,000,000 Subaru telescope developed by the National Astronomical Observatory of Japan. The recent completion of the University of Hawaii-Hilo Institute of Astronomy complex at University Park will support the relocation of the Institute of Astronomy staff from UH-Manoa to UH-Hilo. The UH-Hilo is also working to offer a Bachelor of Science degree in astronomy to allow observatories to hire local astronomers. Approximately \$619,000,000 of capital investments into the County have been made by the astronomy industry, including the creation of approximately 270 permanent jobs. Astronomical activities contribute approximately \$50,000,000 annually to the County's economy. (County of Hawai'i 2005)

The General Plan contains various goals, policies and standards in 15 categories. The following are a list of goals, policies and standards in the general plan that are applicable to the management of the UH Management Areas and the CMP.

Economic

- Promote and develop the island of Hawaii into a unique scientific and cultural model, where economic gains are in balance with social and physical amenities. Development should be reviewed on the basis of total impact on the residents of the County, not only in terms of immediate short run economic benefits.
- Continue to encourage the research, development and implementation of advanced technologies and processes.

Environmental Quality

- Take positive action to further maintain the quality of the environment.
- Advise the public of environmental conditions and research undertaken on the island's environment.

Historic Sites

- Protect, restore, and enhance the sites, buildings, and objects of significant historical and cultural importance to Hawaii.
- Appropriate access to significant historic sites, buildings, and objects of public interest should be made available.
- Agencies and organizations, either public or private, pursuing knowledge about historic sites should keep the public apprised of projects.
- Collect and distribute historic sites information of public interest and keep an inventory of sites.
- Aid in the development of a program of public education concerning historic sites.
- Recognize the importance of certain natural features in Hawaiian culture by incorporating the concept of “cultural landscapes” in land use planning.

Natural Beauty

- Maintain a continuing program to identify, acquire and develop viewing sites on the island.
- Access easement to public or private lands that have natural or scenic value shall be provided or acquired for the public.
- Distinctive and identifiable landforms distinguished as landmarks, e.g. Mauna Kea, Waipio Valley.

Natural Resources

- Protect and conserve the natural resources from undue exploitation, encroachment and damage.
- Provide opportunities for recreational, economic, and educational needs without despoiling or endangering natural resources.
- Protect and promote the prudent use of Hawaii's unique, fragile, and significant environmental and natural resources.
- Protect rare or endangered species and habitats native to Hawaii.
- Protect and effectively manage Hawaii's open space, watersheds, shoreline, and natural areas.
- Ensure that alteration to existing land forms, vegetation, and construction of structures cause minimum adverse effect to water resources, and scenic and recreational amenities and minimum danger of floods, landslides, erosion, siltation, or failure in the event of an earthquake.
- Require users of natural resources to conduct their activities in a manner that avoids or minimizes adverse effects on the environment.
- Encourage a program of collection and dissemination of basic data concerning natural resources.
- Coordinate programs to protect natural resources with other government agencies.
- Encourage public and private agencies to manage the natural resources in a manner that avoids or minimizes adverse effects on the environment and depletion of energy and natural resources to the fullest extent.
- Encourage an overall conservation ethic in the use of Hawaii's resources by protecting, preserving, and conserving the critical and significant natural resources of the County of Hawaii.
- Develop policies by which native Hawaiian gathering rights will be protected as identified under judicial decisions.
- Ensure public access is provided to the shoreline, public trails and hunting areas, including free public parking where appropriate.

2.5.2.2 Environmental Review, HRS Chapter 343 and HAR Section 11-200

HRS Chapter 343 and HAR Section 11-200 establish a system of environmental review at the State and County level. The statute and rules provide that environmental concerns are considered for all proposed actions on State and County lands or for projects using State or County funds. HRS Chapter 343 requires an environmental assessment (EA) for actions that propose the use of any State or County land, including lands classified as within the Conservation District, shoreline areas and historic sites. An environmental impact statement (EIS) is required if it is determined that the proposed action may have a significant impact. HRS Chapter 343 also requires a cultural impact assessment (CIA) study to determine what effects the proposed project would have on Native Hawaiian cultural practices, features, and beliefs. In addition, Section 11-200 HAR provides for public participation through a public review process, as well as listing what classes of action are exempt from submission of an EA.

2.5.2.3 Historic Preservation and Burial Treatment

HRS Chapter 6E establishes that it is a policy of the State to preserve, restore, and maintain historically and culturally significant property. HRS Chapter 6E provides that all proposed projects that may affect any historic property, aviation artifact, burial site, or sites listed on the Hawai'i register of historic places, must be reviewed by SHPD. A project requires departmental agreement in order to progress. The summit region of Mauna Kea is designated as a historic district by the State of Hawai'i.

Several sections of HRS Chapter 6E are integral to cultural resource management issues in the UH Management Areas. Provisions of §6E-7, 6E-8, 6E-10.5, 6E-11, 6E-43, and 6E-43.6 will be applicable to one or more aspects of various future actions. In addition, various chapters of the Administrative Rules implementing HRS Chapter 6E will govern activities within the UH Management Areas. In all of the statutes cited, the phrase "historic property" refers to "...any building, structure, object, district, area, or site, including heiau and underwater site, which is over fifty years old." Similarly, a burial site "means any specific unmarked location where prehistoric or historic human skeletal remains and their associated burial goods are interred, and its immediate surrounding archaeological context, deemed a unique class of historic property and not otherwise included in section 6E-41" (§6E-2). All three UH Management Areas are State land, and therefore HRS Chapters 6E-7 and 6E-8 apply.

According to HRS Chapter 6E-7, historic sites upon State lands or under State waters belong to the State, and are to be managed by DLNR. Departmental oversight includes disposition of historic properties subject to certain conditions and the issuing of any permits for research on historic sites and setting conditions for such research. HRS Chapter 6E-8 requires review of the effects of proposed State projects on historic properties.

HRS Chapter 6E-10.5, HRS (Enforcement) and HRS Chapter 6E-11 (Penalties) apply to any instances of outright damage or vandalism to historic and cultural sites within the UH Management Areas. In addition, the provisions of both chapters also cover any failure to follow approved historic preservation compliance measures such as mitigation plans.

HRS Chapters 6E-43 (Prehistoric and Historic Burial Sites), 6E-43.5 (Island Burial Councils; Creation; Appointment; Composition; Duties) and 6E-43.6 (Inadvertent Discovery of Burials) cover the treatment and disposition of all burials over 50 years old. HAR Title 13, Subtitle 13, Chapter 300 also addresses the inadvertent discovery of human remains. SHPD has jurisdiction over any inadvertently discovered human skeletal remains and any burial goods over fifty years old, regardless of ethnicity. Any discovery must be immediately reported to the appropriate authorities including the SHPD. Upon discovery all activity in the immediate area of the remains must cease and appropriate action must be taken to protect the integrity of the burial site.

2.5.2.4 Natural Resources

HRS Chapter 195D, Conservation of Aquatic Life, Wildlife and Land Plants

HRS Chapter 195D establishes the rules and regulations related to the conservation of indigenous aquatic life, wildlife, land plants, and their habitats. This chapter covers the State rules and regulations regarding endangered and threatened species, most of which are the same as the Federal rules established by the Endangered Species Act. HRS Chapter 195D

provides that the DLNR, after consultation with all appropriate agencies and interested parties, and on the basis of all available scientific, commercial, and other data, may determine that a species, which is Federally listed as threatened, may be listed as endangered within the State, and that a species that is not listed Federally may be listed as endangered or threatened within the State.

HAR Title 4, Administrative Rules of the Department of Agriculture

HAR Title 4 covers the rules and regulations concerning issues that fall under the jurisdiction of the Department of Agriculture. Title 4 establishes the guidelines, limitations, and parameters for specific types of actions within the context of the Hawai'i Revised Statutes for the Department of Agriculture. Regulations set forth by HAR Title 4 govern pesticides, noxious weeds, importation and exportation of plants, prohibited animals, quarantines of plants and animals, restrictions on the importation of microorganisms, intrastate movement of bees, pests for control or eradication, management of agricultural resources, and aquaculture development.

HRS Chapter 152, Noxious Weed Control

According to HRS Chapter 152, “noxious weed” means any plant species that is, or that may be likely to become, injurious, harmful, or deleterious to the agricultural, horticultural, aquacultural, or livestock industries of the State and to its forest and recreational areas and conservation districts, as determined and designated by the department from time to time. HRS Chapter 152 establishes the criteria for the designation of noxious weeds and outlines the duties of the Department of Agriculture in terms of control and eradication of noxious weeds. Among other provisions, HRS Chapter 152 includes the prohibition of transportation of specific noxious weeds and the responsibility of the department to take measures to restrict the introduction and establishment of specific noxious weed species in areas that have been declared free of those noxious weeds.

HRS Chapter 342B, Air Pollution Control

The Department of Health, Clean Air Branch is responsible for air pollution control in the State pursuant to the federal Clean Air Act; HRS Chapter 342B; HAR Title 11, Chapter 59, Ambient Air Quality Standards, and HAR Title 11, Chapter 60.1, Air Pollution Control. The primary services of the branch are provided by its three sections: engineering, monitoring, and enforcement. Those sections conduct engineering analysis, issue permits, perform monitoring and investigations, and enforce the Federal and State air pollution control laws and regulations.

HRS Chapter 342D, Water Pollution Law

The Water Pollution Law provides a comprehensive regulatory program for discharges of pollutants to the waters of Hawai'i. Administrative rules pertaining to wastewater systems are included in HAR Title 11, Chapter 62.

HRS Chapter 342J, Hawaii Hazardous Waste Law

Hawaii's Hazardous Waste Law governs the management of hazardous waste and prohibits hazardous waste releases to the environment. Facilities located within the UH Management Areas, including several observatories, generate small quantities of hazardous wastes that must

be accumulated, stored, and removed from Mauna Kea for off-site treatment and disposal in accordance with strict guidelines.

HAR Title 11, Administrative Rules of the Department of Health

HAR Title 11 covers the administrative rules of items or concerns that fall under the jurisdiction of the Department of Health. Rules governing water quality, water pollution, wastewater management, solid and hazardous waste management, litter control, emergency medical services system, and sanitation all must be considered relevant to activities and Management Actions on Mauna Kea.

3 SUMMARY DESCRIPTION OF THE PROPOSED ACTION

This section provides a general description of the CMP's technical, social, economic, and environmental characteristics pursuant to HRS § 343 and the State Department of Health HAR § 11-200 content requirements for an environmental assessment.

The proposed action is the adoption of management strategies for the UH Management Areas. The CMP provides a management framework addressing existing and future astronomical, recreational, commercial, scientific research and cultural activities in the UH Management Areas. More importantly, the CMP provides a guide for protecting Mauna Kea's cultural and natural resources. The CMP, once approved by the BLNR, will be the guiding management plan for decisions involving the UH Management Areas. All activities within the UH Management Areas will have to be consistent with the provisions of the CMP, as well as with applicable laws and regulations.

The CMP was derived from previous plans, experience gained through many years of management efforts on Mauna Kea and input gathered during consultation with community members and other stakeholders. The primary management goal of the CMP is the protection and preservation of the mountain's many cultural and natural resources.

The following sections summarize the resource management approach adopted for the CMP and the proposed Management Actions of the CMP.

3.1 RESOURCE MANAGEMENT APPROACH

The CMP was developed using an integrated approach that drew on the Hawaiian approach to managing cultural and natural resources, as well as contemporary science-based management tools. This integrated approach recognizes the need to balance cultural sensitivities with natural resources protection and other activities, including recreation and astronomy.

3.1.1 Principles of Hawaiian Cultural Resource Management

First, the *ahupua'a* is the basic unit of Hawaiian cultural resource management. Second, the natural elements – land, air, water, ocean – are interconnected and interdependent. Third, of all the natural elements, fresh water is the most important for life and needs to be considered in every aspect of land use and planning. Fourth, Hawaiian ancestors studied the land and the natural elements and became very familiar with its features and assets. Ancestral knowledge of the land was recorded and passed down through place names, chants which name the winds, rains, and features of a particular district, and legend; therefore, it is important to consult these sources to learn of the culture and natural resources of a particular district (McGregor 1996).

3.1.2 Adaptive Management

The CMP utilizes key concepts from adaptive management and ecosystem management in the development of Management Actions. Adaptive management is defined as a systematic process for continually improving management policies and practices for resource protection by learning from the outcomes of past and current management activities. Adaptive management recognizes that there is a level of uncertainty about the “best” policy or practice for a particular management issue, and therefore requires that each management decision be revisited in the future to determine if it is providing the desired outcome. Management actions in a plan guided by adaptive management can be viewed as hypotheses and their implementation as tests of those hypotheses. Once an action has been completed, the next, equally important, step in an adaptive management protocol is the assessment of the actions effectiveness (results). A review and evaluation of the results allows managers to decide whether to continue the action or to change course. This experimental approach to resource management means that regular feedback guide managers’ decisions and ensure that future strategies better define and approach the objectives of the management plan.

3.1.3 Ecosystem Management

Ecosystem management is an important concept in natural resource management. Management at the ecosystem level approaches the protection, enhancement, and restoration of natural resources from the perspective that ecosystems are structural wholes, and it recognizes that people, policies, and politics are as much a part of an ecosystem as are plants and animals. The five general goals of ecosystem management plans are: 1) maintaining viable populations; 2) having a representation of all ecosystem types on the landscape; 3) maintaining ecological processes, notably natural disturbance regimes; 4) protecting the evolutionary potential of species and ecosystems; and 5) accommodating human uses of the landscape (Grumbine 1994). These five goals have been incorporated into the natural resource Management Actions found in the CMP.

3.2 CMP MANAGEMENT ACTIONS

The 12 management component plans include 103 individual Management Actions. The majority of the 102 Management Actions in the CMP call for future planning, research or studies. Many others recommend communication programs or describe management processes and goals to be adopted by UH. Table 3-1 shows the complete list of Management Actions proposed in the CMP. Each Management Action includes a Type of Recommendation classification. The component plan headings include the reference to the corresponding section of the CMP.

Table 3-1. Categorization of Management Actions Recommended in the CMP

CMP Location¹	Management Action²	Type of Recommendation
7.1.1 Native Hawaiian Cultural Resources		
CR-1*	Kahu Kū Mauna shall work with families with lineal and historical connections to Mauna Kea, cultural practitioners, and other Native Hawaiian groups, including the Mauna Kea Management Board's Hawaiian Culture Committee, toward the development of appropriate procedures and protocols regarding cultural issues.	Planning
CR-2	Support application for designation of the summit region of Mauna Kea as a Traditional Cultural Property, per the National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq. in consultation with the larger community.	Planning
CR-3	Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape	Communications
CR-4*	Establish a process for ongoing collection of information on traditional, contemporary, and customary cultural practices	Study
CR-5*	Develop and adopt guidelines for the culturally appropriate placement and removal of offerings	Cultural Practices
CR-6*	Develop and adopt guidelines for the visitation and use of ancient shrines	Cultural Practices
CR-7*	Kahu Kū Mauna shall take the lead in determining the appropriateness of constructing new Hawaiian cultural features.	Cultural Practices
CR-8*	Develop and adopt a management policy for the UH Management Areas on the scattering of cremated human remains	Cultural Practices
CR-9*	A management policy for the cultural appropriateness of building ahu or "stacking of rocks" will need to be developed by Kahu Kū Mauna who may consider similar policies adopted by Hawai'i Volcanoes National Park.	Cultural Practices
CR-10*	Develop and implement a historic property monitoring program to systematically monitor the condition of the historic district and all historic properties, including cultural sites and burials.	Planning
CR-11	Complete archaeological survey of the portions of the Summit Access Road corridor under UH management	Study
CR-12*	Consult with Kahu Kū Mauna about establishing buffers (preservation zones) around known historic sites in the Astronomy Precinct, to protect them from potential future development.	Planning
CR-13*	Develop and implement a burial treatment plan for the UH Management Areas in consultation with Kahu Kū Mauna Council, MKMB's Hawaiian Culture Committee, the Hawai'i Island Burial Council, recognized lineal or cultural descendants, and SHPD.	Planning
CR-14	Immediately report any disturbance of a shrine or burial site to the rangers, DOCARE, Kahu Kū Mauna, and SHPD.	Management Process
7.1.2 Natural Resources		
NR-1*	Limit threats to natural resources through management of permitted activities and uses	Management Process
NR-2*	Limit damage caused by invasive species through creation of an invasive species prevention and control program.	Planning
NR-3*	Maintain native plant and animal populations and biological diversity	Planning
NR-4*	Minimize barriers to species migration, to help maintain populations and protect ecosystem processes and development	Management Goals
NR-5*	Manage ecosystems to allow for response to climate change	Management Goals
NR-6	Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea's unique natural resources.	Management Process

¹ Items with an asterisk * are described further after this table.

² Table 3-2 includes the location of the 12 component plans in the CMP (e.g., Section 7.1.1 Native Hawaiian Cultural Resources)

Table 3-1. Categorization of Management Actions Recommended in the CMP

CMP Location¹	Management Action²	Type of Recommendation
NR-7*	Delineate areas of high native diversity, unique communities, or unique geological features within the Astronomy Precinct and at Hale Pōhaku and consider protection from development.	Planning
NR-8*	Consider fencing areas of high native biodiversity or populations of endangered species to keep out feral ungulates (applies to areas below 12,800 ft elevation).	Planning
NR-9*	Increase native plant density and diversity through an outplanting program	Planning
NR-10*	Incorporate mitigation plans into project planning and conduct mitigation following new development	Planning
NR-11*	Conduct habitat rehabilitation projects following unplanned disturbances	Planning
NR-12*	Create restoration plans and conduct habitat restoration activities, as needed	Planning
NR-13*	Increase communication, networking, and collaborative opportunities, to support management and protection of natural resources	Management Process
NR-14	Use the principles of adaptive management when developing programs and methodologies. Review programs annually and revise any component plans every five years, based on the results of the program review.	Management Process
NR-15	Conduct baseline inventories of high-priority resources, as outlined in an inventory, monitoring, and research plan.	Study
NR-16*	Conduct regular long-term monitoring, as outlined in an inventory, monitoring, and research plan.	Study
NR-17	Conduct research to fill knowledge gaps that cannot be addressed through inventory and monitoring.	Study
NR-18	Develop geo-spatial database of all known natural resources and their locations in the UH Management Areas that can serve as baseline documentation against change and provide information essential for decision-making.	Management Process
7.1.3 Education and Outreach		
EO-1*	Develop and implement education and outreach program.	Communications
EO-2*	Require orientation of users, with periodic updates and a certificate of completion, including but not limited to visitors, employees, observatory staff, contractors, and commercial and recreational users.	Access Control
EO-3*	Continue to develop, update, and distribute educational materials	Communications
EO-4*	Develop and implement a signage plan to improve signage throughout the UH Management Areas (interpretive, safety, rules and regulations).	Signage
EO-5*	Develop interpretive features such as self-guided cultural walks and volunteer-maintained native plant gardens.	Planning
EO-6*	Engage in outreach and partnerships with schools, by collaborating with local experts, teachers, and university researchers, and by working with the 'Imiloa Astronomy Center of Hawai'i.	Communications
EO-7*	Continue and increase opportunities for community members to provide input to cultural and natural resources management activities on Mauna Kea, to ensure systematic input regarding planning, management, and operational decisions that affect natural resources, sacred materials or places, or other ethnographic resources with which they are associated.	Communications
EO-8*	Provide opportunities for community members to participate in stewardship activities	Management Process
7.1.4 Astronomical Resources		
AR-1*	Operate the UH Management Areas to prohibit activities resulting in negative impacts to astronomical resources	Management Goals
AR-2*	Prevent light pollution, radio frequency interference and dust	Management Goals
7.2.1 Activities and Uses		

Table 3-1. Categorization of Management Actions Recommended in the CMP

CMP Location¹	Management Action²	Type of Recommendation
ACT-1*	Continue and update managed access policy of 1995 Management Plan	Access Control
ACT-2*	Develop parking and visitor traffic plan	Planning
ACT-3*	Maintain a presence of interpretive and enforcement personnel on the mountain at all times to educate users, deter violations, and encourage adherence to restrictions.	Staffing
ACT-4*	Develop and enforce a policy that maintains current prohibitions on off-road vehicle use in the UH Management Areas and that strengthens measures to prevent or deter vehicles from leaving established roads and designated parking areas.	Access Control
ACT-5*	Implement policies to reduce impacts of recreational hiking	Planning
ACT-6*	Define and maintain areas where snow-related activities can occur and confine activities to slopes that have a protective layer of snow	Access Control
ACT-7	Confine University or other sponsored tours and star-gazing activities to previously disturbed ground surfaces and established parking areas.	Access Control
ACT-8*	Coordinate with DLNR in the development of a policy regarding hunting in the UH Management Areas.	Planning
ACT-9*	Maintain commercial tour permitting process; evaluate and issue permits annually	Management Process
ACT-10*	Ensure OMKM input on permits for filming activities	Management Process
ACT-11*	Seek statutory authority for the University to regulate commercial activities in the UH Management Areas	Legislative Action
ACT-12*	Ensure input by OMKM, MKMB and Kahu Kū Mauna on research permits and report results to OMKM	Management Process
7.2.2 Permitting and Enforcement		
P-1*	Comply with all applicable federal, state, and local laws, regulations, and permit conditions related to activities in the UH Management Areas	Management Process
P-2*	Strengthen CMP implementation by recommending to the BLNR that the CMP conditions be included in any Conservation District Use Permit or other permit.	Management Process
P-3*	Obtain statutory rule-making authority from the legislature, authorizing the University of Hawai'i to adopt administrative rules pursuant to Chapter 91 to implement and enforce the management actions.	Legislative Action
P-4	Educate management staff and users of the mountain about all applicable rules and permit requirements	Communications
P-5*	Continue coordinating with other agencies on enforcement needs	Management Process
P-6*	Obtain legal authority for establishing, and then establish, a law enforcement presence on the mountain that can enforce rules for the UH Management Areas on Mauna Kea.	Legislative Action
P-7*	Develop and implement protocol for oversight and compliance with Conservation District Use Permits.	Management Process
P-8*	Enforce conditions contained in commercial and Special Use permits	Management Process
7.3.1 Infrastructure and Maintenance		
IM-1*	Develop and implement an Operations Monitoring and Maintenance Plan	Management Process
IM-2	Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	Management Process
IM-3*	Conduct historic preservation review for maintenance activities with potential adverse effect on historic properties	Management Process
IM-4*	Evaluate need for and feasibility of a vehicle wash station near Hale Pōhaku, and requiring that vehicles be cleaned.	Planning
IM-5*	Develop and implement a Debris Removal, Monitoring and Prevention Plan	Planning
IM-6*	Develop and implement an erosion inventory and assessment plan	Planning
IM-7	Prepare a plan, in collaboration with the Department of Defense, to remove	Planning

Table 3-1. Categorization of Management Actions Recommended in the CMP

CMP Location¹	Management Action²	Type of Recommendation
	military wreckage from a remote area of the UH Management Areas, while ensuring protection of natural and cultural resources.	
IM-8*	Assess feasibility of paving the Summit Access Road	Planning
IM-9*	Evaluate need for additional parking lots and vehicle pullouts and install if necessary.	Planning
IM-10	Evaluate need for additional public restroom facilities in the summit region and at Hale Pōhaku, and install close-contained zero waste systems if necessary	Planning
IM-11*	Encourage existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.	Management Process
IM-12*	Conduct energy audits to identify energy use and system inefficiencies, and develop solutions to reduce energy usage	Management Process
IM-13*	Conduct feasibility assessment, in consultation with Hawaii Electric Light Company, on developing locally-based alternative energy sources.	Planning
IM-14*	Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations.	Management Process
7.3.2 Construction Guidelines		
C-1*	Require an independent construction monitor who has oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements.	Management Process
C-2*	Require use of Best Management Practices Plan for Construction Practices.	Management Process
C-3*	Develop, prior to construction, a rock movement plan	Management Process
C-4*	Require contractors to provide information from construction activities to OMKM for input into OMKM information databases	Management Process
C-5*	Require on-site monitors (e.g., archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agency	Management Process
C-6*	Conduct required archaeological monitoring during construction projects per SHPD approved plan.	Management Process
C-7*	Education regarding historical and cultural significance	Management Process
C-8*	Education regarding environment, ecology and natural resources	Management Process
C-9*	Inspection of construction materials	Management Process
7.3.3 Site Recycling, Decommissioning, Demolition and Restoration		
SR-1*	Require observatories to develop plans to recycle or demolish facilities once their useful life has ended, in accordance with their sublease requirements, identifying all proposed actions.	Management Process
SR-2*	Require observatories to develop a restoration plan in association with decommissioning, to include an environmental cost-benefit analysis and a cultural assessment.	Management Process
SR-3*	Require any future observatories to consider site restoration during project planning and include provisions in subleases for funding of full restoration.	Management Process
7.3.4 Considering Future Land Use		
FLU-1*	Follow design guidelines presented in the 2000 Master Plan	Management Goals
FLU-2*	Develop a map with land-use zones in the Astronomy Precinct based on updated inventories of cultural and natural resources, to delineate areas where future land use will not be allowed and areas where future land use will be allowed but will require compliance with prerequisite studies or analysis prior to approval of Conservation District Use Permit.	Planning
FLU-3*	Require cataloguing of initial site conditions for use when conducting site restoration.	Management Process

Table 3-1. Categorization of Management Actions Recommended in the CMP

CMP Location¹	Management Action²	Type of Recommendation
FLU-4*	Require project specific visual rendering of both pre- and post-project settings to facilitate analysis of potential impacts to view planes.	Management Process
FLU-5	Require an airflow analysis on the design of proposed structures to assess potential impacts to aeolian ecosystems.	Management Process
FLU-6	Incorporate habitat mitigation plans into project planning process	Management Process
FLU-7*	Require use of close-contained zero-discharge waste systems for any future development in the summit region, from portable toilets to observatory restrooms, if feasible.	Planning
7.4.1 Operations and Implementation		
OI-1*	Maintain OMKM, MKMB, and Kahu Kū Mauna in current roles, with OMKM providing local management of the UH Management Areas, and MKSS providing operational and maintenance services.	Management Process
OI-2*	Develop training plan for staff and volunteers.	Management Process
OI-3*	Maintain and expand regular interaction and dialogue with stakeholders, community members, surrounding landowners, and overseeing agencies to provide a coordinated approach to resource management.	Communications
OI-4*	Establish grievance procedures for OMKM, to address issues as they arise.	Management Process
OI-5*	Update and implement emergency response plan.	Planning
7.4.2 Monitoring Evaluation and Updates		
MEU-1*	Establish a reporting system to ensure that the MKMB, DLNR, and the public are informed of results of management activities in a timely manner.	Communications
MEU-2*	Conduct regular updates of the CMP that reflect outcomes of the evaluation process, and that incorporate new information about resources.	Planning
MEU-3*	Revise and update planning documents, including the master plan, leases, and subleases, so that they will clearly assign roles and responsibilities for managing Mauna Kea and reflect stewardship matters resolved with DLNR.	Planning

3.2.1 Management Action Discussions

This section provides additional detailed discussions of the Management Actions that are marked in Table 3-1 with an asterisk.

CR-1. Appropriate procedures regarding cultural issues

Culturally appropriate protocols developed in consultation with Kahu Kū Mauna, families with lineal and historic connections to Mauna Kea, cultural practitioners, and other Native Hawaiian individuals and organizations may describe culturally appropriate practices and what may be considered culturally disrespectful behaviors that should either be discouraged or, perhaps, banned altogether. Subject to compliance with the legal requirements for access to traditional and customary practices of the State Constitution, no restrictions shall be placed on any Native Hawaiian cultural observance except those observances that are considered culturally inappropriate by a collective consensus of Kahu Kū Mauna, the MKMB Hawaiian Culture Committee, families with lineal and historic connections to Mauna Kea, cultural practitioners, and other Native Hawaiian groups. Access shall not be denied or unduly restricted for Native Hawaiians wanting to visit sites such as burials or shrines or exercise their religious and spiritual practices within the UH Management Areas. Public tours of burial sites shall be prohibited. The

rangers or other management staff shall be notified of visits to burial sites prior to the visits for security and safety reasons.

CR-4. Collection of information on traditional and customary cultural practices

Several methods may be used to establish a process for the ongoing collection of information on traditional and customary cultural practices and their significance. OMKM should partner with educational institutions such as the UH-Hilo and Hilo Community College, to establish an oral history program that would memorialize the traditional and customary practices associated with Mauna Kea. Native Hawaiian families or communities that have a connection to Mauna Kea shall be invited to work with OMKM to identify traditional and customary practices associated with Mauna Kea and ensure those practices are protected and respected.

CR-5. Guidelines for the culturally appropriate removal of offerings

One practice that has become a major management issue in many places in Hawai'i is the placement of offerings on altars. Offerings include both biodegradable items (e.g., leis and foods such as bananas) and a variety of other objects, including unmodified stones, artifacts, prayer flags, and crystals. Accumulations of offerings can have an adverse effect on the integrity of historic properties as well as on natural resources. In most cases, to protect resources, offerings must be removed; however, this process must be done in a culturally appropriate manner. Guidelines will include a stipulation that food offerings be removed immediately following the ceremony, and a means of handling non-food offerings during and after removal. Consultation with cultural practitioners is critical to the development of these guidelines. A culturally trained staff person or a specially designated individual shall be responsible for the removal of offerings.

CR-6. Guidelines for the visitation and use of ancient shrines

Guidelines for the visitation and use of ancient shrines are necessary to provide a mechanism that allows for access and use by modern cultural practitioners yet preserves their integrity and the underlying meaning they had for the ancestors that built them. Guidelines shall include the provision that access shall not be denied or unduly restricted for any Native Hawaiian wanting to visit the shrines within the UH Management Areas. No restrictions shall be placed on any observance or practice that is deemed culturally appropriate (see *CR-1 Appropriate procedures regarding cultural issues*), as long as the practice does not violate Chapter 6E, which prohibits the alteration of historic properties. Practitioners shall be informed of the same general rules and precautions as are all public users. A program to regularly monitor the condition of ancient shrines shall be established and if effects of heavy use become apparent, measures will be considered to control access (see CR-9, CR-13, and CR-14).

CR-7. Determining the appropriateness of constructing new Hawaiian cultural features

This is an extremely sensitive issue as most Native Hawaiians will be the first to say that it is not their *kuleana* to judge the cultural practices of another Hawaiian. However, the intent of this management measure is to develop a process to determine culturally appropriate protocols. Kahu Kū Mauna and/or the MKMB's Hawaiian Cultural Committee in consultation with families with lineal connections to Mauna Kea, *kūpuna*, cultural practitioners, or Native Hawaiian organizations will work in collaboration to develop these protocols. Guidelines should be adopted to assist in formulating culturally appropriate protocols (e.g., to determine which kinds of features and locations are appropriate or inappropriate, as well as if and when a regulatory review process is necessary). Construction of new features will be evaluated to determine whether a CDUP is required. New construction not complying with the applicable protocols, the

conditions imposed by guidance provided by Kahu Kū Mauna, MKMB, and/or the MKMB Hawaiian Cultural Committee or administrative rules, if/when adopted, will be dismantled.

CR-8. Management policy on the scattering of cremated human remains

The scattering of the ashes of cremated human remains and the burial of urns in the summit area of Mauna Kea are on-going cultural practices. These private affairs are not well known or documented, but they may impact historic properties. One recommendation is to adopt a policy similar to that recently instituted at Hawai'i Volcanoes National Park, with the following considerations:

The scattering of cremated human remains requires a special use permit. A death certificate is required to obtain a special use permit. Conditions of the permit include: scattering must take place in a such a manner and in such a location that the ashes will not be located and identified as human remains; no memorials, plaques, photos or flowers may be left behind; the permittee recognizes and is aware of the sensitivity of this activity and agrees to perform it in a discrete and private manner; all local, state, and county rules and regulations must be followed; violation of the terms and conditions of the permit may result in the immediate revocation of the permit and/or other law enforcement action.

However the ultimate determination will be based upon appropriate cultural consultation and applicable rules.

CR-9. Management policy on the piling and stacking of rocks

Ahu, which are created by placing single rocks or stacks of rocks on boulders and outcrops, dot the landscape in the summit area of Mauna Kea. Most of the 336 “find spots” recorded in the 2005–2007 archaeological survey are piled and stacked rocks. Such features, which are widespread in Hawai'i, may have as their basis a traditional cultural practice, but whose purpose and meaning have probably changed over time. At the same time, there is reason to believe that a large number of the single rock features and small concentrations of piled or stacked rocks on Mauna Kea are modern and that many were constructed by non-Hawaiian visitors in the last decade or so.

The management policy for piling and stacking rocks could be similar to that recently instituted at Hawai'i Volcanoes National Park (Kubota 2005). A culturally trained staff person will be responsible for the culturally appropriate removal of rock piles that are made on Mauna Kea. Visitors to and users of Mauna Kea will be educated about the importance of preserving the cultural landscape, with particular attention to prohibitions on the piling and stacking of rocks.

CR-10. Historic Property Monitoring Program

A historic property monitoring program would provide a plan for monitoring the condition of identified historic properties within the UH Management Areas. The primary purpose of monitoring these sites is to determine what uses, if any, are affecting historic properties and the degree and frequency of these effects. This information would, in turn, help in developing ways to prevent or minimize the occurrence of damaging uses. The long-term effects of human activities and natural processes on historic properties shall be monitored and management policies adjusted, as needed. Inventories of areas that have not yet been surveyed, such as the road corridor, should be a priority. In addition, new discoveries and Hawaiian cultural features that are newly erected should be described and their locations recorded, so that they can be

protected and monitored as part of this program. The recording and monitoring of new cultural features may depend on what guidelines or policies are adopted for new cultural features. While

the recording of new features should be done, to continue the process of developing a baseline, the monitoring of all features, which already number over 300, would be an overwhelming and expensive task and would need to be sensitive to the desire of some Hawaiians to not have their features recorded. The findings of the historic property monitoring program will be used to inform management decision-making.

CR-12. Establishing buffer zones around historic sites

In order to protect all known historic sites within the Astronomy Precinct, a specified buffer shall be established around each site, if and when a specific set of development plans is proposed. OMKM and Kahu Kū Mauna will work with DLNR, including SHPD and appropriate divisions, on establishing buffers. Each buffer would vary in size based on the area of potential effect, which is defined as the geographic area or areas within which an action may affect historic properties. HAR §13-277-4 requires buffer zones to be established to ensure that the integrity and context of historic properties are preserved. Establishing and marking buffers with fences, the most common type of buffer, would draw attention to the sites, and is not recommended unless a site needs to be identified for a particular activity.

CR-13. Burial Treatment Plan

Components of the burial treatment plan should include documenting inadvertently exposed burials and reburial sites for inclusion in the historic property catalogue; appropriate treatment protocols for human remains exposed due to natural causes; and monitoring protocols for burial sites. The burial treatment plan must adhere to all state laws and shall be approved by SHPD in consultation with the HIBC and where appropriate, recognized lineal and cultural descendants, and Kahu Kū Mauna. Determinations on the treatment and disposition of inadvertent discoveries of human remains fall to the DLNR and SHPD, in consultation with the HIBC, the Office of Hawaiian Affairs, and any known descendants (cf. §6E-43.6, HRS, and HAR 13-300-40). Although circumstances for each inadvertent burial find may differ, the procedures specified in §6E-43.6(a) through (c) should always be followed. Depending on the results of consultation with Kahu Kū Mauna and other stakeholders, including the HIBC and any known descendants, treatment measures may also include the covering up or securing of any exposed skeletal remains.

NR-2. Limiting damage caused by invasive species

Management tools to deal with invasive species include preventing new species from becoming established and controlling established species. Monitoring is a necessary component of both these tools. Prevention and control measures for invasive species to consider include

- Work with neighboring land managers to control invasive plants and animals that occur near property borders.
- Remove or control populations of invasive species at the developed areas of Hale Pōhaku and along Summit Access Road, to prevent spread into the UH Management Areas.

-
- Remove any species or individuals that appear to have been intentionally introduced to the UH Management Areas. Report any observation of intentional introductions to USDA Animal and Plant Health Inspection Service and DLNR.
 - Request that everyone who comes up the mountain brush down their clothes and shoes to remove invasive plant seeds and invertebrates.
 - Require wash-down of all construction vehicles and heavy equipment before they enter Hale Pōhaku or the UH Management Areas.
 - Evaluate installation of a vehicle wash-station, to remove invasive plant seeds and invertebrates from vehicles.

NR-3. Minimizing population decline and loss of native biodiversity

The goal of maintaining native plant and animal populations and biological diversity in the UH Management Areas can be accomplished through the following objectives: 1) minimizing human-induced population declines or loss of biodiversity; 2) detecting changes in population size of rare or protected native species; 3) determining causes of population declines; and 4) restoring declining populations through adaptive management. Causes of population declines may include invasive species, habitat alteration, hunting and sample collection, wildfires, pollution, loss of pollinators and seed dispersers, genetic bottlenecks (inbreeding depression), small population size, and climate change.

NR-4. Minimizing barriers to species migration

Barriers to migration may include habitat alteration through development, the presence of invasive species, low dispersal rates or small population sizes of the migrating species, and missing species in the new habitat, such as prey items or symbiotic species. For example, if development is blocking the movement of a native plant species, a potential management action would be to conduct outplanting and restoration projects on the other side of the development (downslope, if species are moving to lower elevations, or upslope, if species are moving to higher elevations).

NR-5. Addressing climate change

Detecting the impacts of climate change will require monitoring of changes in climate and natural resource abundance and distribution. Monitoring climate change is a global, collaborative effort to which the University could contribute by collecting weather data at Hale Pōhaku and in the UH Management Areas and providing it as a public resource for use in climate change modeling and other studies.

The goal of managing ecosystems to allow for response to climate change can be accomplished through 1) detecting the impacts of climate change through long-term monitoring; 2) understanding the impacts of climate change on natural resources; 3) aiding or supplementing natural migration of communities using adaptive management (see NR-11); and 4) collaborating with other landowners and managers on Mauna Kea.

NR-7. Delineating areas for protection

Areas considered for protection may include

- Cultural and historical resources
- Unique geological features (Lockwood 2000)
 - Undeveloped *pu'u*
 - Glacial features (high standing rock outcrops)
 - Sub-glacial lava-ice contact features
- Habitat for important, rare, threatened, or endangered native species, including
 - Wēkiu bug
 - Mauna Kea silversword
 - Palila
 - Hawaiian hoary bat
 - Māmane trees

NR-8. Fencing plan to control feral ungulates

Non-native feral ungulates feed on the native flora and fauna in the UH Management Areas. Fencing areas of high native biodiversity or populations of endangered species in areas below the 12,800 foot elevation will help protect natural resources from feeding activity. A fencing plan will identify priority areas for fencing protection when funds become available, and should consider whether a CDUP or other approval is necessary before fences can be constructed.

NR-9. Increasing native plant density and diversity through an outplanting program

Native plant density and diversity can be increased by planting greenhouse- or field-grown plants in sensitive or unique habitats, using native plants in landscaping at Hale Pōhaku, and by creating educational native gardens. The native gardens will also help educate the public by providing living examples of unique and rare plant species found in the area. Only plants grown from locally obtained seeds or stock should be used. All plantings must be first cleared through DLNR.

NR-10. Mitigation planning

All future development in the UH Management Areas should include mitigation plans for preventing or repairing damage to sensitive habitats caused by construction and development activities. Any habitat that will be permanently removed should be replaced on at least a one-to-one basis, through either creation of new habitat, restoration of degraded existing habitat, or by permanent protection of similar unique habitats. Mitigation plans should be paid for and prepared by the project proposer, but should be reviewed and approved by the University and DLNR. If the disturbed habitat contains protected species or other critical habitats, mitigation plans may also have to be approved by state and federal agencies. Mitigation projects should include a minimum of two to five years follow-up monitoring, to assess the results of the project. The length of time that monitoring must occur will depend on the scale of the project and the organisms for which the habitat is being mitigated. Mitigation projects on the summit should focus on creation of new wēkiu bug habitat. Mitigation projects conducted at Hale Pōhaku should focus on restoration or enhancement of existing māmane woodlands.

NR-11. Habitat rehabilitation

Rehabilitation activities should be conducted when unintentional damage occurs. If desired, habitat can be restored rather than rehabilitated. Examples of rehabilitation projects include

cleanup of contaminant spills, roadside repair projects following vehicle accidents, and erosion repair projects.

NR-12. Restoration

The goal of restoring damaged ecosystems can be achieved through the following objectives: 1) creating restoration plans, 2) conducting restoration activities, and 3) monitoring and

maintaining restoration projects. Examples of restoration projects to conduct in the UH Management Areas include: restoration of wēkiu bug habitat in disturbed areas (e.g., near trails and existing observatory facilities); roadside restoration projects; silversword restoration projects; māmane woodland restoration through fencing, invasive species control, and out-planting; and habitat restoration following observatory decommissioning.

It is recommended that plans be coordinated with other agencies. Many of these agencies have existing restoration programs or projects that might be expanded to include UH Management Areas, provide assistance or funding, or provide guidance and techniques for restoration planning.

NR-13. Increasing collaboration and cooperation between OMKM and State and Federal agencies

Currently there is no mechanism for integrated or coordinated management of Mauna Kea's natural resources, including lands outside of the UH Management Areas. No regular meetings are held between the governmental agencies with management responsibilities for Mauna Kea. Increasing communication between the stakeholders on the mountain and identification of opportunities for collaboration can be achieved in part through the development of an interagency working group involving all entities that are responsible for, or involved in, natural resource management in high elevation areas (above 6,200 ft, or 1,900 m) on Mauna Kea, including the University, State and Federal agencies, non-profit organizations, and other agencies and persons involved in the day-to-day management of Mauna Kea lands.

NR-16. Conducting regular, long-term monitoring

The results from monitoring and research programs should be used to adjust management policies, as needed, to better manage the resources (adaptive management). Long-term monitoring should include monitoring of enhancement, mitigation, and restoration projects to determine whether projects have been successful and to provide guidance for future management activities.

EO-1. Education and Outreach Program Development

The Educational and Outreach Program should focus on increasing public understanding and appreciation of Mauna Kea and on involving people in education, volunteer projects, and in research aimed at protecting the cultural and natural resources. A preliminary step will be creation of an education and outreach plan that should address visitor and user education; Mauna Kea as an educational and scientific resource; outreach activities; and implementation. Program needs and management activities for these four topics are discussed in further detail below.

Visitor and User Education: A major goal of the Education and Outreach Program is to educate both visitors and workers about the cultural and natural significance of the mountain, including

its sacredness. It would also teach them how to minimize their impact on Mauna Kea and would reduce uninformed behavior that can lead to inadvertent damage to resources. Education and outreach activities should be developed to promote a greater knowledge base and understanding of cultural resources; Hawaiian cultural practices; and the significance of archaeological sites, place names, and geophysical elements such as cinder cones and glacial deposits. Native Hawaiian values and cultural information should be integrated into the program, and all users should be provided with specific guidelines for culturally appropriate behavior on Mauna Kea. In addition to increasing cultural awareness, educational activities should provide users with information on the unique biological and geological resources found in the subalpine and alpine zones on Mauna Kea, and the best ways to protect these resources.

The Education and Outreach Plan should identify ways to enhance the visitor experience at Hale Pōhaku and the summit and to increase off-site education of interested people and potential visitors. It should also educate a larger community, including non-residents, about Mauna Kea. This can be accomplished by using a range of mechanisms for education, including rangers, docents and volunteers, videos, brochures, displays, school programs, and public meetings and forums. Multiple venues for education and outreach activities, and providing key material in languages in addition to English (e.g., Hawaiian, Japanese), will ensure greater accessibility by the community and allow educational efforts to reach a wider audience. Incorporating media such as newspapers, DVDs, the internet, and podcasts³ into educational efforts will also increase coverage. School programs are a valuable way to ensure that Hawaii's children learn about the importance of Mauna Kea. The development of school programs is discussed further in *EO-6, Outreach and partnerships with schools*.

The need for a mandatory visitor orientation, similar to what is required at Hanauma Bay, Oahu, has been identified on several occasions (Group 70 International 2000; Conant et al. 2004). The education and outreach plan should outline the process and discuss a venue for mandatory visitor orientation, and community consultations should play a part in development the orientation program. More information is provided below, in *EO-2, Mandatory Visitor Orientation*.

Because VIS staff, volunteers, and rangers are important information sources for visitors to the mountain, the plan should also address education and training needs for these personnel. Staff training materials should provide background information on cultural, archaeological, historical, and natural resources and they should promote cultural sensitivity. Field trips should be incorporated into the training process, in order to improve ability of staff to identify and locate cultural and natural resources. Commercial tour operators are also an important source of information to a subset of visitors, and the education and outreach plan should include the development of training requirements for professional tour guides. At minimum, educational materials should ensure the quality and accuracy of information tour guides give to visitors.

Another important part of the education and outreach program will be development of materials to educate people on health and safety issues and applicable laws, rules, and regulations. Using information in Section 2.5, which is a summary of applicable laws and regulations, materials can be developed to educate users on rules, regulations, and policies regarding

³ A podcast is a series of audio or video digital-media files which is distributed over the Internet to portable media players and personal computers. A podcast is distinguished from other digital-media formats by its ability to be syndicated, subscribed to, and downloaded automatically when new content is added.

protected natural resources and historic properties and the penalties for disturbing these resources. For example, users should be made aware that disturbance (injuring, destroying, or altering) of archaeological sites is prohibited by law (HRS, §6E-11). The plan should also discuss additional signage needs, to reduce emergency incidents on the summit and the summit access road (see *EO-4, Development of a signage plan*, below), and should address developing additional materials to provide information on health and safety concerns and how to safely approach the summit.

Outreach Activities: The Plan should address development of outreach activities including gathering public opinion through community consultations and encouraging community stewardship of Mauna Kea.

EO-2. Mandatory Visitor Orientation

One method to ensure that all visitors receive the information they need in order to better protect Mauna Kea's cultural and natural resources is to require everyone who visits the summit to participate in an orientation. The easiest form of orientation would be a video. There are several details that must be worked out before implementing an orientation program, including how often individuals would be required to attend the orientation (e.g., for each visit, annually, every five years, or each time video is updated); location of orientation (at VIS, elsewhere at Hale Pōhaku, 'Imiloa, commercial operator's vans, on the internet); and whether there will be any exceptions to requirements for an orientation. It is recommended that, at minimum, commercial tour operators and existing and potential future observatory facilities staff be required to incorporate the orientation video into their program. This requirement can be included in the tour operators' permit conditions. Other details include working out how proof of attendance will be provided. Options include maintenance of a database of registered users, a colored armband or bracelet, a pin or button, a rear-view mirror tag, or a printed certificate with name and date of completion.

Contents of the orientation video must also be determined. At a minimum, the video should include information on health and safety, rules and regulations, concerns regarding sensitivity of cultural and natural resources, the NAR, rangers as a resource, litter and debris control, prohibitions on off-road vehicle use, and emergency procedures. To protect cultural resources, the video should inform visitors to not alter or disturb cultural artifacts, and should provide specific guidelines for culturally appropriate behavior on Mauna Kea (e.g., piling and stacking of rocks may be prohibited because it is disrespectful and "because the piles don't belong there"). Consideration should be given to providing a short reenactment of traditional cultural activities associated with Mauna Kea, as a way to increase visitor awareness of the significance of Mauna Kea to the Hawaiian people. It is recommended that the community (particularly *kūpuna*) be consulted in development of cultural aspects of the video. To protect natural resources, the video should inform visitors to stay on marked trails, to avoid crushing cinders, and to pack out all trash. It should also provide tips on preventing the spread of invasive species (e.g., instructing people to brush down clothes and shoes in a designated area at Hale Pōhaku prior to hiking or visiting the educational gardens). To increase public safety, the video should orient visitors to the potential hazards of high altitude environments, recommend acclimation time at the VIS, and educate drivers by including information on safe driving on the Summit Access Road.

Mandatory orientation training for tour operators, rangers, VIS staff, and volunteers should be required, regardless of whether mandatory orientation for the general public is implemented.

This training program should be implemented immediately, and no rule-making authority is required to implement it.

EO-3. Development and distribution of educational materials

Educational materials in a variety of formats can be used on and off site to explain important aspects of Mauna Kea. While printed brochures are useful for visitors on site and can be distributed from various outlets (e.g., VIS, Hale Pōhaku, IfA/OMKM office in Hilo, 'Imiloa, commercial tour operators), web-based products are more interactive and can reach a broader audience. OMKM shall continue to develop, update, and distribute educational material, including newsletters, videos, and brochures on topics such as safety, cultural resources, natural resources, and recreational activities. OMKM should provide educational materials to commercial tour operators, to ensure the quality and accuracy of the information they provide to visitors. A high quality educational video (DVD) on the unique cultural and natural resources of Mauna Kea should be produced. The DVD could be sold in the VIS and 'Imiloa gift shops for a nominal fee (to cover manufacturing expenses) and be provided to tourists by tour operators as part of the tour package. Copies should be donated to local schools and libraries, and be made available on the internet.

Web sites are an effective means of broadly distributing information. OMKM's website, www.malamamaunakea.org, should be updated regularly to include information on the natural and cultural resources found at Mauna Kea, and on visiting the mountain safely and responsibly. It should also contain video or printable versions of brochures available at VIS, and (if/when implemented) entrance requirements and rules and regulations. The website and an email list-serve can be used to distribute information pertinent to the community, to keep the public informed. Such information shall take the form of newsletters, announcements of public meetings and educational opportunities, and the MKMB minutes. Podcasts and web-casts should be added to the website to highlight Mauna Kea's unique resources. It may be possible to involve students at UH-Hilo and other local colleges or universities in their production. Subjects could include the orientation video, historical and cultural review, natural resources review, self-guided tour of the trail system (including information on cultural resources, native plants and animals, and physical resources), self-guided tour of the summit (showing the telescope facilities and discussing the unique ecosystem at the summit), and a self-guided tour of the DLNR botanical enclosure.

As a general policy, Hawaiian and English languages should both be used for signs, pamphlets, videos and other material developed for the general public and, where practical, the Hawaiian language should be given the position of prominence in the communication format (Group 70 International 2000).

EO-4. Development of a signage plan

The education and outreach plan should include development of a signage plan, which should address sign development and design and installation requirements.

Sign development addresses needs for “Do Not” signage, health and safety information, trail markers, and interpretive signs. “Do Not” signage provides information on prohibited activities such as alcohol consumption, tampering with historical sites, littering, or hiking off-trail. Condition 13 of the 1995 Management Plan stipulates that “There shall be signs about the protection of historic sites as well as discouraging people from making ahus, subject to funding” (DLNR 1995). Signage pertaining to historic sites within the UH Managed Areas should reference HRS §6E-11, indicating that “it is a civil and administrative violation for any person to take, appropriate, excavate, injure, destroy or alter any historic property or aviation artifact located upon lands owned or controlled by the State.”

Health and safety signage should include signage in the summit area to reinforce awareness of safety issues and hazards (e.g., speeding, using 4-wheel drive and low gear, underage children, pregnant women and persons in poor health, proper clothing); providing safety signs or information posters at the VIS in English, Hawaiian, and Japanese languages and including universal symbols for health and safety issues.

Interpretive signs include trail markers for primary trails; signage alerting people to areas of sensitive cultural and natural resources and instructing them to stay on trails; and educational signage providing information to the visitor on what they are seeing. Consideration should be given to the development of educational areas (such as pull-outs along the Summit Access Road), with interpretive signage informing visitors about unique geological, meteorological, biological, and cultural features and ways to protect them. Another use of interpretive signage would be the labeling of key native and invasive plant species near the VIS and within the DLNR botanical enclosure.

Sign design considerations: Signs must be made from materials that can withstand severe weather (wind, snow, sun). Signage should use traditional Hawaiian place names and, whenever possible, include the Hawaiian language along with English. A subset of the signs should also contain Japanese translations. Consideration should be given to producing brochures summarizing the information provided on signage in a variety of languages.

Sign installation: Sign installation must comply with applicable rules and contain appropriate references to rules, including the requirements in HAR §13-277-7. The natural and cultural setting should be considered when locating signs. Establishing signage and trail markers in the UH Management Areas may lead to an increase in visitor use both on- and off-trail. There are cultural sensitivity concerns relating to continued disturbance of the summit environment and impacts on sacred land resulting from the installation of structures and visual distractions. Any signage installed in the summit region must be sensitive to cultural concerns and coordinated with Kahu Kū Mauna. It is possible that improving interpretive information at the VIS will eliminate the need for interpretive signage in the summit region.

EO-5. Development of interpretive features

Cultural resources: OMKM should work with SHPD to designate historic properties suitable for public visitation. Brochures or maps showing locations of sites can also provide information on these sites and encourage visitation through self-guided tours or docent-guided tours. This will provide opportunities for visitors to see and learn about cultural sites, while guiding them away from sensitive or unsuitable sites.

Natural resources: OMKM should work with DLNR to improve the DLNR botanical enclosure at the VIS, to support education, restoration, and volunteer involvement. This can be achieved through installation of interpretive signage and with volunteer-based restoration activities. Other possibilities for interpretive features include a self-guided tour (using brochures or podcasts) of geological resources at the summit and development of small pull-out gardens along the Summit Access Road, from Hale Pōhaku to the Summit, planted with representative vegetation and accompanying interpretive signage, to illustrate change of vegetation communities with an increase in elevation.

EO-6. Outreach and partnerships with schools

OMKM should work with local public and private schools, and universities to develop educational programs to be presented at local schools. For example, OMKM could work with the UH College of Education on developing a science curriculum revolving around Mauna Kea, and with 'Imiloa and the Na Pua No'ēau Program, at UH-Hilo, to develop an educational curriculum for Mauna Kea.

The school programs should focus on the cultural and natural resources found in high-elevation areas on Mauna Kea, and should incorporate field trips to Hale Pōhaku and the UH Management Areas. Field trip locations and activities should be age-appropriate, as young children should not visit the summit for health safety reasons. Consideration should be given to establishment of "Star Camps," where students learn about natural and cultural resources during the day and star-gaze in the evening. This may require access to facilities such as the dormitories and cafeteria, at Hale Pōhaku.

EO-7. Community input

OMKM shall continue and expand efforts to ensure diverse community representation during community input opportunities, to ensure systematic input regarding planning, management, and operational decisions. Outreach efforts shall include contacting local civic and environmental groups, local experts in natural and cultural resources, and members of the Native Hawaiian community, including *kūpuna* and those with lineal ties to Mauna Kea. Input should be gathered during both public meetings and more informal private consultations with the above community members. OMKM shall maintain a list of interested individuals, families, and organizations who should be notified and consulted when individual development projects requiring regulatory review are proposed (e.g., under Section 106, NEPA, HRS 343) or when other issues arise that may be a concern. Although Web sites and email list-serves should be used to distribute information pertinent to the community and to keep the public informed, other mechanisms, such as telephone, regular mail, and meetings may be required to reach all interested parties. Establishing means for collecting and addressing feedback, suggestions, questions, and concerns will help ensure that the entire community is included in consultation efforts. This should include a web-based forum and a comment box at the VIS, for both management and project related information, as well as for visitors to Mauna Kea.

EO-8. Providing opportunities for community members to participate in stewardship of Mauna Kea

Methods that can be used to encourage public involvement in the stewardship of Mauna Kea's resources include public meetings, workshops, citizen advisory groups, "friends" groups, and volunteer opportunities. Community involvement efforts should also include school programs, to get children involved.

Volunteer opportunities are a great way to inform more people about Mauna Kea and to encourage greater community participation in the protection of cultural and natural resources. There is already a very successful volunteer program to support the astronomy component. A decent program could be developed to provide guided tours highlighting cultural and natural resources. Service projects that fulfill stewardship objectives while also providing education and enjoyment to volunteers should be developed. Projects related to natural resources should include basic maintenance (trash pick-up and inspection for damage to facilities or signs); care of the botanical enclosure (weeding, watering, and inspecting the enclosure); enhancing native plant communities (weeding, outplanting, and care of native species around VIS and dormitories); trail maintenance and development; and restoration projects for native plant communities. Projects related to cultural resources should include training of archaeology students in field methods during the monitoring of historic properties. OMKM should cooperate and collaborate with other State and Federal agencies that run volunteer-based projects, to increase the volunteer pool and conduct larger-scale projects.

AR-1. Operate the UH Management Areas to Prohibit Activities Resulting in Negative Impacts to Astronomical Resources

The UH Management Areas were originally intended to act as a buffer to prevent negative impacts on astronomical resources. Management actions to protect other resources in the UH Management Areas will also protect astronomical resources.

AR-2. Prevent light pollution, radio frequency interference (RFI) and dust.

The use of outside lights in the UH Management Areas shall be discouraged and minimized, and the use of outside lights in the Astronomy Precinct shall be prohibited. All management activities should coordinate with Federal, State and County agencies to control light pollution from sources within the UH Management Areas and, to the extent feasible, in areas outside the UH Management Areas.

The use of fixed radio transmitters shall be prohibited, as shall any other sources of radio frequency interference.

Uses causing the emission of dust shall be discouraged and minimized. If any activities cause the emission of dust in the Astronomy Precinct, appropriate dust control measures shall be required.

ACT-1. Managed access policy

The permitted uses and controls as set forth in the 1995 Management Plan shall be maintained. Additional rules will be instituted to better manage access and protect resources. To establish or enforce access policies, University would need to obtain statutory authority to adopt administrative rules.

A key component of a managed access policy will be visitor registration and orientation to ensure that all who work at or visit Mauna Kea are taught about its unique, sensitive landscape, potential impacts of activities, health and safety issues, and rules and regulations. An entrance control protocol shall be developed to manage the summit road and the number of visitors at the

summit. Access to the summit region would be managed through a control point, with registration required for travel beyond Hale Pōhaku. The logistics of this process need further refinement, but would include establishment of an entrance kiosk at Hale Pōhaku. Signage stating hours of operation and access policies shall be displayed prominently at the entrance kiosk. Information regarding rules, safety and leave-no-trace practices shall be distributed. An orientation will ensure visitors are educated on safety and resources issues as well as on prohibited uses. Provisions will include that repeat users only attend the mandatory orientation only at certain time intervals (i.e., once per year). Consideration of adopting an entrance fee will be left open as an option if the University obtains rule making authority. Fees could be charged either per person or per vehicle.

Users shall be provided with information on historic properties, restrictions that protect historic properties and the historic district, and penalties. Users shall be informed that invasive species may be carried on clothes, boots and vehicles and areas for cleaning shall be provided. Advice for minimizing erosion caused by hiking off trail and by vehicles shall be given. Visitors will be advised that high winds, which occur regularly, can scatter unsecured debris and personal belongings across the landscape, possibly damaging natural and cultural resources. Simply informing users on the effects of disturbance caused by actions such as hiking off trail, the cumulative effects of the introduction of invasive species and erosion and the locations of trash receptacles, restrooms, and parking lots may help minimize disturbance.

Other considerations not currently covered in existing policies:

- Require permits for large groups (>15) to go 'off road' (but not in vehicles) in the UH Management Areas. Permits would be subject to fees and orientation requirements.
- Except for certified assistance animals for the disabled, such as hearing guide and seeing eye dogs, no animals shall be permitted out of vehicles within the UH Management Areas.
- Control the use of "air conveyance" by requiring special use permits for scattering ashes by helicopters and planes, and for aerial photography, and filming.
- Evaluate restricting travel to the summit to 4-wheel-drive vehicles for all users. Currently policy states that until the entire road is paved, all commercial and astronomy related vehicles must be 4-wheel-drive. This stipulation is not required for individual visitor vehicles.⁴

Certain visitor activities shall be confined to designated areas or allowed only under certain conditions. Activities taking place on the summit cones, which have been identified as traditional cultural property should be conducted in a manner that does not further alter the current condition and integrity of the summit cones. Visitors engaged in hiking, sightseeing and nature studies shall confine activities to designated roads and trails. Snow-play activities, such as skiing, sledding etc., shall be confined to areas where there is sufficient snow to allow the activity.⁵ Snow-play activities are not permitted in areas of known archaeological sites. Certain activities may be prohibited altogether within the Astronomy Precinct.

⁴ *Reevaluate this policy if shuttle service is developed. For cultural, research, education, special recreation and other approved special uses private 4-wheel-drive vehicles may be used in the UH Management Areas, with passes, even if the shuttle is developed.*

⁵ *Snow-play involving the use of snow designed equipment will be allowed on the steep slopes of cinder cones. Snow-play will be prohibited on the steep slopes of cinder cones when snow pack at a representative location is eight inches (203 mm) or less.*

“Extreme sports” is a relative new kind of recreational activity that was not addressed in the 1995 Management Plan, but was discussed in the Master Plan (2000), where it was defined as “recreational activities that seek dangerous and unusual thrills” (Group 70 International 2000). Prior to the acceptance of the Master Plan, DLNR reviewed and denied a request to conduct an extreme sports event on Mauna Kea because of the potential for significant harm to the environment and insensitivity to the cultural significance of the mountain. The University has determined that extreme sports shall be a prohibited activity.

ACT-2. Parking

Visitor parking on the shoulder of the Summit Access Road and in other undesignated areas may negatively impact resources and cause erosion. A plan to provide adequate parking for visitors must be devised. As visitor use increases the use of a shuttle may be necessary to reduce the overall number of vehicles on the road to and at the summit. MKSS (or other concessioner) would operate a shuttle service between the VIS (or an alternative location) and the summit. This would help minimize parking issues and safety issues resulting from too many vehicles on the summit road. If visitor use is consistently high, a daily shuttle service may be available, or shuttles may be used only during times of high traffic such as on snow days and during special events such as an eclipse or meteor shower. The University also has the option to ask other agencies for extra enforcement staffing to help handle days when visitor use is high and has the right to restrict the number of visitors in the UH Management Areas.

ACT-3. Interpretive and enforcement personnel

The ranger program has been successful in providing a presence on the mountain for operational and visitor support. If and when University receives rule making authority, it will need enforcement personnel, and rangers may be able to perform those duties. One potential option would be for the rangers to be cross-deputized as officers of DLNR DOCARE. It may not be necessary for all rangers to have enforcement responsibilities; the program could support a mix of enforcement and interpretive rangers. OMKM personnel with enforcement authority should maintain a presence at Hale Pōhaku and the summit region to deter violations and encourage adherence to restrictions. Interpretive personnel such as rangers, VIS staff and volunteers, shall be present on the mountain during operating hours.

ACT-4. Off-road vehicle use policy

Off-road vehicle use has the potential to irreversibly damage cultural and natural resources (see Section 6.3). The use of off-road vehicles is prohibited in the UH Management Areas, however there is a need to develop an official policy that also details any exceptions. The policy shall prohibit the operation of all motorized and unmotorized land vehicles except on roads or trails specifically designated for their use. Vehicles shall be restricted to designated parking areas, whether paved or unpaved. Existing guardrails and boulder barriers shall be maintained and new barriers installed as determined by a road safety inspection. Mitigation measures to restore or obscure off-road tracks created by unauthorized vehicles shall be devised and implemented as needed. Any policy will include the conditions contained in the NAR administrative rule on off-road vehicles. Permits for otherwise prohibited activities, such as ATV use, for purposes such as research, education and management shall be issued on a very limited basis and in consideration of the overall effects and benefits. Use of off-road vehicles will be permitted for emergency response and evacuation.

It is important that the off-road vehicle policy for the UH Management Areas be advertised widely. Visitors to the mountain shall be educated about the policy in orientation materials. OMKM shall coordinate with DLNR to ensure that all off-road vehicle users of the adjacent land areas are informed of the policy. OMKM and DLNR shall consider establishing a working group with surrounding land owners and the user-community to educate users and manage ATV use in the region.

ACT-5. Minimizing impacts of recreational hiking

A maintained trail network will help to reduce the formation of new unwanted trails. Proposed creation of any new, formalized trails or substantial alteration of an existing route will be subject to review by SHPD. The trail network shall be delineated on maps, marked with signs, and patrolled by rangers. Hikers will be requested to self-register at the VIS and be provided with maps. They will also be informed that hiking off trail is prohibited and about safety concerns, including that hiking alone at high elevations is dangerous and discouraged. All unwanted trails shall be removed through restoration. The creation of self-guided tours and regular guided tours will help to reduce potential impacts by focusing visitation on specific areas. Having a guide present will help to monitor visitor activities.

ACT-6. Snow-play activities

Snow-play is defined as skiing, sledding, snowboarding or other recreational activities involving snow. Users shall be informed of designated snow-play areas through maps, temporary signs or directions given by rangers. Areas with consistently deep layers of snow will be delineated on maps for future reference, to create snow-play maps and to monitor these areas for any effects once the snow is gone. Snow-play activities shall be confined to areas with a layer of snow deep enough to provide protection to resources (a minimum of eight inches). Rangers shall regularly patrol snow-play areas to ensure visitor safety and protection of resources. Shuttle service to the summit may be made available during times of high use or during periods of heavy snow that require frequent plowing.

ACT-8. Hunting in the UH Management Areas

University and DLNR shall work together to establish a clear policy regarding recreational hunting. Because access to hunting areas may not require hunters to pass through Hale Pōhaku, where information about prohibited areas is available, getting this information to hunters is a challenge that this policy-making effort must address. Development of partnerships with hunting associations and other land stewards in devising and disseminating information on the hunting policy will improve compliance with established rules for the UH Management Areas. Hunters shall be provided with maps of designated hunting and parking areas. They will also be informed on prohibitions regarding off-road vehicles, the requirement to remove any debris created while hunting, the threats of invasive species and accelerated erosion and methods of prevention, and information on historic properties and need to avoid them.

ACT-9. Commercial tour permitting

The commercial tour permitting process shall be reviewed at regular intervals to determine any changes that should be made. Relevant information relating to permit violations or impacts to cultural and natural resources will be considered during the review process. Commercial tour permits shall be updated to include a requirement for an orientation if that policy is implemented. Brochures or maps distributed by commercial operators must be approved by OMKM. The

current policy of commercial permit funds being collected by OMKM and deposited into a revolving fund used to support management of the mountain shall be maintained.

ACT-10. Film policy

OMKM shall have input on all permits for activities in the UH Management Areas initiated through the Hawai'i Film office. OMKM shall consult with observatories and MKSS, as appropriate, to ensure that the proposed filming activity would not interfere with their operations. OMKM receives about 30 requests for filming every year. Rangers educate film crews on Mauna Kea and minimize potential negative impacts on the mountain's resources. Permits shall not be required for filming related to news coverage and astronomical activities.

ACT-11. Other commercial activities

Various commercial activities have been proposed in the UH Management Areas, including concessions, resource extraction, and special events. The University currently has no express statutory or regulatory authority to issue permits for such activities. Statutory amendments allowing the University to control these activities in a manner consistent with the CMP would be beneficial. Special one-time or yearly events (e.g., conferences, cultural festivals or other permitted organized gatherings) should require a permit limiting the number of participants, fees, and other conditions imposed on daily commercial operators such as insurance requirements. Fees generated from other commercial projects, such as one-time events, should be deposited into the revolving fund used to support management of the mountain (see *ACT-9, Commercial Tour Permitting*). Requests for potential commercial activities should also be subject to review and approval by OMKM and DLNR. Commercial events expected to draw a large number of visitors, or that will be ongoing should also be subject to community input. Cultural and eco-tours will be subject to the same conditions as currently permitted commercial tours (see *ACT-9, Commercial Tour Permitting*). Cultural tour operators will be required to consult with Kahu Kū Mauna and SHPD to determine which sites are appropriate for visitation. Permits should also be required for and the location for such concessions should be limited to the VIS or other facilities. Commercial permits shall not be granted for snow-play tours, ski meets or any snow-play events.

ACT-12. Research permits and proposals

Currently, research activities in the Conservation District are regulated by the DLNR and/or BLNR pursuant to the Conservation District rules. DLNR and BLNR shall consult OMKM, MKMB and/or Kahu Kū Mauna, as appropriate, regarding permit applications for research in the UH Management Areas. If research is proposed near known historical or cultural sites, SHPD and Kahu Kū Mauna shall be consulted, as appropriate. Research activities must be consistent with the CMP and the Conservation District rules. Appropriate and enforceable conditions may be placed on permits to help regulate and monitor any type of disturbance and incidental take or damage. All permits relating to the study of cultural, archaeological or natural resources shall contain a condition requiring that the results be reported to OMKM for inclusion in OMKM's database or to establish baseline information. Research projects that contribute to improved management decisions, address existing data gaps, and further the objective of protecting natural and cultural resources should be approved if in compliance with the CMP and the Conservation District rules.

Research shall be conducted as to have minimal impact on cultural and natural resources. Potential effects include inadvertent alteration of shrines, other archaeological sites, or burial sites by researchers; alteration of the landscape by installing permanent equipment or instruments; visual intrusion by installed equipment or instruments in the historic district; habitat disturbance through access and sampling, and the potential for introduction or spread of invasive species. Research must use best practices to minimize negative effects on cultural, archaeological and natural resources. In order to minimize effects on astronomical research, projects must control dust and light conditions near the summit. The use of equipment or instruments that emit radio or sound waves shall be prohibited, unless special permission is granted after consultation with IfA and OMKM. In evaluating requests for incidental take related to research projects the reviewer shall consider whether the resources to be collected can be obtained elsewhere and whether collection will severely deplete or damage the integrity of the resource.

P-1. Compliance with all applicable laws, regulations and permit conditions

Responsibility for compliance rests with the University (the lessee), observatories (sub-lessees), permittees, permit applicants, and the public. Responsibility for internal enforcement rests with the University, and externally with appropriate regulatory authorities.

P-2. Strengthen CMP implementation through Conservation District Use Permit conditions

Once approved by BLNR, the CMP will be the approved management plan for the UH Management Areas. Subject to HAR 13-5, in order to ensure regulatory compliance with specific management actions set forth in the CMP designed to protect Mauna Kea's cultural and natural resources, the University will recommend that the BLNR include the applicable CMP provisions as a condition of approval in future CDUPs approved by BLNR. Additionally, subject to DLNR approval, similar conditions shall be considered for inclusion in future subleases or Operating and Site Development Agreements, as appropriate (Group 70 International 2000).

P-3. Obtaining rule making authority for the University

The University must balance the enforcement of rules and the granting of public access in order to protect resources. The University will pursue administrative rule making authority as well as enforcement authority, to equip OMKM to meet its mission of sustainable management and stewardship of the UH Management Areas. Adopting administrative rules specific to the UH Management Areas will help simplify the overall enforcement effort in that all the required procedures, prohibitions, and penalties applicable to all resources and uses on the mountain will be available in one document, and would be enforceable by the University. Rules, regulations and fines will ensure accountability for actions and deter violations necessary for resource protection.

P-5. Coordination with other agencies regarding enforcement needs

Management entities must be aware of rules and regulations for adjacent lands, since resources available for on-mountain management are limited. Management entities shall work to develop and enforce consistent policies for access and use, in order to limit confusion for users of the high elevation areas of Mauna Kea.⁶

⁶ *It is recognized that landholders have different priorities and mandates for managing lands under their jurisdiction. Coordinated policies are not intended to change these, but rather to facilitate consistency as much as possible.*

OMKM has tentatively agreed in concept to enter into a cooperative agreement with the Mauna Kea Ice Age NAR to address some of these issues. Modification to this proposed agreement may become necessary, if and when the University obtains legal authority to have law enforcement personnel.

P-6. Establish a law enforcement presence on the mountain

Effective enforcement is an essential component to protecting resources and managing visitor use and safety. If and when the University receives the statutory authority to promulgate rules, they will need to designate enforcement personnel. OMKM Rangers may be able to perform these duties, and it might be feasible to have the rangers cross-deputized as DLNR DOCARE officers, so that they would also have the authority to oversee activities and respond to violations in the Mauna Kea Ice Age NAR. In addition, enforcement personnel must maintain up-to-date training on all relevant issues. Formal agreements between agencies would enhance effective law enforcement on the mountain.

P-7. Protocol for oversight of Conservation District Use Permit compliance

DLNR, the University and OMKM shall continue to oversee compliance with all terms and conditions of CDUPs. Known or suspected non-compliance or violations shall be reported to DLNR. In the absence of monitoring for compliance with CDUP conditions there is a risk of damage to the summit, and other areas of the UH Management Areas. Moreover, tenant violators should bear the full consequences of their infractions, including taking corrective actions and paying fines. Observatories shall be reminded annually, in writing that violations of permit conditions may result in permit cancellation and closure of facilities by BLNR. OMKM shall establish and enforce a permit and sublease monitoring system to promote responsible stewardship, prevent damage to Mauna Kea, and report infractions to DLNR, which has statutory authority to pursue enforcement in the conservation district as well as enforcement of permit conditions.

P-8. Commercial and Special Use permits

All permits issued by OMKM require the user to comply with all of the conditions specified or the permit may be revoked and fines imposed. Commercial permits currently apply to tour operations. Permits shall be required for certain activities within the UH Management Areas, including research, one-time commercial events, and activities such as scattering of remains. OMKM, MKMB, and in some cases Kahu Kū Mauna shall review permit applications to determine if the permit should be granted. OMKM shall use technical experts, when necessary, to determine the potential effects of issuing commercial or special use permits. Permits shall be consistent with the provisions of the CMP, including a mandatory orientation, if implemented. Special conditions attached to any issued permit shall be clearly stated. Permittees shall be made aware that failure to comply with all conditions of the permit may result in fines, administrative action, or revocation of permit.

IM-1. Operations, Monitoring, and Maintenance Plan

The OMMP is a document that coordinates all maintenance plans, activities and schedules. It identifies personnel necessary to conduct tasks, monitoring requirements to ensure compliance, and reporting procedures to document the actions that were implemented. The OMMP should address existing maintenance tasks carried out by MKSS and the observatories, as contained in their CDUP, along with new recommendations presented in the CMP.

IM-3. Historic preservation review for maintenance activities

Daily operations and routine maintenance operations occur throughout the UH Management Areas, along the Summit Access Road, in the summit area, and at Hale Pōhaku. Many of these activities carried out by MKSS and the observatories will not affect historic properties and need not be subject to historic preservation review. This includes all types of activities that do not involve ground disturbance and those occurring in highly altered areas. Certain maintenance activities will, however, be subject to required historic preservation review. The SHPD review process would stipulate one or more of the following: no survey, consultation or monitoring needed; consultation with Kahu Kū Mauna and other Native Hawaiian community members required; or monitoring of specific activities needed. In consultation with DLNR, OMKM will develop a list of routine maintenance activities that can be excluded from the historic preservation review process and a list of routine maintenance activities requiring review. An agreement between DLNR and OMKM should be developed for a prescribed list of activities and could be incorporated into the OMMP (see *IM-1, Operations, Monitoring, and Maintenance Plan*).

A useful tool in the evaluation of the potential impacts of routine management activities will be maps that show previously altered areas, including degree of disturbance, and maps of areas potentially affected by activities requiring review.

IM-4. Vehicle wash station

The need for and feasibility of establishing a vehicle wash-station near Hale Pōhaku to prevent the transport of invasive plants and animals should be evaluated. Several scenarios were presented to account for different types of visitors and vehicles:

1. Provide a voluntary vehicle wash-station and signage along Mauna Kea Access Road, at the southern border of Hale Pōhaku. Operators with vehicles used off road and/or on dirt roads will be encouraged by signs to clean their vehicles.
2. Require that the undercarriages of all vehicles that routinely access the summit be power washed on a weekly basis.
3. Require that all construction and road grading equipment be washed down prior to arrival at the mountain, preferably using a pressure washer.
4. Coordinate with Pōhakuloa Training Area on the use of their vehicle wash station for large construction vehicles.

IM-5. Debris Removal, Monitoring and Prevention Plan

A *Debris Removal, Monitoring and Prevention Plan* should be developed to address fugitive trash, which could impact cultural resources directly, through impact, and indirectly, through clean-up activities. The plan also should be developed to limit alteration of the viewscape, direct and indirect damage to surfaces, and attraction of invasive species. Key elements that should be contained in this plan include assignment of responsibilities for regular trash maintenance

(observatories: dumpsters, MKSS: trash receptacles, Rangers: fugitive trash); provision of adequate, secured receptacles, including temporary receptacles during high-use periods; a post-snow-season inspection and clean-up at high use areas; discussion of potential impacts to cultural and natural resources; provision of a map of sensitive areas, to limit impacts to cultural and natural resources; and an educational component, to address potential threats of trash, methods to prevent escape, and a “pack it in, pack it out” strategy.

IM-6. Erosion Inventory and Assessment Plan

Potential impacts from erosion are discussed in Section 6.3 of the CMP. An erosion inventory and assessment plan will identify areas of accelerated erosion or other disruptions associated with the movement of sediment, prioritizing those that are either safety-related or that have the potential to negatively affect cultural or natural resources. The plan should include designs for site-specific solution and general recommendations for minimizing impacts of erosion.

IM-8. Paving Summit Access Road

The feasibility of paving the Summit Access Road needs to be evaluated based on known considerations related to safety; road maintenance costs (including direct costs, as well as indirect costs such as wear and tear on State vehicles); potential adverse environmental impacts from dust, cinder movement, and erosion; and the potential impacts from paving on natural and cultural resources. An archaeological inventory of the road corridor has not been completed, nor have baseline natural resource surveys. Road paving would be a major endeavor and would require a separate environmental analysis.

IM-9. Parking and pullouts

As recommended in the 2000 Master Plan, options for expanding the parking area in the vicinity of the VIS should be evaluated and implemented if necessary, to provide a safe and convenient environment for visitors (Group 70 International 2000). For safety reasons, all parking should be on the same side of the road as the existing Hale Pōhaku facilities. To minimize erosion, low impact development practices should be employed. Vehicle pullouts may be recommended as part of the road safety inspection. Safety and view plane criteria should be considered if pullouts are installed. Pullouts are also ideal sites to erect interpretive signage and to conduct demonstration habitat restoration projects. Although parking does become challenging in the summit region on high-use snow days, no formal visitor parking lots are being recommended for the summit region. Rangers shall continue current practice of establishing a one-way loop system to keep cars flowing during periods of high traffic, including high-use snow days. Parking areas shall be designated by unobtrusive signs, temporary signs when needed, and on maps distributed to public users.

IM-11-14. Sustainable technologies

Options for using sustainable technologies should be explored for both existing and potential new facilities. Sustainable technologies can be used to reduce demand for water and electricity and to minimize the direct and indirect impacts of facility operations. In particular, since water needs to be trucked to the summit facilities, and wastewater disposal is a concern, all efforts to reduce water use and contain waste will benefit the resources. Potable water use should be reduced by installing low use water fixtures at Hale Pōhaku facilities. Close-contained, zero-discharge human waste systems shall be used for any future development in the summit region, from portable toilets to observatories if feasible. Water harvesting systems and systems that

separate grey waste water from sewage waste should be explored to provide water for irrigation, especially for habitat restoration efforts. Solar water heaters could provide hot water for use at Hale Pōhaku facilities. An energy audit would identify energy use and system inefficiencies, setting the baseline for developing solutions to reduce energy use and investigating forms of locally-based alternative energy production. Sources of alternative energy could include a photovoltaic array or a wind farm near Hale Pōhaku to offset current electricity use. Since the use of hazardous materials is of particular concern, observatories should be encouraged to investigate options to reduce the use of these materials in telescope operations.

C-1. Independent construction monitor

During all periods of construction (including, but not limited to, the delivery of construction materials to the site or to staging areas), there shall be on-site a construction monitor, whose responsibility shall be to monitor compliance with the terms and conditions of any CDUP as related to construction activities, as well as any terms and conditions agreed to between the constructing entity and OMKM.

The on-site construction monitor shall have the authority to order that any or all construction activity under a CDUP cease if and when, in the construction monitor's judgment, (a) there has been a violation of the terms or conditions of the CDUP that warrants cessation of construction activities, or (b) that continued construction activity will unduly harm natural or cultural resources; provided that the construction monitor's order to cease construction activities shall be for a period not to exceed seventy-two (72) hours for each incident. All orders to cease construction issued by the construction monitor shall be immediately reported to the Chairperson of BLNR and the OMKM. The Chairperson may issue a cease and desist order to extend the period of time that construction activity is prohibited, or such other order as the Chairperson deems appropriate.

The construction monitor shall be selected by the OMKM with the concurrence of the DLNR. The construction monitor shall have experience and be knowledgeable in construction management. Prior to assuming on-site duties, the construction monitor shall have completed the educational and training programs as provided in C-7 and C-8, below.

The construction monitor will be funded by the project.

C-2. Best Management Practices Plan for Construction Practices

Each project proposer shall prepare a *Best Management Practices Plan for Construction Practices* that covers a range of topics and incorporates sustainable practices. The project proposer will bear all costs of implementing the BMPs. BMPs should minimize construction time (for example, by scheduling construction work so that, to the extent possible, the activity schedule includes concurrent work); water use; traffic; use and transport of toxic materials, including petrochemicals; disturbance to ground surface and dust generation; noise; and transport of invasive species. A protocol for construction vehicle wash down and inspection shall be established. The wash down station should be located outside of the UH Management Areas and have a capture area to contain wash down effluent. The wash down procedure ensures that vehicles are free of plants and animals alien to the UH Management Areas. BMPs shall include vehicle inspections that focus on ensuring safety and identifying any mechanical issues such as

leaks. In addition to vehicle inspections, the BMP plan should require inspection of construction materials, equipment, crates, and containers carrying materials and equipment by a trained biologist, selected by OMKM and approved by DLNR. The biologist shall certify that all materials, equipment, and containers are free of flora and fauna that may impact the Mauna Kea summit ecosystem. As part of an adaptive management approach, OMKM should study past projects to learn which BMPs were most successful, and should be used for future projects.

C-3. Rock Movement Plan

Any future construction in the summit region, including new development or site demolition and restoration, may require the movement of rock material. Excess excavated cinder shall be placed within the UH Management Areas after consultation with the SHPD and with the prior approval of the OMKM and the DLNR. Use of areas within the UH Management Areas as construction staging or storage areas shall be confined to areas already developed, improved, or previously disturbed provided that the use of such area shall be coordinated with, and shall require the prior approval of, the OMKM and the DLNR.

As part of the process to obtain approval from OMKM, the project proposer shall develop a rock movement plan that: identifies the location and type of the source material, estimates the volume of material to be moved, details the extraction and movement process (employing appropriate construction BMPs), and identifies storage or disposal locations. Any future rock movement in the summit region of Mauna Kea will need to consider the source of material used for site restoration or, for potential new construction, the logistics of storing extracted material for future use.⁷ Important considerations include assessing the cultural sensitivity of the rock material (e.g., use of non-summit material on the summit); the visual impacts of the extraction site, the stored material, and any restored site using rock material; preventing the side-casting of cinder and other materials into wēkiu bug habitat; and the potential for transport of invasive species if rock material is moved to the summit from lower elevations. It is possible that sturdy barriers, able to withstand 100 mile-per-hour winds, will be needed to contain stockpiled cinder (Pacific Analytics 2000).

Whenever construction activities include earth movement or disturbance, OMKM shall consult with DLNR to determine whether a trained biologist selected by the OMKM and approved by the DLNR, shall be on site to monitor any impacts, real or potential, of construction activity on the wēkiu bug. The trained biologist shall be funded by the project.

Whenever construction activities include earth movement or disturbance, OMKM shall consult with DLNR to determine whether a trained archaeologist, selected by the OMKM and approved by the DLNR, shall be on site to monitor any impacts, real or potential, of construction activity on archaeological and historical resources. The archaeological monitor shall be funded by the project.

C-4. Information

As part of routine construction activities, information and data on environmental conditions are recorded in accordance with construction quality assessment and quality control documentation and for use in engineering analysis. These construction activities often provide opportunities for

⁷ Any excavations involved in the dismantling of the observatories will be filled with natural cinder from an approved source.

resource managers to acquire information that otherwise would not be collected. It is recommended that as part of maintenance and construction practices OMKM require submittal of field logs, laboratory analyses, and other construction documents that contain information on the biotic and abiotic environmental variables documented.

C-5. On-site monitors during construction

The need for on-site monitors during construction activities will be determined by the appropriate agency (e.g., SHPD, DLNR). Primarily for those activities involving earth movement or disturbance, experts (e.g., archaeologist, cultural resource specialist, entomologist), selected by OMKM and approved by the appropriate agency, shall be on site to monitor any impacts, real or potential, on resources. All independent on-site monitors shall be funded by the project.

C-6. Archaeological Monitoring Plan

The project proposer, in consultation with OMKM, shall consult with SHPD about whether archaeological monitoring is required during a construction project. Should SHPD require archaeological monitoring during any construction project, an acceptable archaeological monitoring plan will be prepared for review and approval by SHPD, prior to the start of any ground-disturbing work. Monitoring will be conducted according to the plan. In the event of an inadvertent discovery of any human burial during construction, the permittee shall stop work in the immediate area of the burial and contact SHPD, OMKM, and Kahu Kū Mauna. SHPD has jurisdiction over inadvertently discovered human remains.

C-7. Education regarding historical and cultural significance

All persons involved with the construction and installation of any future facilities including, but not limited to, the construction manager, contractors, supervisors, and all construction workers, and all persons involved in the operation and maintenance of future astronomy facilities, including, but not limited to, scientists and support staff, shall be educated about the historical and cultural significance of the Mauna Kea summit area, and shall be given training as to what constitutes respectful and sensitive behavior while on the summit area. A detailed plan for complying with this condition (including both the content of training and the procedures for implementation, including, but not limited to, a means for certifying persons who have completed the training program) shall be developed by OMKM following consultation with Kahu Kū Mauna or other Native Hawaiians or Native Hawaiian organizations known to have lineal or cultural ties to Mauna Kea, and reviewed and approved by the DLNR. A specialist or specialists in the field of Native Hawaiian culture shall be selected by OMKM with the concurrence of the DLNR for the purpose of implementing the compliance plan, including, but not limited to, the conduct of educational and training programs for all persons described in this condition. To be qualified for appointment to this position(s), a person shall have worked as a Native Hawaiian cultural specialist and shall be knowledgeable of the types of cultural resources and practices relating to the summit of Mauna Kea.

C-8. Education regarding environment, ecology and natural resources

All persons involved with the construction and installation of any future astronomy facilities in the UH Management Areas, including, but not limited to, the construction manager, contractors, supervisors, and all construction workers, and all persons involved in the operation and maintenance of the future astronomy facilities, including, but not limited to, scientists and support staff, shall be educated about the environment, ecology and natural resources of the Mauna Kea summit area, and shall be given training as to what constitutes appropriate behavior

while on the summit area for the protection of the natural resources. A detailed plan for complying with this condition (including both the content of training and the procedures for implementation including, but not limited to, a means for certifying persons who have completed the training program) shall be developed by OMKM following consultation with scientists and environmental organizations knowledgeable about the Mauna Kea summit area, selected by OMKM, and reviewed and approved by DLNR.

C-9. Inspection of construction materials

Prior to entry into the UH Management Areas, all construction materials, equipment, crates, and containers carrying materials and equipment shall be inspected by a trained biologist, selected by OMKM and approved by the DLNR, who shall certify that all materials, equipment, and containers are free of any and all flora and fauna that may potentially have an impact on the Mauna Kea summit ecosystem.

SR-1&2, Existing Observatories, Site Recycling, Decommissioning, Demolition, or Restoration

Each observatory has specific provisions in its agreement related to what is to become of the structure at the end of its term. Unless and until existing observatories revise their agreements, they need only comply with existing terms. It is possible that some observatories will be upgraded or demolished prior to the end of the term. Demolition would be the responsibility of the terminating observatory. Observatories will be required to develop plans in coordination with IfA, to be approved by OMKM, for site recycling, demolition and restoration. The plans will require compliance with terms and conditions identified by OMKM and the CMP, including all maintenance and construction management actions. The plans will need to consider the range of issues related to decommissioning including the impacts of demolition, waste management, substrate contamination, removal of underground storage tanks, habitat restoration, and cost. In the event one or more observatory facilities consider decommissioning of their facility before the end of the State lease, the University in consultation with DLNR and OMKM shall initiate discussion on a decommissioning and site restoration plan to allow adequate time for decision-making, community input, and review process.

Each observatory has provided written confirmation to IfA and OMKM that it understands and will comply with the conditions of its agreement related to site recycling or demolition (see Appendix A9). In some cases, it may be beneficial to negotiate termination arrangements different from those specified in the agreement. For example, resources that would have been used for certain required aspects of removal and restoration could be applied instead to other things that are considered more beneficial. Such modifications in termination requirements will need the approval of OMKM, DLNR, the University, and the observatory.

SR-3, Potential Future Observatories, Restoration

New observatories have the advantage of knowing that they need to plan for restoration while developing construction plans, so this might play a role in certain design considerations. It will be possible to impose specific conditions on any future observatories with respect to site restoration and funding assurances. Such conditions should be incorporated into their agreement.

FLU-1. Master Plan Design Guidelines

Section XI of the 2000 Master Plan contains a set of design guidelines to direct development of renovations of existing facilities and new construction in a way that integrates the facility into the landscape (Group 70 International 2000). General goals address: facility siting; scale; heights and widths; colors; surfaces, textures and materials; parking; roadway and utility development; roofs; fences, walls and barriers; and signage. These guidelines shall be conveyed to project proposers, to guide project development, and shall be used in the evaluation of projects by OMKM.

In addition to outlining facility needs to support astronomy, the 2000 Master Plan addressed support facilities to meet the operational needs for activities not related to the observatories. These would include activities such as VIS renovations, parking and road improvements, construction or renovation of restrooms, and construction of a staging area for commercial operators. It is important to maintain compatibility and consistency of recommendations between the 2000 Master Plan and the CMP, to ensure that identified facility needs and designs are consistent with the overarching management plan put forth in the CMP.

FLU-2. Land use zones

Any potential future observatories will be located inside the Astronomy Precinct. The goal of this process is to refine telescope siting areas defined in the 2000 Master Plan based on updated cultural and natural resource information. Land use zones will be developed that will delineate areas where future land use will not be allowed and areas where future land use will be allowed, but where compliance with prerequisite studies or analyses prior to approval of a CDUP, will be required. When assessing proposed infrastructure expansion, additional consideration will be given to the location of current infrastructure and previously disturbed areas. New land uses should be located close to existing infrastructure or previously disturbed areas, to reduce impacts on undisturbed areas and to minimize unnecessary damage to geological features. As stated in the 2000 Master Plan, all major undeveloped cinder cones and their intervening areas will be protected from future development by astronomical or other interests. These include the following *pu'u*: *Ala, Hoaka, Kūkahau'ula, Līlinoe, Māhoe, Mākanaka, Pōepoe, Polī'ahu, and Ula*.

FLU-3. Cataloguing initial site conditions

In order to have a baseline for use during the site restoration process, the initial conditions at a development site must be catalogued. Necessary information to collect would include topography, substrate composition, and presence/absence and densities of species. This information should be retained by OMKM and the project proposer for use when preparing site restoration plans.

FLU-4. Visual rendering

New development projects shall use architectural designs, color schemes, and materials that are compatible with the background landscape in order to minimize impacts to viewplane and other aesthetics. Visual rendering shall be a required element of any major project proposal, and shall be included as part of the public review process for proposed future land uses. Project specific visual rendering of both pre- and post-project settings will facilitate analysis of potential impacts to the view-shed, including minimizing impacts to views from significant cultural areas and avoiding or minimizing views of built facilities from down-slope communities. The natural forms of the summit can be used to shield views of built facilities. Incorporate to the extent

possible technologically advanced methodologies, for example paint that can help to disguise a facility.

FLU-7. Close-contained zero-discharge waste systems

For several reasons close-contained zero-discharge waste systems are ideal for use in the high elevation, dry Mauna Kea summit region. These systems are evaporative and require less water input than conventional waste systems, thereby reducing the amount of water needing to be trucked to the summit and the amount of waste needing to be trucked off the mountain. The closed systems are fully contained and will not result in the discharge of any material into a cesspool, septic tank, or leach field, effectively eliminating a potential source of cinder and groundwater contamination. They should be used where feasible.

OI-1. Local management of the UH Management Areas

OMKM is the local management entity responsible for the UH Management Areas. Ensuring consistent implementation of the CMP, as the approved management plan for the area, will be its primary responsibility. Implementation of the CMP will require that OMKM work with the range of agencies, committees, and stakeholders with responsibility for the UH Management Areas and their neighboring properties. The CMP recommends additional program development on a range of topics. OMKM shall work with the current boards, councils, and committees, which will continue their advisory roles, providing expertise and guidance in developing the management program. As proposed in the 2000 Master Plan, to centralize operations and management responsibilities, portions of MKSS functions and personnel should be transferred to OMKM, subject to negotiations with IfA and current tenants.⁸

OI-2. Training Plan

A training plan for employees and volunteers should be developed. Training needs to be addressed in the plan include specialized ranger training, field-personnel training, volunteer training and general staff training. General training requirements include review of applicable laws and regulations, basic cultural and natural resources orientation, and standard procedures for documenting potential violations (for non-enforcement personnel). Training requirements for all OMKM personnel involved in field-based management activities include general safety training, 4-wheel drive vehicle operation, orientation to working at high elevations, emergency response, CPR and first aid, Global Positioning System (GPS) operation, and recognition of culturally significant areas and items and protected flora and fauna. All staff who access the mountain should receive safety orientation and basic cultural and natural resources training. It is also advisable to provide basic emergency response training (including CPR and first aid) to all VIS staff. Education and training requirements for the Cultural Resource Coordinator (CRC) include gaining an intimate familiarity with the written literature on Mauna Kea's cultural resources, including historic properties and cultural practices, and detailed knowledge of the location and status of historic properties on the UH Management Areas.

OMKM Rangers should receive high-level training in emergency response, including CPR and first aid. They should also receive in-depth cultural and natural resources training, to enable them to better understand and protect the resources. Rangers should be trained in a variety of monitoring techniques to enable them to recognize and record changes to the most accessible

⁸ Existing agreements specify IfA involvement in the provision of specific utility services and support functions, and any transfer of responsibilities would be contingent on agreement from existing sublease or agreement holders.

and frequently visited areas, such as the summit. Although thorough monitoring of the cultural landscape will require the services of qualified professional archaeologists, rangers can serve an important function because they are always present on Mauna Kea. Rangers will require training on how to relocate sites using GPS units and how to read and interpret archaeological site maps to determine whether any changes in a site have occurred since the site was first recorded or last visited. If a decision is made to have the rangers continue to monitor activities affecting cultural resources along the road, some additional training in the reporting of incidents may be required. A training program would also be required if a policy or protocols are developed relating to cultural practices. This assumes that the rangers would be the ones most directly involved on a day-to-day basis in the enforcement of a policy. In particular, they should receive training in recording damage to historic properties, such as that given national park rangers.

OI-3. Coordinated Management

The principles of ecosystem management require that neighboring landowners and OMKM work together, guided by well-established management goals and visions, to protect, enhance or restore natural and cultural resources. Overlapping and adjacent jurisdictions at the high elevations of Mauna Kea involve multiple agencies in management and decision-making. OMKM will serve as the focal point for coordinating actions related to the management of the UH Management Areas, including cross-boundary issues. OMKM will communicate issues and concerns that it receives to the appropriate agencies and will follow through in their resolution. OMKM should formalize management objectives and cross jurisdictional activities with memorandums of agreement or understanding similar to the recently proposed cooperative agreement between the DLNR and the University with respect to the Mauna Kea Ice Age NAR.

It is also recommended that OMKM lead or participate in the development of an interagency working group involving all entities that are responsible for or involved in resource management in high elevation areas (above 6,200 ft, or 1,900 m) on Mauna Kea. These would include OMKM, state and federal agencies, non-governmental organizations (NGOs), and other agencies and persons involved in the day-to-day management of Mauna Kea lands. The working group should develop an interagency set of mountain-wide management goals based on the principles of ecosystem management. Goals will need to take into account the participants' differing approaches to resource management, their policy foundations, and the decision criteria used by different institutions involved in multi-agency planning processes. This working group should hold meetings at a minimum, once a year.

OI-4. Grievance Procedures

OMKM should establish grievance procedures to address issues as they arise. All grievances should be presented to the OMKM director, who will determine the best way to resolve the issue. If the issues represent broad planning or policy questions beyond the management authority of OMKM, the director should refer the questions or questioner to specific contacts at the appropriate agencies, usually DLNR, the UH-Hilo Chancellor, the President, or the University Board of Regents as appropriate. OMKM should follow the progress of the grievance and assist where it is able. When the grievance concerns management issues or items within the jurisdiction of OMKM, the director will receive and respond to the questions. If the issue requires management, operational, or other changes by OMKM, the director will research the

question and bring it before the MKMB for review. All grievances should be handled in a sensitive and timely manner (Group 70 International 2000).

OI-5. Emergency Response Plan

The emergency response plan should address response procedures for a variety of emergency types. Procedures should include means for protecting natural and cultural resources during emergency responses; resource repair or restoration after damage caused by emergency responses; management activities to reduce likelihood of emergencies occurring; and health and safety protocols. It should outline potential impacts on resources, establish response protocols, and detail reporting protocols. The existing emergency response plan should be reviewed and updated to reflect additional safety and resource protection measures provided in the CMP. All staff members stationed at Hale Pōhaku or in the UH Management Areas should receive emergency response training (see *OI-2, Training Plan*). OMKM staff should review emergency plans at the beginning of each winter season.

The section on emergency response procedures should begin by identifying types of emergencies that could occur in the UH Management Areas (e.g., fires, chemical or petroleum spills, rescue of injured and lost visitors or employees, skiing accidents, vehicle accidents, and injured construction workers) and locations where these emergencies could occur. For each emergency category, the plan should determine the procedures for coordinated emergency response. The plan should also determine procedures for response to accidental or negligent pollution events, including identification of who will respond. OMKM should take the lead in assisting and coordinating with responding agencies, and should contact DLNR-SHPD, county fire and police departments, and military units at Pōhakuloa, when appropriate. Procedural descriptions should include identification of staging areas, preferred helicopter landing areas, development of an emergency evacuation plan, and establishment of follow-up reporting protocols to SHPD and Kahu Kū Mauna. Use of vehicles off road may be permitted, to assist in emergency response.

The section concerning protection and recovery of cultural and natural resources should begin with identification of areas containing sensitive resources needing protection. With the virtual completion of a major portion of the archaeological field work, OMKM now has location maps for historic sites, which should be used in determining the best plan for avoiding impacts to historic properties during an emergency situation. Activities in these areas should be limited, in order to reduce the likelihood of an incident resulting in damage to the resources. The section should also identify potential impacts to resources from various accident types and develop methodologies to minimize impacts to resources (such as habitat disturbance) resulting from emergency response activities. Response activities to be addressed include retrieval of large objects; response to collapse of road embankment or cinder cone face; need to create a detour road; and chemical or fuel spills (including hazardous materials). Additionally, the section should detail a process to assess cultural and natural resource damages and conduct repair or restoration projects following an incident. Assessment activities to determine the extent of damage from a particular emergency event should be coordinated with applicable federal and state resource damage assessment programs.

The emergency prevention section should outline management activities to reduce frequency of accidents (e.g., signage, limiting ignition sources for fires, spill prevention plans, inspection of

roads, and installation of additional guard rails, if needed) and to establish strict standards to prevent pollution from operations in the UH Management Areas. This may be addressed, in part, through development of a spill prevention control and countermeasure plan and a fire protection plan. The fire plan should cover visitor education, establishment of a trained volunteer fire crew, emergency procedures, and a habitat management plan for the Hale Pōhaku māmane forest (Group 70 International 2000).

Because it is OMKM's responsibility to coordinate medical emergency response activities in the UH Management Areas, the health and safety section of the emergency response plan should detail OMKM's procedures for coordinating responses to medical emergencies. It should incorporate the educational and health and safety management activities identified in the CMP to reduce threats to public health, including response procedures for medical emergencies. Rangers should have ready access to first-aid supplies, including oxygen, and be trained in emergency rescue procedures (see *OI-2, Training Plan*).

MEU-1. Reporting system

A variety of annual and five-year reports are recommended as part of the evaluation process for the CMP.

Annual Reports

At the end of each year OMKM should produce an annual progress report (Progress Report) describing in detail the management goals, objectives, and actions for the year and what progress was made towards meeting them. The Progress Report should also describe actions to be taken to improve the program for the next year(s). The Progress Report is not intended to be a status report on the resources in the UH Management Areas; rather, it is meant to inform management and stakeholders of the progress of the program and direction it is to take in the future.

On June 30 of each year, OMKM shall submit to BLNR a written report detailing its activities generally, along with the Progress Report. Reports may also be submitted to various State and Federal agencies, if required.

Five-Year Outcome Analysis Report

In preparation for the CMP five-year revision, OMKM shall prepare a Five-Year Progress Report that describes the state of the resources, the status of the various management programs, progress towards meeting CMP goals, and other relevant information. This report should be based on information obtained from Progress Reports, and any other pertinent sources.

The first section of the Five-Year Progress Report will discuss the state of the cultural and natural resources in the UH Management Areas. This section will summarize data collected during monitoring, research, restoration, and threat prevention and control activities conducted over the preceding five years. This portion of the report will analyze trends in cultural and natural resources, and the impacts (positive, negative, or neutral) that management actions have had on them. It will also summarize what future management actions are needed to protect, enhance, or restore Mauna Kea's natural resources.

The second section of the Five-Year Progress Report should include a summary of the progress of the programs towards meeting management goals, objectives, and actions, as outlined in the CMP. This analysis will be based on information in the annual progress reports from the last five years.

The report will be reviewed and approved internally and will then be submitted to the stakeholders and agencies participating in the review process, allowing ample time before the meeting for the agencies to review it. This report, along with feedback received from stakeholders, will be used to conduct the five-year update of the CMP.

MEU-2. Update and revision process

Once the CMP is approved by BLNR, it will be considered the approved management plan for UH Management Areas, supplementing the 1995 Management Plan. OMKM will be responsible for implementing the CMP and ensuring adherence to its provisions. The CMP should be updated every five years, based on data collected during various program management activities (e.g., natural or cultural resources monitoring, research projects), analysis of program strengths and weaknesses, and relevant new laws, regulations, and policies that have come into effect since the last update. Conditions under which a significant revision of the CMP would be required at an interval of less than five years include changes to the University lease with DLNR lands for Mauna Kea Lands, new development, or changes to state and federal laws and regulations with direct impact in UH Management Areas.

During the update process, OMKM should solicit recommendations for modifications to the management plan from the wide range of stakeholders including agency partners and community members. It is recommended that stakeholders first be given a copy of the five-year progress report, so that they are aware of program successes, failures, and ongoing activities, as well as updated on the current status of the resources. Comments received on program needs and recommended management activities can then be addressed in the update of the CMP.

MEU-3. Revising and updating planning documents

The 2000 Master Plan was adopted by the University Board of Regents as the policy framework for the responsible stewardship and use of University-managed lands on Mauna Kea. This plan provides a long-term vision for facilities planning on Mauna Kea. When this plan is updated, it

should incorporate and reference the CMP. In addition, if and when leases or agreements are renegotiated, they should be updated to be consistent with the CMP.

3.2.2 Controls Adopted from the 1995 Management Plan

In addition to the Management Actions presented in Table 3-2, Section 7.5 of the CMP adopts most of the controls established in the 1995 Management Plan. The controls adopted from the existing Management Plan are presented below.

Hours of Operation

Mauna Kea Science Reserve. Public recreational activities within the Mauna Kea Science Reserve will be allowed from one-half hour before sunrise to one-half hour after sunset. During times of heavy ski and snowplay activity, the area may be closed earlier to allow designated personnel to make a sweep of the mountain for stragglers and be able to reach lower altitude by dark.

Because lights from autos interfere with astronomical observations, UH may install a gate or chain across the Mauna Kea Road at night to prevent unauthorized after-hours vehicles from reaching the summit area. This barrier will be located in such a way that visitors can safely turn around and return to lower elevations.

Hale Pōhaku. Hours for activities at the Visitor Information Station can vary, depending on events scheduled. Both UH and commercial stargazing tours will be permitted. Groups may be permitted to use the Information Station after closing hours, for approved reasons, by obtaining a temporary permit from Mauna Kea Support Services (MKSS). Unauthorized use of the Information Station is prohibited.

Mauna Kea Science Reserve Access Controls

Periods of Controlled Access. UH and/or DLNR Enforcement Officers will control access, as required, during periods of heavy usage, transportation of heavy equipment and during certain road maintenance activities. All visitors must comply with their directives.

Unscheduled Closings of the Access Road. UH may close any or all portions of the road between Hale Pōhaku and the summit if it is determined that hazardous conditions exist. The road will be closed when it is being cleared of snow and when it is being otherwise worked on due to snow conditions. UH will keep the public informed of the status of the road through the local media and through a recorded telephone message.

Following unscheduled closings, no private or commercial tour vehicles will be allowed access above the Onizuka Center for International Astronomy (OCIA) until two-lane traffic is established and the road is opened by UH Mauna Kea Support Services (MKSS) personnel. During and immediately after snow removal and road maintenance activities, official vehicles (those identified as being associated with UH and the telescopes) shall have priority over private vehicles or those of commercial operators.

Visitor Vehicles

Until the entire road is paved, all commercial vehicles and those used in astronomy-related activities must be 4-wheel-drive. Four-wheel drive is also strongly recommended for private vehicles. UH reserves the right to require 4-wheel drive on all vehicles proceeding to the upper elevations of Mauna Kea when driving conditions are hazardous. Off-road use of vehicles is prohibited. Drivers must handle their vehicles in a safe manner. They must obey all posted signs and any directives given by UH or DLNR personnel. If violations are flagrant, Hawaii County Police may be called in to assist.

Waiver of Liability

Visitors will be warned that if they proceed up the mountain it will be at their own risk. UH reserves the right to require a waiver of liability from each driver (commercial and private) before the vehicle is allowed to proceed to the upper elevations.

Alcoholic Beverages

No drinking of alcoholic beverages is permitted above Hale Pōhaku. Commercial operators must guarantee that their clients will not use alcoholic beverages within the Science Reserve.

Archaeological Sites Within the UH Management Areas

All activities covered by this Plan shall be conducted in accordance with Chapter 6E-11 HRS, which states: *"It shall be unlawful for any person, natural or corporate, to take, appropriate, excavate, injure, destroy or alter any historic property located upon lands owned, or controlled by the State...except as permitted by the Department (DLNR)."* If UH personnel observe visitors tampering with the sites, they will, at their discretion, inform them of the law and instruct them to desist. They will log and report all such incidents to the DLNR Historic Preservation and/or Enforcement Division for appropriate action in accordance with Chapter 6E HRS.

Mauna Kea Ice Age Natural Area Reserve

Features within the Natural Area Reserve (NAR) will be managed by the Natural Area Reserves Commission and DLNR according to the Management Plan for that area. Information and regulations on the NAR will be available at the Information Station.

General Controls at Hale Pōhaku

Visitors to the Information Station will be informed of the dangers of fire to the flora and fauna in the Hale Pōhaku area by means of signs and published information. No outdoor fires (hibachis, etc.) will be allowed. Visitors will also be cautioned against littering, which may attract predators that could endanger the fauna in the area, and urged to walk only on designated paths so as not to disturb the flora.

The general control in the 1995 Management Plan relating to assistance rendered by the National Ski Patrol is eliminated in its entirety, as the National Ski Patrol does not maintain a presence in the UH Management Areas.

In addition, the following controls from the 1995 Management Plan, applicable to specific public activities and commercial operators shall also continue in full force and effect as part of the CMP.

Management and Control of Specific Public Activities

Astronomy. UH and the other astronomy users associated with the Mauna Kea Observatories will manage and control visitor activities involving tours of the telescopes.

Hiking. For their safety, all hikers will be encouraged to visit the Information Station prior to proceeding upslope. At that time they will be warned of the hazards of high-altitude hiking and given a copy of the regulations for public use of the Science Reserve.

Sight-seeing and Snow Activities. The public will be encouraged to stop at the Information Station to obtain information on precautions which must be taken and rules to be followed when driving upslope. They will be warned that proceeding up the mountain will be at their own risk; drivers may be required to sign a waiver of liability.

Hunting. Hunting on Mauna Kea will be allowed only in areas designated for that purpose by DLNR. The activity is allowed pursuant to the applicable regulations of the Department of Land and Natural Resources.

Management and Control of Commercial Activities

In addition to the controls and rules specified for the general public, the following conditions apply to all commercial operators. It should be noted that all commercial operators who use the Visitor Information Station, the Mauna Kea Access Road and the parking areas, even though the activity they sponsor does not actually take place within the UH Management Areas, are subject to these controls.

- Commercial use will be monitored. In the future it may be necessary to limit the number of commercial operators at the summit at one time and/or limit the total number of permits issued.
- All commercial operators are required to:
 - use four-wheel drive vehicles only,
 - be familiar with the general conditions for high-altitude driving,
 - register at the Information Station to inform UH of their presence on the mountain,
 - park in specific parking areas when told to do so,
 - pick up all rubbish generated by the activities and carry it back to their base operations, and
 - ensure that their clients comply with all regulations.
- The maximum size commercial vehicle allowed at the Information Station and above will be 14-passenger vans – unless special arrangements for larger vehicles are made with UH on a case-by-case basis.
- The number of commercial vehicles allowed at any one time to park at the Information Station or on the adjacent roadways will be set by UH.

-
- During the periods of heavy use—usually during weekends when there is snow—the number of commercial vehicles allowed in the Mauna Kea Science Reserve will be limited to a number determined by UH in consultation with DLNR. Initially this number will be 18.
 - Commercial operators, drivers and guides will be provided with guidelines on mountain driving and emergency procedures when they receive their permits. Operators will be required to warn their clients of the dangers of altitude sickness and other hazards of traveling to high elevations.
 - Ski and snowplay operators shall be required to identify suitable staging areas in their permit applications. These areas shall not be located near known archaeological sites.
 - Ski and snowplay operators may be required to carry reasonable emergency rescue equipment in their vehicles for emergency rescues.
 - The operator will be responsible for ensuring that his/her clients are clothed appropriately and have adequate liquids and food.
 - If the commercial activity engaged in above the OCIA requires toilet facilities, the commercial operator must provide, operate, and maintain pre-positioned portable toilets for the clients' use.
 - Except in the case of emergency, access to the OCIA buildings shall be limited to the designated public areas.
 - Radio transmitters, including cellular telephones, will be restricted to emergency use only with the Science Reserve.

The following prohibited uses in the 1995 Management Plan shall continue to be prohibited:

“Off-Road” Vehicles

Recreational activities involving “off-road” vehicles are not allowed. This restriction applies to both the general public and commercial tour operators and their customers. These vehicles include: motorcycles, dune buggies, snowmobiles, and 4-wheel-drive passenger vehicles, vans and trucks. Note: this restriction only applies to recreational activities. Vehicles such as snowmobiles and 4-wheel drives can be driven “off-road” for emergency rescue and medial purposes.

Commercial Hunting Tours

Hunting tours are not allowed within the UH Management Areas.

4 ALTERNATIVES ANALYSIS

This section describes the Proposed Action and alternatives that were considered in this DEA.

The following alternatives were analyzed:

- Proposed Action
- No Action

No additional viable alternatives were identified for consideration in this DEA.

4.1 DESCRIPTION OF THE PROPOSED ACTION

The Proposed Action is approval of the CMP. The CMP is an integrated planning tool for resource management within the UH Management Areas. The CMP provides a framework for managing existing and future activities, such as astronomy, recreational and commercial activities, scientific research, and cultural and religious activities. The CMP provides an important guide for protecting Mauna Kea's many unique cultural and natural resources. Section 3 of this DEA provides a detailed description of the CMP.

4.2 DESCRIPTION OF THE NO ACTION ALTERNATIVE

The No Action Alternative maintains the current status in the UH Management Areas. UH authorities and responsibilities would continue as defined in its lease agreements with DLNR and in the 1995 Management Plan. OMKM could continue its programs to study and identify natural and cultural resources on Mauna Kea. However, under the No Action Alternative, the Management Actions in the CMP would not be implemented. The integrated protection of natural and cultural resources in a single, comprehensive management plan would not be achieved. A planning framework to support UH rule making authority would continue to be absent, as would a vehicle for increased community planning in the management of Mauna Kea. DLNR would continue to have authority to enforce violations of DLNR Rules, but not the authority to enforce the access or activity restrictions designed to protect the natural and cultural resource present in the UH Management Areas.

5 AFFECTED ENVIRONMENT

Mauna Kea is located on the island of Hawai'i, the southernmost island in the Hawaiian archipelago. It is a dormant volcano that rises 13,796 feet (4,205 m) above sea level and encompasses a wide variety of ecosystems on its slopes. The UH Management Areas covered by the CMP encompass approximately 11,288 acres beginning at approximately 9,200 ft and extending to the summit. The CMP is intended to guide activities in all three parts of the mountain for which the University has responsibility: the Mauna Kea Science Reserve (Science Reserve), the mid-level facilities at Hale Pōhaku, and the Summit Access Road. Figures 5-1, 5-2, and 5-3 show these three UH Management Areas. The UH Management Areas are in the resource subzone of the State Conservation District and are regulated by the Board of Land and Natural Resources (BLNR).

The following sections describe the existing natural and built environments of the UH Management Areas.

5.1 LAND USE

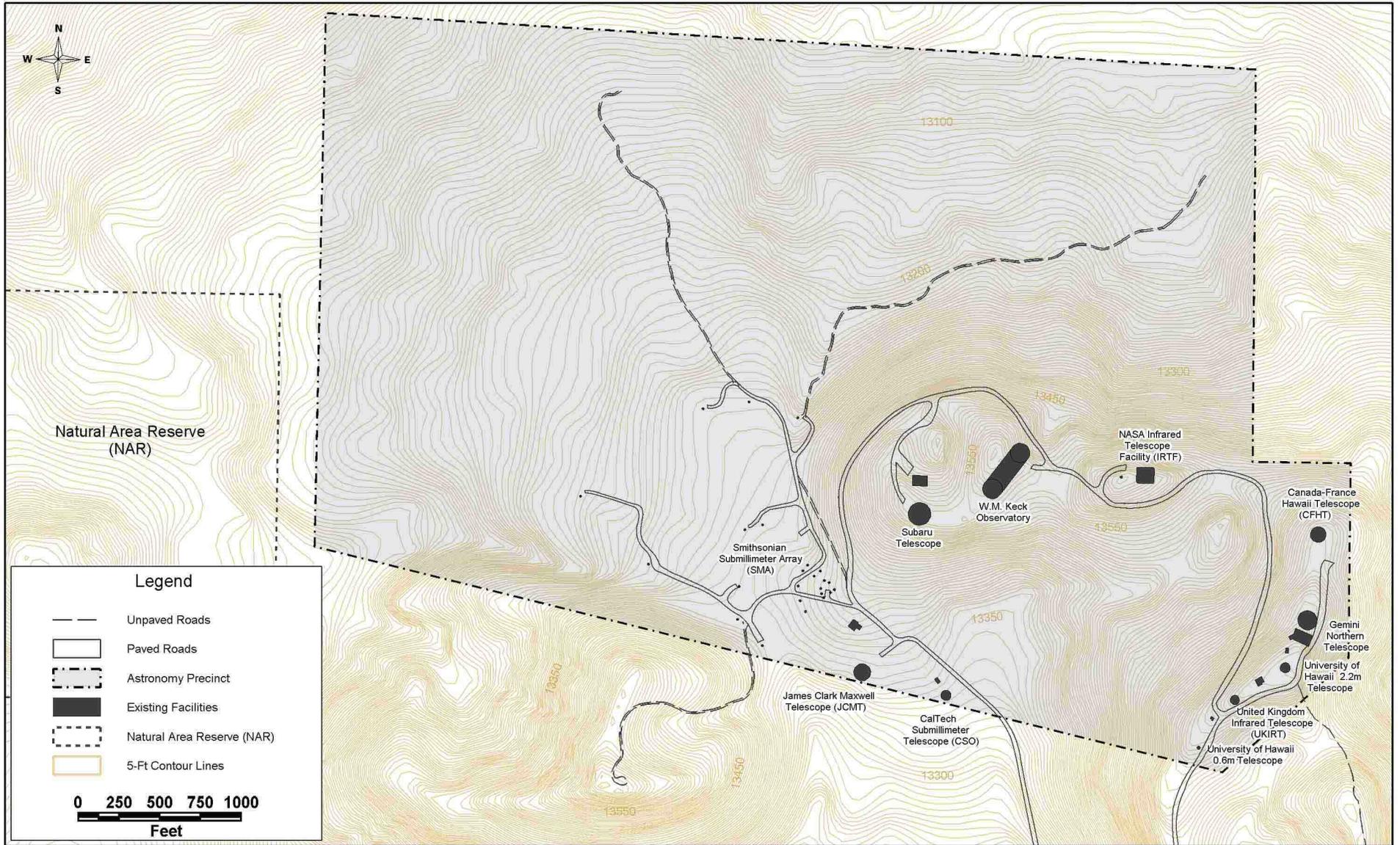
The following section includes a description of the land uses on Mauna Kea and a description of the facilities and uses within the UH Management Areas.

5.1.1 Regional Land Use

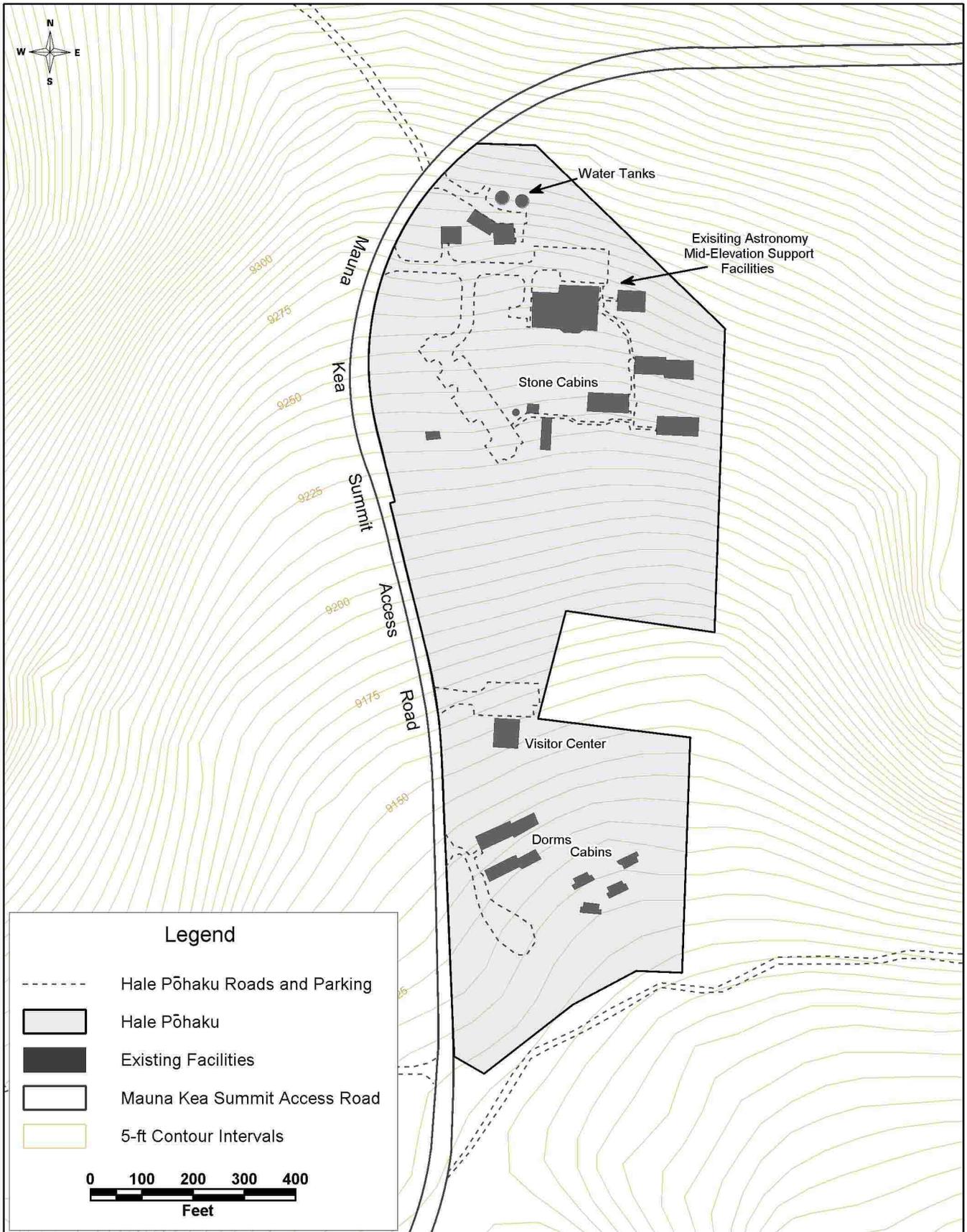
Mauna Kea covers a vast expanse of land and maintains a diversity of ecosystems and land uses in addition to the UH Management Areas. The Mauna Kea Ice Age Natural Area Reserve (NAR), Mauna Kea Forest Reserve, Hakalau Forest National Wildlife Refuge, Hawaiian Home Lands, and the Pōhakuloa Training Area (PTA) are located on Mauna Kea. Figure 5-4 shows the state land use district boundaries and adjacent land uses to the UH Management Areas.

5.1.1.1 *Mauna Kea Ice Age Natural Area Reserve (NAR)*

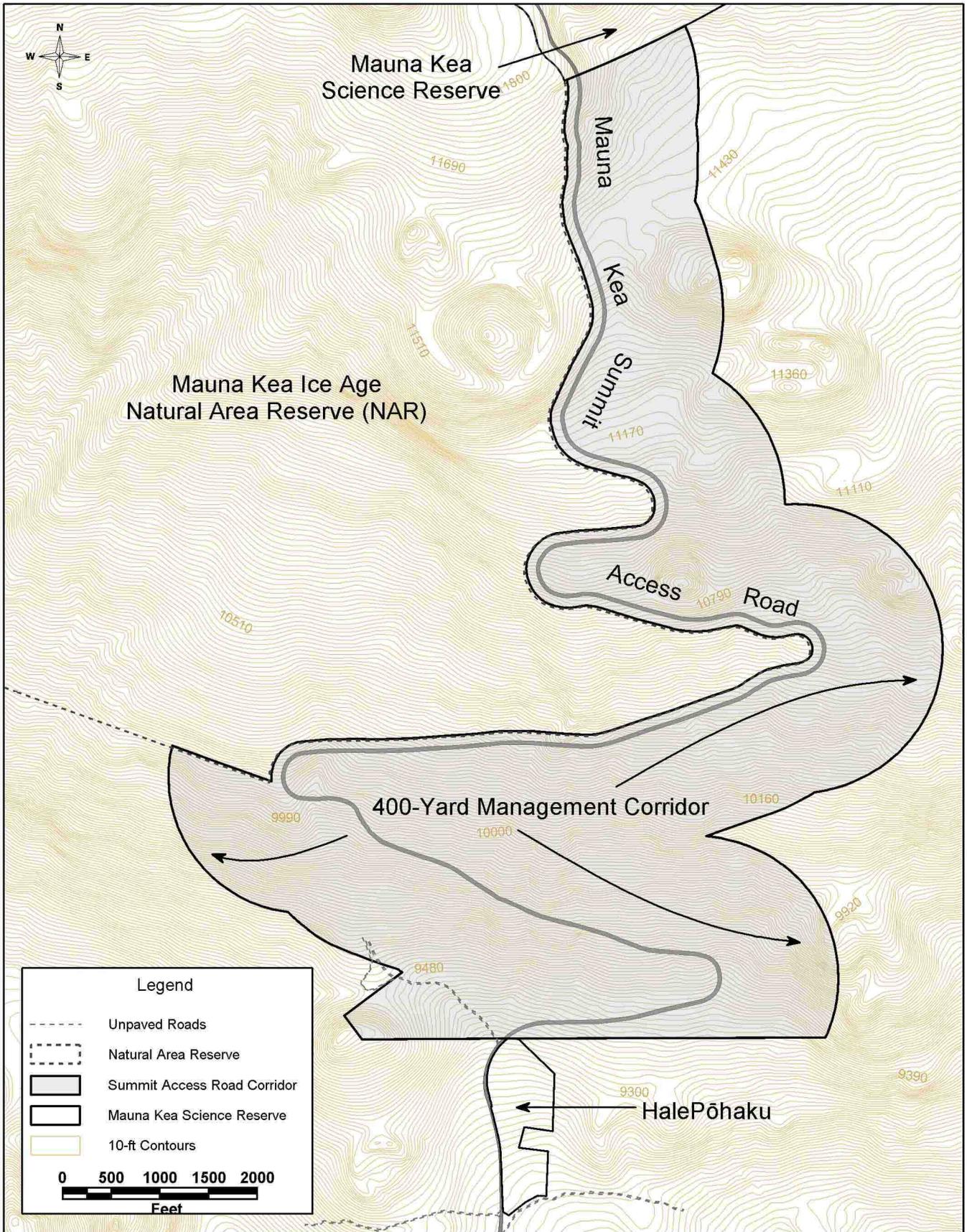
The Mauna Kea Ice Age NAR, established in 1981, is comprised of two parcels that are surrounded by and adjacent to the Science Reserve. The NAR is under the jurisdiction of the DLNR Natural Area Reserves Commission. A 143.5 acre (58 ha) square parcel around Pu'u Pōhaku, is located to the west of the summit area. Fossil ice left behind by glaciations has been found within its boundaries. The larger 3,750 acre (1,518 ha) triangular-shaped parcel extends from approximately 10,070 ft (3,069 m) up to 13,230 ft (4,033 m) at the upper tip of the parcel. Within this piece are several special features: the Mauna Kea Adze Quarry; Lake Waiau – the only high elevation lake in the State; and geomorphic features created by glaciers such as moraines and glacial till. In addition to the lake, the NAR includes another rare ecological community, the invertebrate-dominated aeolian desert. Special status species found in the NAR include the federally-listed endangered Mauna Kea silversword, and the wēkiu bug, a candidate for Federal-listing as endangered.



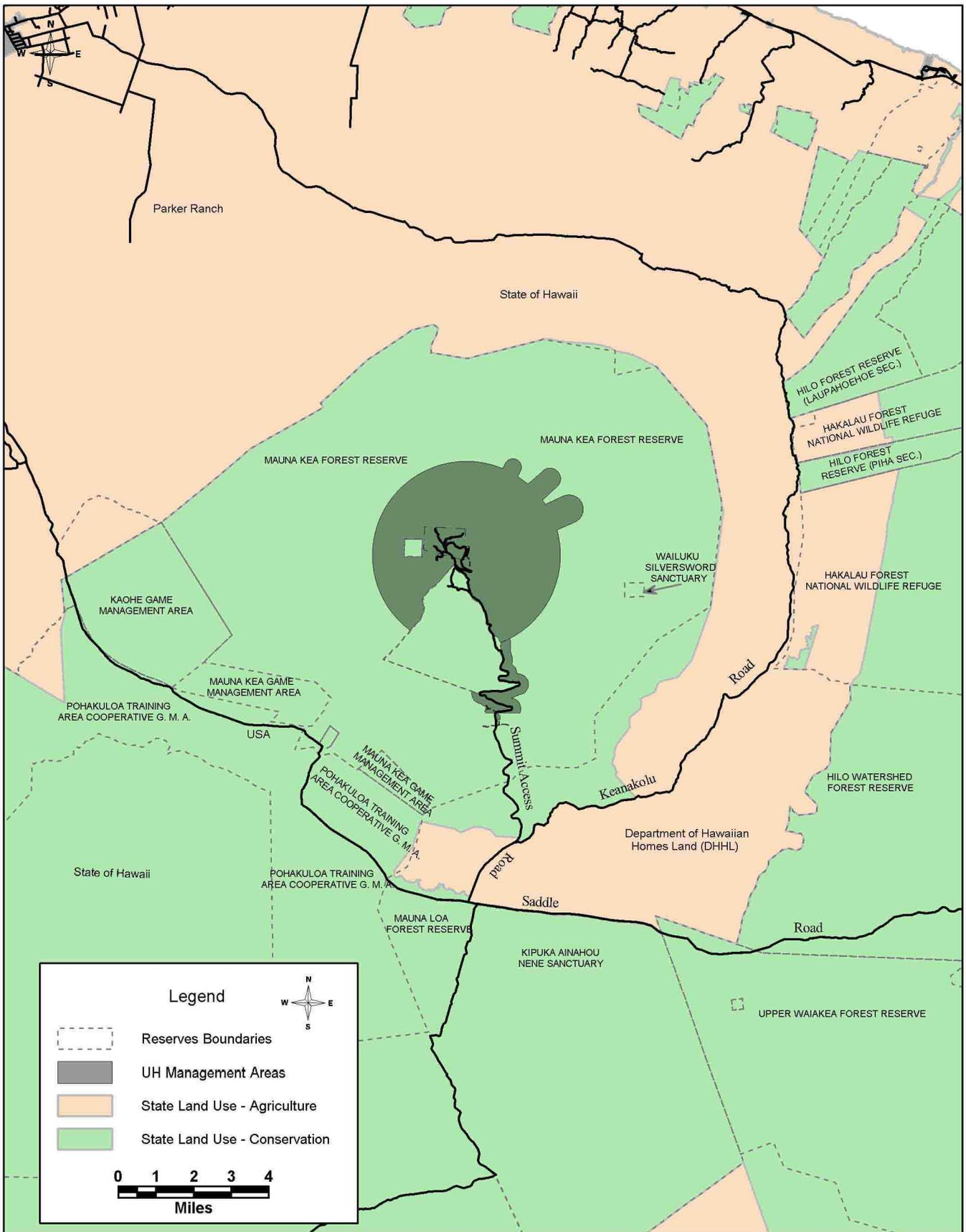
Existing Facilities - Astronomy Precinct



Existing Facilities - Hale Pōhaku



Existing Facilities - Mauna Kea Summit Access Road and Management Corridor



Land Use

In 2008, BLNR, DOFAW-NARS and OMKM reached a tentative agreement to formalize coordinated management of cross-boundary issues between OMKM and the NAR. Under the proposed agreement, OMKM would provide visitor assistance using OMKM rangers, engage in joint research and educational efforts with NAR staff, and report violations occurring in the NAR.

5.1.1.2 *Mauna Kea Forest Reserve*

The Mauna Kea Forest Reserve encompasses approximately 52,500 acres (21,246 ha) above 7,000 ft (2,134 m) surrounding the Science Reserve, Hale Pōhaku, and the Mauna Kea Ice Age NAR. The forest reserve is under the jurisdiction of the DLNR Division of Forestry and Wildlife (DOFAW). The forest reserve contains māmane (*Sophora chrysophylla*) forest, critical habitat for the federally-listed endangered Palila bird. The māmane forests on Mauna Kea contain the entire known world population of Palila. Management issues include browsing by introduced ungulates (e.g., sheep, mouflon, and goats), increasing populations of invasive plant and exotic animal species, and human-caused wildfires. In an effort to curb habitat degradation, ungulate control is conducted by DOFAW and recreational hunting is permitted year-round.

5.1.1.3 *Hakalau Forest National Wildlife Refuge*

The Hakalau Forest National Wildlife Refuge consists of the 33,000 acre (13,355 ha) Hakalau Forest Unit and the 5,300 acre (2,145 ha) Kona Forest Unit on the slopes of Mauna Kea and Mauna Loa, respectively. It was established to conserve endangered forest birds and their habitat. The Hakalau unit of the refuge occupies an area between 2,500 ft and 6,600 ft (762 m and 2,012 m) on Mauna Kea and contains native-dominated montane rainforest, mixed native/exotic forest areas, and grasslands dominated by exotic plants. This area contains at least nine federally-listed endangered plant species, eight federally-listed endangered bird species, and one federally-listed endangered bat species.

5.1.1.4 *Humu'ula Mauka*

The Department of Hawaiian Home Lands (DHHL) has jurisdiction over approximately 53,000 acres (21,448 ha) of the lands of Humu'ula Mauka that were designated by the Hawaiian Homes Commission Act of 1920 to be made available for homesteading purposes. This land was held under leases by Parker Ranch from 1914 to 2002. Today, limited cattle ranching continues on Humu'ula, under a permit issued by DHHL. DHHL, along with beneficiaries and applicants for pastoral lease lands, is currently working on a plan for land stewardship and lessee opportunities on Humu'ula lands near the junction of Saddle Road and the Summit Access Road.

5.1.1.5 *Pōhakuloa Training Area*

At 108,863 acres (44,055 ha), Pōhakuloa Training Area (PTA) is the largest military training area in Hawai'i, extending up the lower slopes of Mauna Kea to approximately 6,800 ft (2,073 m). PTA lands are within the general, limited, and resource subzones of the State conservation district. PTA lands are under the jurisdiction of DLNR, with a portion having been leased to the US Army since 1956. At least nine archaeological and culturally significant sites are known to be located within PTA. PTA is known to contain 15 federally-listed threatened and endangered

plants, three federally-listed endangered bird species, and one federally-listed endangered bat species.

5.1.2 Land Uses in the UH Management Areas

The UH Management Areas support a diversity of uses ranging from scientific research to outdoor recreation and cultural and religious practices. Various facilities including observatories, a visitor center, and support and maintenance building have been developed within the UH Management Areas to support these uses. The following sections include descriptions of the land uses and facilities currently supported in the three UH Management Areas.

5.1.2.1 Astronomy

The summit of Mauna Kea hosts the world's largest ground-based astronomical observing site, considered to be the finest in the world. Physical characteristics that set Mauna Kea apart from other sites include: high altitude, atmospheric stability, minimal cloud cover (about 325 days per year are cloud free at the summit), low humidity, dark skies (because of its distance from urban development), and the transparency of the atmosphere to infrared radiation. A tropical inversion layer about 2,000 ft (600 m) thick that exists between 5,000 and 9,000 ft (1,520 and 2,743 m) provides the upper atmosphere with a buffer from the lower, moist, maritime air, keeping it clear, dry, and free of atmospheric pollutants. Due to the location of the Hawaiian Islands within the northern hemispheric tropics, astronomers can observe the entire northern sky and nearly 80 percent of the southern sky.

In the 1960s, the University of Hawai'i initiated an astronomical research program to attract global interest in constructing and operating telescopes in Hawai'i. The Board of Land and Natural Resources created the Mauna Kea Science Reserve in 1968, granting the University a 65-year lease (Lease No. S-4191) for a scientific complex including observatories. Since the creation of Science Reserve, 14 observatories have been built on Mauna Kea, operated by eleven countries,¹ and used by scientists from around the world. The Gemini observatory was constructed on the site of a former telescope that was decommissioned, hence there are 13 observatories now present (McLaren 2009). The observatories include eight optical and infrared telescopes, two single-dish millimeter- and sub-millimeter-wavelength telescopes, a sub-millimeter array, and a very long baseline array antenna (see Table 5-1). Astronomers access the telescopes both on-site and remotely. As technology allowing remote access and control of the scopes continues to improve, more astronomers are likely to access data remotely, decreasing the amount of astronomy-related traffic traveling to the summit. Figure 5-1 shows the locations of facilities in the Astronomy Precinct.

¹ U.S., Canada, France, the United Kingdom, Japan, Taiwan, Argentina, Australia, Brazil, Chile, and the Netherlands.

Table 5-1 Mauna Kea Telescopes (2008)

Sources: http://www.ifa.hawaii.edu/mko/telescope_table.htm; McLaren 2009

	Name	Mirror	Owner/Operator ²	Year Built
Optical/Infrared				
UH 0.6m ³	UH 0.6-m telescope	0.6m	University of Hawai'i	1968
UH 2.2m	UH 2.2-m telescope	2.2m	University of Hawai'i	1970
IRTF	NASA Infrared Telescope Facility	3.0m	NASA	1979
CFHT	Canada-France-Hawai'i Telescope	3.6m	Canada/France/UH	1979
UKIRT	United Kingdom Infrared Telescope	3.8m	United Kingdom	1979
Keck I	W. M. Keck Observatory	10m	Caltech/University of California	1992
Keck II	W. M. Keck Observatory	10m	Caltech/University of California	1996
Subaru	Subaru Telescope	8.3m	Japan	1999
Gemini	Gemini North Telescope	8.1m	USA/UK/Canada/Argentina/Australia/Brazil/Chile	1999
Submillimeter				
CSO	Caltech Submillimeter Observatory	10.4m	Caltech/NSF	1987
JCMT	James Clerk Maxwell Telescope	15m	UK/Canada/Netherlands	1987
SMA	Submillimeter Array	8x6m	Smithsonian Astrophysical Observatory/Taiwan	2002
Radio				
VLBA	Very Long Baseline Array	25m	NRAO/AUI/NSF	1992

The 525-acre Astronomy Precinct encompasses twelve of the thirteen telescopes on Mauna Kea. The total disturbed area for the installation of the existing observatories at the summit is approximately 17 acres, of which 4 acres is impervious surface, and the area remaining being adjacent and mostly unpaved leveled areas and access roads or driveways (NASA 2005). As depicted on construction drawings, the foundation depths and sizes of the buildings vary, but can extend over a hundred feet below the ground surface and cover hundreds of square feet of surface area. Some of the building's useable areas are also located below grade. The VLBA antenna is situated approximately 1,591 ft below the summit. The dish antenna and control building are accessed by a dirt-road spur from the Summit Access Road.

Buildings at Hale Pōhaku include a support facility for the observatories, construction camp facilities, and Visitor Information Station facilities. The observatory support facilities contain dormitories, dining facilities, and recreational areas and offer a place for astronomers and technicians working at the summit to acclimate before going up, and to live while working. The Visitor Information Station, a 950 sq ft facility, houses an interpretive center and a rest stop for visitors on their way to the summit. Figure 5-2 shows the location of facilities in the Hale Pōhaku area.

² AUI: Associated Universities, Inc.; NASA: National Aeronautics and Space Association (NASA); NRAO: National Radio Astronomy Observatory; NSF: National Science Foundation (NSF)

³ UH Hilo is in the process of replacing the 0.6-meter telescope with a 0.9-meter telescope for instructional use.

5.1.2.2 Scientific Research

Mauna Kea is a tropical high altitude environment with unique geological, biological and cultural features. Although there are hundreds of cultural features on Mauna Kea, until recently much of the research focused on the adze quarry complex located in the Mauna Kea Ice Age NAR. Recently, archaeological field work was conducted for almost the entire UH Management Areas to document and map the locations of historical and cultural resources. This comprehensive work details many previously undocumented resources and provides a baseline with which to gauge future creation and alteration of sites.

Although there have been some in-depth scientific studies conducted on geological history, geomorphic processes and meteorological attributes, the main focus of scientific work on the mountain has been astronomy. The focus of most biological research at the summit has been on the wēkiu bug, and less is known about the other species. Recent research to understand microhabitat and microclimate selection by the wēkiu bug was initiated in 2001, and analysis of meteorological data is being conducted.

OMKM both funds and provides logistical support for scientific studies. The existing facilities at Hale Pōhaku are occasionally used to support visiting scientists, other than astronomers, who are conducting research on the mountain. As use of the mountain for ground-based scientific research grows, managers must consider the potential impacts of further studies, weighed against potential benefits. Recent scientific studies commissioned by OMKM give significant consideration to minimizing the potential impacts on natural and cultural resources in the Science Reserve and involve consultation with Kahu Kū Mauna, the MKMB Environment Committee, and the MKMB.

5.1.2.3 Cultural and Religious Practices

Mauna Kea has been a center of cultural activities and practices by Hawaiians for centuries. Although cultural activities may be documented by the rangers in their daily observation reports, there is no estimate of the level of use of the mountain by cultural practitioners. Lake Waiau and the Adze Quarry are destinations of interest, as is the summit Pu'u Wēkiu.

5.1.2.4 Commercial Activities

Commercial tours are a popular way for out-of-town visitors, including cruise ship passengers, to journey to Mauna Kea. Since rental car companies prohibit the use of their vehicles on Saddle Road, and a 4-wheel-drive vehicle is recommended for driving to the summit, many individuals choose to join an organized tour. OMKM regulates commercial tour use and is responsible for issuing permits. Proceeds collected under OMKM from the permitting process are deposited into a revolving fund used to support management of the mountain. At this time each of the nine permitted operators is allowed two evening tours per day, with no restrictions on the number of daytime or sunrise tours until further notice. The maximum number of passengers per vehicle is 14 with a total capacity including the driver, not to exceed 15. The number of commercial vehicles in or on the premises is not to exceed 18 at any time and no more than two standard commercial tour vehicles or one modified vehicle per tour operator are allowed in the VIS parking lot at any one time.

OMKM reviews requests for the commercial use of the Science Reserve, including filming, concessions, resource extraction and special events. Filming is the most common request, and all permits are initiated through the State of Hawai'i Film office.

5.1.2.5 Recreation and Tourism

The natural beauty, scenic vistas and accessible high peaks of Mauna Kea provides visitors with a unique experience unlike anywhere else. Tourism and private recreational activities, including hiking, biking, hunting, snow-play and sightseeing, has increased over the past several decades due to better access and a greater number of organized commercial and educational tours. Except for commercial activities and time of day limits, public access to all three of the UH Management Areas is currently unrestricted. The Visitor Information Station of the Onizuka Center for International Astronomy (VIS), established in 1986 at Hale Pōhaku, serves to increase visitor knowledge. The VIS provides information on safety and hazards, astronomy, the observatories, and the natural and cultural resources of Mauna Kea as well as restrooms, a gift shop, and an evening stargazing program.

DLNR DOCARE is tasked with providing enforcement on Mauna Kea. To help ensure the safety of visitors, a ranger program was established in 2001 by OMKM. While the rangers do not have any enforcement authority, they do wear uniforms, drive state-owned vehicles and interact extensively with visitors. The perception this creates likely has the benefit of reducing the impact of visitors (e.g., making them less likely to litter, to respond favorably to requests to stay on trails and deter actions that disturb historic properties). The rangers also fulfill a variety of duties including visitor education, recording visitor activity, search and rescue, trail maintenance and litter pick-up. There are at least two OMKM rangers on duty daily.

While there is no official registration system to track users, in recent years OMKM has been keeping detailed records on the number of people visiting the VIS and the summit (Nagata 2007). It is estimated that in 2002, 105,000 visitors stopped at the VIS (Good 2003). Byrne (2008) indicates similar estimates of greater than 100,000 visitors per year at the VIS over the past few years. The recorded total for all types of summit visitations by vehicles was 32,066 in 2006 and 32,017 in 2007 (OMKM, unpublished data).⁴ Observatory vehicles and visiting 4-wheel drive vehicles represent, by far, the largest percentage of total vehicles on the mountain, with just over 13,000 of the former and over 10,500 of the later, in 2007 (OMKM, unpublished data). Ranger estimates indicate an average of about 30 non-commercial visitors a day to the summit, most of them staying less than 30 minutes (OMKM Rangers 2007). The majority of non-observatory traffic occurs in the afternoon. It is anticipated that as tourism on the Big Island continues to grow, and with the ongoing improvements to Saddle Road, more tourists and recreational visitors will visit Mauna Kea in coming years. Currently OMKM rangers estimate that most recreational visitors are from the mainland or overseas, but there is no official tracking of visitor demographics (OMKM Rangers 2007).

Hiking is currently a popular day-use activity for visitors to Mauna Kea. There are several established (but unmarked) trails in the summit region and other trails at lower elevations.

⁴ The reference (OMKM, unpublished data) refers to data from OMKM database on Ranger patrol reports, ongoing collection 2001–present. Data is housed in a Microsoft Access database at the OMKM main office.

Rangers monitor the trails that lead to the most popular places of interest and work to curtail unwanted new trails by directing visitors to the established ones and covering over evidence of unwanted trails. New trails are mainly created when visitors or researchers opt to explore new terrain. Due to lack of signage and a maintained trail network, a faint trail used infrequently may be discovered by others and become more established and impacted. Trail maps are available at the VIS and hikers are requested to register there and inform rangers of their travel plans. Ranger reports between 2001 and 2007 suggest that approximately five to six thousand hikers visit the summit region every year (OMKM, unpublished data).

Hunting occurs in many areas on Mauna Kea. Although hunters are known to start looking for animals as far up as 12,000 ft (3,660 m), mammal hunting typically takes place at lower elevations outside the UH Management Area in the DLNR Mauna Kea Forest Reserve where the animals are more numerous. As a result of a lawsuit filed to protect designated critical habitat for the endangered Palila, the māmane-naio forest, a Federal court ordered the eradication of sheep and goats from Mauna Kea, in 1979. Although this goal was nearly achieved in 1981, the animals are still present on the slopes of Mauna Kea, and hunting continues to be a popular recreational and subsistence activity with local residents. DLNR maintains an active control program for sheep, goats and mouflon from the lower boundaries of the Mauna Kea Forest Reserve up into the Mauna Kea Science Reserve.

Skiing and snow-play are a common winter pastime on the Big Island when the conditions are right. Other than for plowing the roads (conducted by Mauna Kea Observatory Support Services [MKSS]) and directing parking, there is no logistical support for snow operations on the summit and it is difficult to control use and access. During periods of heavy snow, rangers keep the road closed at Hale Pōhaku until they receive confirmation that conditions are safe for visitors to proceed up the mountain. Sometimes people wait overnight in their cars for the opportunity. The primary area used for snow play, known as the Poi Bowl, is located directly east of the Caltech Submillimeter Observatory—in part because it is accessible by road both at both the top and bottom of the run. Because there are no designated trails or ski lifts, visitors often hike off-trail to reach the ski runs, sometimes traveling across open cinder between the snow-covered areas. Vehicle and visitor traffic to the summit may be particularly high on snow days, especially when they fall on weekends. Many people (especially locals) visit the mountain only when there is snow. As many as 600 vehicles were recorded traveling to the summit on one heavy snow day, and each of these is likely carrying several passengers (OMKM, unpublished data). On New Year's Day 2004, after a period of particularly heavy snowfall, rangers estimated there were 1,400 vehicles on the summit (Mauna Kea Management Board 2004) and during the nineteen days documented by OMKM Rangers as snow days in 2007, a total of 2,547 vehicles were recorded on the mountain (OMKM, unpublished data).

5.2 CULTURAL RESOURCES

Articles IX and XII of the State Constitution, other state laws, and the courts of the state require government agencies to promote and preserve cultural beliefs, practices, and resources of native Hawaiians and other ethnic groups. To assist decision-makers in the protection of cultural resources, the Chapter 343, HRS and the HAR § 11-200 rules for the environmental impact assessment process require project proponents to assess proposed actions for their potential impacts to cultural properties, practices, and beliefs. This process was clarified by the

Hawai'i State Legislature in Act 50, SLH 2000. Act 50 recognized the importance of protecting native Hawaiian cultural resources and specifically required that environmental impact statements include the disclosure of the effects of a proposed action on the cultural practices of the community and State; and amended the definition of "significant effect" to include adverse effects on cultural practices.

The Environmental Council developed guidelines for preparing "cultural impact assessments" as part of the Chapter 343, HRS process. The Environmental Council stated that cultural impacts differ from other types of impacts assessed in environmental assessments or environmental impact statements and that a cultural impact assessment should include information relating to the practices and beliefs of a particular cultural or ethnic group or groups (Environmental Council 1997). Such information may be obtained through scoping, community meetings, ethnographic interviews and oral histories. Information provided by knowledgeable informants, including traditional cultural practitioners, can be applied to the analysis of cultural impacts in conjunction with information concerning cultural practices and features obtained through consultation and from documentary research (Environmental Council 1997). While the content guidelines have been used to clarify how cultural should be used in the preparation of environmental impact assessment documents, they have not been adopted as rules in HAR § 11-200. The Environmental Council's Guidelines for assessing cultural impacts may be found on the OEQC's website (<http://oeqc.doh.hawaii.gov/default.aspx>).

This DEA's Section 5.2 and Section 6.3 were developed pursuant to Chapter 343, HRS and HAR § 11-200 and using the Environmental Council's guidelines for assessing cultural impacts. This DEA includes a discussion of the cultural assessment sources of information, historic properties, cultural practices, and beliefs, while Section 6.3 includes a discussion of the potential affects of the Proposed Action on cultural resources.

5.2.1 Summary of Consulted Source Materials

This cultural impact assessment is drawn from various cultural-historical documentation sources, including archaeological investigations, ethnohistorical reports, ethnographic oral history interviews, public hearings, and archival historic documents.

Sources of ethnographic detail include primary-document historical surveys (Alexander 1892; Ellis 1979; Gregory & Wentworth 1937; Kilmartin 1974; Preston 1895; Thrum 1921), primary-document historic-period ethnographies (Kamakau 1961; Kamakau 1964; Kamakau 1991), and secondary-source ethnographic surveys and analyses (Barrere et al. 1980; de Silva & de Silva 2006; Kanahale & Kanahale 1997; Langlas 1999; McEldowney 1982; Pukui & Elbert 1971; Pukui et al. 1972; Valeri 1985; Westervelt 1963).

Several oral history investigations have been conducted in the recent past concerning Mauna Kea's cultural and historical significance to Native Hawaiian people. In 1999, as a part of the update of the Complex Development Plan of MKSR and Hale Pōhaku for the University of Hawai'i, Kepā Maly (*Kumu Pono Associates*) conducted a detailed oral history project (Maly 1999). Transcripts from three previously recorded interviews conducted in 1956, 1966, and 1967 were made available. Transcripts of a total of fourteen interviews that Maly conducted with nineteen individuals in 1998 were also published. In addition, Maly's report included excerpts of testimony provided before the Mauna Kea Advisory Committee in public hearings

that occurred in 1998. From 2000 to 2005, Maly conducted another twenty interviews with twenty-one individuals at the request of the University of Hawai`i's Office of Mauna Kea Management (Maly & Maly 2006). Finally, three oral history interviews with individuals recommended by Maly were conducted by Maria Orr (*Kaimi Pono Consulting Services, LLC*) in 2004 for NASA's W.M. Keck Observatory Outrigger Telescopes project (Orr 2004). All these oral history interviews were reviewed for information pertaining to Native Hawaiian cultural practices and beliefs as they concern to Mauna Kea.

In recent years, on behalf of the University of Hawai`i's Office of Mauna Kea Management, Kepā Maly and Onaona Maly (*Kumu Pono Associates*) compiled archival historic documents relating to the *`āina mauna* (Maly & Maly 2005). Maly's exhaustive review draws from the following historical primary source documents – traditional Hawaiian *mele* (poems, chants), native Hawaiian and foreign accounts dating to the 19th and early 20th centuries that are found in Hawaiian language newspapers, government records of the Hawaiian Kingdom and the Hawaiian Territory (i.e. Māhele and Boundary Commission testimony and land lease records), historic maps, and finally the journals, letters, manuscripts, and field notes of foreign visitors, settlers, and scientific expedition party members.

5.2.2 Historic Properties

The number, variety and significance of the historic properties located in the UH Management Areas is unusual and, indeed, unparalleled elsewhere in Hawai`i. An historic property, as defined in Chapter 6E-2 (HRS), is “any building, structure, object, district, area or site, including heiau and underwater site, which is over fifty years old. Historic property is an umbrella term that includes and is often used interchangeably with “archaeological site” and “historic site.” A type of historic property is a traditional cultural property (TCP). TCP's are defined as follows:

A traditional cultural property, then, can be defined generally as one that is eligible for inclusion in the National Register because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community. (National Register Bulletin 38: 1998:1)

A total of 223 historic properties have been identified and recorded in the UH Management Areas as of 2008 (Table 5-2). All but one of the properties is located in the Science Reserve. The other historic property is located at Hale Pōhaku.

Table 5-2. Historic Property Types in the UH Management Areas

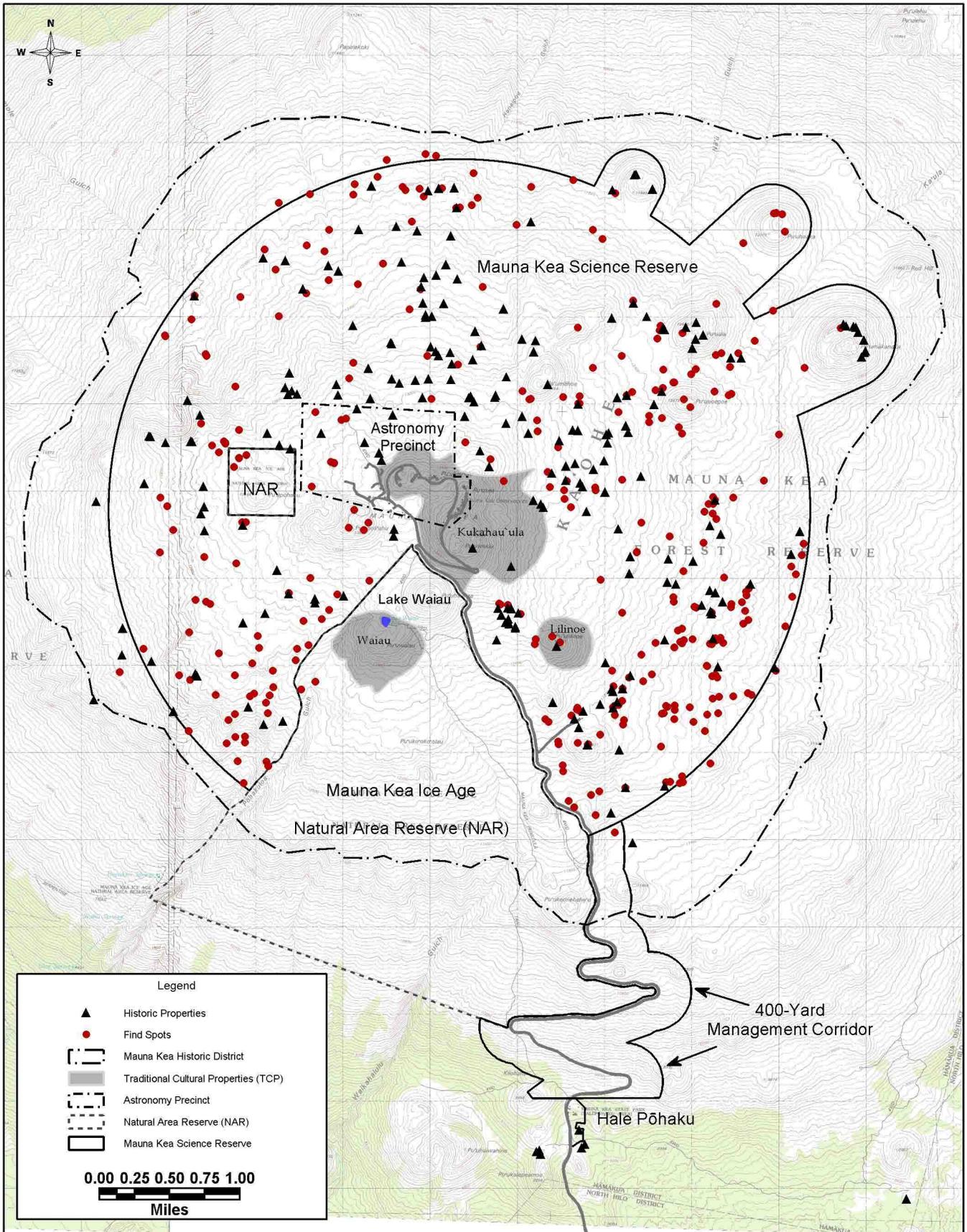
Site Type	Number	Percent of Total
Traditional Cultural Properties	2	0.90
Shrines	147	65.91
Burials and Possible Burials	28	12.56
Stone Tool Quarry/Workshop Complexes	2	0.90
Adze Quarry Ritual Center	1	0.44
Isolated Adze Manufacturing "Workshops"	17	7.62
Isolated Artifacts	3	1.35
Stone Markers/Memorials	10	4.50
Temporary Shelters	3	1.35
Historic Campsites	1	0.44
Unknown Function	9	4.03
TOTAL	223	100%

Within the UH Management Areas, there are a large number of sites that, at present, cannot be classified as sites as normally defined in State and Federal laws, but which nevertheless need to be considered in developing appropriate management strategies. In 1997, SHPD instituted a process of recording what were initially referred to as "locations" but are now being termed "find spots," although this term generally refers to isolated artifacts (cf. McCoy 1984a). "Find spots" are cultural resources that are either obviously modern features (e.g., camp sites with tin cans, pieces of glass and other modern material culture items), or features that cannot be classified with any level of confidence as historic sites because of their uncertain age and function (e.g., a pile of stones on a boulder). The archaeological fieldwork of the Science Reserve identified a total of 336 "find spots". The determination whether, these "find spots" constitute "cultural resources" is a matter more appropriately delegated to Kahu Kū Mauna in consultation with families with lineal connections to Mauna Kea, cultural practitioners, and other Native Hawaiian organizations.

Figure 5-5 shows the location of identified historic properties and find spots in UH Management Areas. The survey identified various historic properties and find spots immediately outside of the UH Management Area boundaries. While these historic properties are not within the UH Management Areas, and consequently included in the scope of the CMP, they were considered in the cultural impact analysis on the area because of their close proximity to the UH Management Areas.

5.2.2.1 Traditional Cultural Properties

In 1999, three areas in the summit region were designated Traditional Cultural Properties (TCPs) by the State Historic Preservation Division based on their association with legendary figures and on-going cultural practices (Group 70, Inc. 2000:Appendix F). Two of the TCPs, the summit (Kūkahau'ūla) and Pu'u Lilinoe, are located in the Science Reserve. The third TCP is Lake Waiau, which is located just outside of the Science Reserve in the Mauna Kea Ice Age Natural Area Reserve. Figure 5-5 includes the locations of TCPs on Mauna Kea.



Historic Properties, Traditional Cultural Properties, and Find Spots

5.2.2.2 *Shrines*

Shrines are the most common site type in the UH Management Areas. The quintessential characteristic of all the remains identified as shrines is the presence of one or more upright stones, which are god-stones. Each upright probably represented a different god. On current evidence there are, at a minimum, two functional classes of shrines: (1) occupational specialist shrines related to adze manufacture, and (2) all the others, which appear to be “non-occupational.” Morphologically, there is nothing to distinguish these two classes, each of which exhibits considerable variability in groundplan, number of uprights, etc. The Mauna Kea shrines are in this regard no different from Hawaiian shrines in general. According to Buck, “Shrines varied considerably in construction, and similar forms were distinguished merely by their function” (Buck 1957:528). The only thing that distinguishes the occupational shrines from the others is the presence of stone artifacts related to adze manufacture. Figure 5-6 provides examples of typical shrines located on UH Management Areas.

5.2.2.3 *Burials & Possible Burials*

There are currently 28 sites in the Science Reserve that have been interpreted as burials or possible burials (see Table 5-2). They are the second most common site type in the UH Management Areas. For the sites classified as possible burials there are compelling reasons, such as the topographic location and morphological characteristics of the structures, to believe that these sites are indeed burials, but because human remains were not seen at the time they were recorded they are classified as possible burials. No burials have been identified within the Astronomy Precinct.

5.2.2.4 *Stone Tool Quarry/Workshop Complexes*

Two kinds of stone tool quarry/workshop complexes have been found in the UH Management Areas, one in the Science Reserve and one at Hale Pōhaku. The complex in the Science Reserve is a part of the Mauna Kea Adze Quarry Complex and consists of a large number of quarries, workshops, shrines and at least several habitation rockshelters. The site at Hale Pōhaku is a multi-functional site complex, consisting of several temporary camp sites where the manufacture of adzes and octopus lure sinkers took place. Two shrines, both related to sinker manufacture, are a part of this unusual site complex, which is the only one of its kind known at the present time.

5.2.2.5 *Adze Quarry Ritual Center (Keanakāko‘i)*

Site 50-10-23-16204, comprises shrines, enclosures and a diffuse scatter of adze manufacturing by-products. McCoy (1999b) has interpreted the site, which is located outside of the quarry proper because there is no local source of stone-tool quality basalt, as the locus of initiation rites for apprentice adze makers. The Adze Quarry Ritual Center is not within the Astronomy Precinct.



Figure 5-6 Examples of Shrines Identified on UH Managed Land

5.2.2.6 *Isolated Adze Manufacturing ‘Workshops’*

There are currently 17 sites in the Science Reserve that have been tentatively classified as adze manufacturing “workshops” based on the presence of one or more of the following kinds of artifacts---flakes, cores, unfinished adzes, and hammerstones (see Table 5-2). These are “workshops” of a different kind than those found in the adze quarry, however. First, with one or two possible exceptions, there is little question that the artifacts in these sites were transported from the quarry, even though a geochemical analysis has not yet been conducted to confirm this. Second, in some cases there seems to be a disproportionate number of unfinished adzes compared to the number of flakes, thus pointing to the high probability that some of the adzes were flaked elsewhere and/or transported to these localities at a later stage in the manufacturing process. At other sites the predominant artifact type is flakes. These characteristics, combined with the small size of most of the artifact assemblages, indicate that these were not ordinary workshops. Indeed, the evidence for *in situ* manufacture, as opposed to a place where offerings were made, is in many instances ambiguous. If manufacture did take place it would appear to have been an essentially symbolic act.

Associated with several of these workshops is one or more shrines. Unfinished adzes, flakes and occasionally other manufacturing byproducts were found on or near the shrines at several sites. These assemblages, like those found on many shrines in the quarry, are interpreted as offerings to the tutelary gods of adze making (Malo 1951; McCoy 1990, 1999b). All of these sites are highly significant for the information they convey about the quarry as a social process. None of these isolated manufacturing workshops are within the Astronomy Precinct.

5.2.2.7 *Isolated Artifacts*

Isolated artifacts found in the survey of the Science Reserve include adze preforms, adze manufacturing waste flakes, hammerstones, and a horseshoe. They possess historic integrity and have yielded information that is contributing to a more detailed understanding of the adze manufacturing process on Mauna Kea. Their locations alone provide important data on the ascent and descent routes utilized by at least some of the adze makers whose homes would have been on the Hamakua Coast.

5.2.2.8 *Stone Markers/Memorials*

Nine sites are classified as either survey markers or markers left by unknown visitors. These include cairns, mounds, and less formal piles of rocks on top of a boulder. Morphologically, all are quite unlike those which have been interpreted as burials. Some of the more elaborate examples are cylindrical in shape and faced.

It is possible that some of the simple stacked-stone constructions that have been interpreted as modern may be memorials of the kind described by Thomas Thrum in Haleakala:

“It was a recognized custom of Hawaiians to erect stone piles--pile is one meaning of the word ahu--as way marks, memorials of parties traveling or resting, division points of survey, and also guides to most accessible routes of travel. One such marks the safest of three ridges leading from the rim of the crater to the district of Nuu. That some ahu mark burial places is in accord with the present practice in certain districts of Maui and of Hawai'i, and perhaps elsewhere.

Most, if not all, of the ahus of three stones, one upon the other, are tributes to the deity of the locality and are designed by travelers to assure safety in their journey.” (Thrum 1921:259)

5.2.2.9 Temporary Shelters

Crude stone walls were found at various localities in the Science Reserve, usually in association with other features, such as lithic scatters. Three sites consist of nothing more than walls. Two to a maximum of four walls were found at these sites. Some are linear, while others are roughly C-shape in planview. They are interpreted as temporary shelters based on their morphology and environmental setting. There is no means of dating any of these sites, which are probably either late prehistoric or historic in age.

5.2.2.10 Historic Campsites

One of the camps (Camp Site 3) occupied by the United States Geological Survey team in 1926 was found in 2007 on the north slope of the mountain near Pu’u Mahoe. Another possible USGS campsite was found near Pu’u Makaanaka, just outside of the Science Reserve.

5.2.2.11 Unknown Function

There are nine sites of uncertain or unknown function, including the only known site on the summit (see Table 5-2). Three of the sites are either cairns or piles of rocks that could be markers. One site, a terrace with a possible upright, may be an unfinished shrine.

5.2.2.12 The Mauna Kea Summit Region Historic District

In 1999, during the preparation of the Master Plan, SHPD proposed that the cultural landscape on the top of Mauna Kea be formally recognized as a historic district based on the large number and significance of historic properties found in the upper elevations of the mountain. Because most of the sites appeared to be located on or near the boundary of the summit plateau at roughly the 12,000 ft elevation the district was called the Mauna Kea Summit Region Historic District. The historic district proposal was summarized in the cultural impact assessment for the Master Plan (PHRI 1999:30-32) and discussed in more depth in the early planning process for the proposed Keck Outrigger project (Hibbard 1999; NASA 2005). The preliminary district boundary is shown in Figure 5-5.

All of the sites in the Science Reserve are contained within the proposed boundaries of the historic district. They are what are called contributing properties in the National Register:

A **contributing** building, site, structure or object adds to the historic architectural qualities, historic associations, or archaeological values for which a property is significant because a) it was present during the period of significance, and possesses historic integrity reflecting its character at that time or is capable of yielding important information about the period, or b) it independently meets the National Register criteria (National Register Bulletin 24:45).

5.2.3 Utilizing The Ka Pa‘akai Analytical Framework

One of the fundamental approaches to the development of the CMP was based upon addressing the Hawai‘i Supreme Court’s analytical framework to ensure that traditional and customary Native Hawaiian rights are preserved and protected. This framework has its foundation in *Ka Pa‘akai*. This includes at a minimum addressing: “(1) the identity and scope of ‘valued cultural, historical, or natural resources’ in the petition area, including the extent to which traditional and customary native Hawaiian rights are exercised in the petition area; (2) the extent to which those resources – including traditional and customary native Hawaiian rights – will be affected or impaired by the proposed action; and (3) the feasible action, if any, to be taken by the [agency] to reasonably protect native Hawaiian rights if they are found to exist.” *Ka Pa‘akai*, 94 Hawai‘i at 52, 7 P.3d at 1089.

The CMP methodically applies the three components to ensure that traditional and customary Native Hawaiian rights and cultural, historical, and natural resources are preserved and protected.

- 1) *The identity and scope of valued cultural, historical, or natural resources that are found within the UH Management Areas, including the extent to which traditional and customary Native Hawaiian rights are exercised in the areas*

The identification and scope of the valued cultural resources to a large extent was gathered from personal interviews and meetings, as well as historical documentation about cultural resources and traditional and customary practices that may have been historically and are contemporarily exercised within the UH Management Areas. There were several families who claim a lineal connection to Mauna Kea as demonstrated by burying *iwi* or bones of their families or the *piko* of their children on Mauna Kea. There were other Native Hawaiian practitioners who shared that historically and contemporarily their *ohana* gathered mamake, ko‘oko‘olau, and māmane for medicinal purposes. Others talked about accessing through Mauna Kea for subsistence hunting and gathering purposes. Some Native Hawaiians did not provide details as to their activities on the mountain, as it is deemed to be “*maha‘o*” (rude) to ask a Hawaiian what and where they gather. Rights of confidentiality were respected. Additional information came from the archaeological surveys and existing documentation about historical uses of Mauna Kea and some contemporary uses, including the building of shrines and altars.

Valuable natural resources were identified through literature review, reports on past surveys conducted on the UH Management Areas, and interviews with local experts and concerned community members. All natural resource management activities have the overarching goal of protecting, preserving, and enhancing natural resources in the UH Management Areas.

- 2) *The extent to which those resources – including traditional and customary Native Hawaiian rights – will be affected or impaired by the proposed action*

In this case, the proposed action is the adoption of the CMP to manage the multiple activities and uses on Mauna Kea in a way that will preserve and protect the valuable cultural, historical and natural resources. The proposed action is designed to protect, not impair, Native Hawaiian rights as well as valued cultural, historical and natural resources. There are existing activities, including unrestricted access, astronomy, scientific research, recreation and tourism, commercial activities, and cultural and spiritual practices that may affect the protection and

preservation of these valued resources. There are also existing uses and activities related to infrastructure, including facility maintenance, utilities, water and waste removal, roads, safety, and future land uses that may pose similar impacts.

3) *The feasible action, if any, to be taken by the agency to reasonably protect Native Hawaiian rights if they are found to exist*

There is no doubt that there are Native Hawaiians who are exercising traditional and customary rights on Mauna Kea. The CMP is designed to ensure that those rights are preserved and protected, balanced against the preservation and protection of natural and cultural resources and the protection of public safety. Access to engage in traditional and customary rights will not be adversely affected by the CMP. The Management Actions in the CMP are designed specifically to provide a set of management actions with guidelines to manage existing and potential future activities and uses to ensure that the cultural, historical, and natural resources are properly managed and protected not only for this generation but for future generations. In those instances where specific cultural protocols need to be addressed and developed, the CMP recommends that Kahu Kū Mauna or the Mauna Kea Management Board (MKMB) Hawaiian Cultural Committee work in coordination with families that have a lineal connection to Mauna Kea, cultural practitioners, and other Native Hawaiian organizations to develop culturally appropriate protocols.

5.2.4 Hawaiian Cultural And Natural Resource Management Principles

Davianna Pomaika'i McGregor attributes the quality and abundance of natural resources within a community to the persistence of *'ohana* (family) values and practices in the conduct of subsistence activities. "An inherent aspect of these *'ohana* values is the practice of conservation to ensure availability of natural resources for present and future generations. These rules of behavior are tied to cultural beliefs and values regarding respect of the *'aina*, the virtue of sharing and not taking too much, and holistic perspective of organisms and ecosystems that emphasizes balance and coexistence. The Hawaiian outlook that shapes these customs and practices is *lokahi* or maintaining spiritual, cultural and natural balance with the elemental life forces of nature" (McGregor 1996). It is the ancestral knowledge about the land and its resources that is reinforced through continued subsistence practices. "The practitioners stay alert to the condition of the landscape and the resources and their changes due to seasonal and life cycle transformations. This orientation is critical to the preservation of the natural and cultural landscape. The land is not a commodity to them. It is the foundation of their cultural and spiritual identity as Hawaiians. They proudly trace their lineage to the lands in their region as being originally settled by their ancestors. The land is a part of their *'ohana* and they care for it as they do the other living members of their families" (McGregor 1996).

5.2.4.1 Principles of Hawaiian Cultural Resource Management

First, the *ahupua'a* is the basic unit of Hawaiian cultural resource management. Second, the natural elements – land, air, water, ocean – are interconnected and interdependent. Third, of all the natural elements, fresh water is the most important for life and needs to be considered in every aspect of land use and planning. Fourth, Hawaiian ancestors studied the land and the natural elements and became very familiar with its features and assets. Ancestral knowledge of the land was recorded and passed down through place names, chants which name the winds,

rains, and features of a particular district, and legend; therefore, it is important to consult these sources to learn of the culture and natural resources of a particular district (McGregor 1996).

5.2.4.2 Cultural Land Use Practices

Within a Hawaiian context the land and ocean are an integrated whole. McGregor notes that the methods and techniques of accessing, acquiring or utilizing traditional and natural resources may have changed over time but this does not detract from the fact that the resources are used and prepared for Hawaiian custom and practice related to subsistence, culture and religion. Hawaiian custom and practice is embedded in the honor and respect for traditional *'ohana* values and customs to guide subsistence harvesting of natural resources. For example, only take what is needed, don't waste natural resources, take care of the *kupuna* who passed on the knowledge and experience, and respect the resources (McGregor 1996).

5.2.4.3 Sources of Information About Cultural Practices

Traditionally, cultural knowledge was remembered and passed down through oral tradition in chants, legends, myths, genealogies, and place names. There is still a wealth of knowledge that is kept alive and practiced by living generations of Hawaiian families, and those who received traditional training such as *kumu hula* and *kahuna la'au lapa'au*. Moreover, the living culture is constantly undergoing growth and change. Therefore, any effort to understand and document the natural and cultural resources of an area must include consultation with the Hawaiian *'ohana*, *kumu*, and cultural groups who live in the area and take responsibility for the cultural and natural resources of the area (McGregor 1996).

5.2.4.4 Cultural Landscape

A cultural landscape is composed of physical elements which manifest the technological and cultural basis of human use of the land through time. While McGregor identifies several components of a Hawaiian cultural landscape, of relevancy to Mauna Kea is the following. *Wahi pana*, which are sacred sites such as *heiau*, shrines, burial caves and graves and geographic features associated with deities and significant natural, cultural, spiritual or historical phenomenon or events. Ed Kanahale offers a description of *wahi pana* in the introduction in *Ancient Sites of O'ahu*, by Van James (1991) as "The gods and their disciples specified places that were sacred. The inventory of sacred places in Hawai'i includes the dwelling places of the gods, the dwelling places of venerable disciples, temples, shrines, as well as selected observation points, cliffs, mounds, mountains, weather phenomena, forests, and volcanoes." Domains of *'aumakua* or ancestral deities is another component of the cultural landscape. These are places where particular natural and cultural areas are important as traditional domains of *'aumakua* or ancestral spirits and deities, where Hawaiians renew their ties to ancestors through experiences with natural phenomena and witnessing *ho'ailona* or natural signs. Finally, trails and roads are part of the cultural landscape as they provide access to the cultural resource and use areas (McGregor 1996).

5.2.4.5 *Mauna Kea in Creation Stories and as a Home of the Gods*

Native Hawaiian traditions state that ancestral *akua* (gods, goddesses, deities) reside within the mountain summit area. These personages are embodied within the Mauna Kea landscape – they are believed to be physically manifested in earthly form as various *pu`u* and as the waters of Waiau. Because these *akua* are connected to the Mauna Kea landscape in Hawaiian genealogies, and because elders and *akua* are revered and looked to for spiritual guidance in Hawaiian culture, Mauna Kea is considered a sacred place.

Native Hawaiian genealogical *mele* (poems, chants) explain the centrality of Mauna Kea within Hawaiian genealogy and cultural geography. *Mele* recount that as a result of the union of Papa and Wākea, who are considered the ancestors of Native Hawaiians, the island of Hawai`i was birthed. In the *Mele a Paku`i*, a chant describing the formation of the earth, Mauna Kea is likened as the first-born of the island children of Papa and Wākea, who also gave rise to Hāloa, the first man from whom all Hawaiians are descended (Kamakau 1991:126 in Maly & Maly 2005:7-8). A *mele hānau* (birth chant) for Kamehameha III, who was born in 1814, describes the origins of Mauna Kea:

*Born of Kea was the mountain,
The mountain of Kea budded forth.
Wākea was the husband, Papa
Walinu`u was the wife,
Born was Ho`ohoku, a daughter,
Born was Hāloa, a chief,
Born was the mountain, a mountain-son of Kea.*
(Pukui & Korn 1973:13-28 in Maly & Maly 2005:9).

Some contemporary Native Hawaiian cultural practitioners continue to view Mauna Kea as a first-born child of Papa and Wākea, and thus, the mountain is revered as “the *hiapo*, the respected older sibling of all Native Hawaiians” (Kanahele & Kanahele 1997 in Langlas 1999:7). Cultural practitioner Kealoha Piscotta explains that this link to Papa and Wākea “is the connection to our ancestral ties of creation” (Orr 2004:61). Pualani Kanaka`ole Kanahele states that “the very fact that it is the ‘Mauna a Wākea’ tells you that it is the mauna that is meeting Wākea” (Maly 1999:A-368).

Traditional genealogical *mele* (poems, chants) and *mo`olelo* (stories, traditions) recount associations between Mauna Kea and the following *akua* – Poli`ahu, Lilinoe, Waiau, and Kahoupakane. In a *mo`olelo* recounting the travels of Pūpū-kani`oe, it was said that Mauna Kea was a mountain “on which dwell the women who wear the *kapa hau* (snow garments)” (Maly & Maly 2005:31). Yet another *mo`olelo*, which dates to the 1300s, explains that Ka-Miki was sent atop Mauna Kea’s summit to the royal compound of Poli`ahu, Lilinoe, and their ward, Ka-piko-o-Waiiau, to fetch water for use in an *ai-lolo* ceremony (Maly & Maly 2005:42-43).

In the post-Contact period, Native Hawaiian historian S.N. Haleole transcribed *Ka Mo`olelo o Laiekawai* in 1844, which tells that after Poli`ahu broke her engagement to Aiwohikupua, she took up residence on Mauna Kea along with her three maidens Lilinoe, Waiaie (Waiau), and Kahoupakane (Maly & Maly 2005:20-26). As well, other 19th century ethnographers published on the associations between Mauna Kea and Poli`ahu, Lilinoe, and Waiau. W.D. Westervelt

claimed that Poli`ahu, Lilinoe, and Waiau were snow goddesses “who embodied the mythical ideas of spirits carrying on eternal warfare between heat and cold, fire and frost, burning lava and stony ice” (Westervelt 1963:55-56). Westervelt also credits Poli`ahu as the rival of the fire-goddess, Pele, said that she battled Pele on numerous occasions, and credits her with having “kept the upper part of the mountain desolate under her mantle of snow and ice” (Westervelt 1963:62).

In 1931, Emma Ahu`ena Taylor, a historian of Hawaiian descent and with genealogical ties to the lands of Waimea and Mauna Kea, reported on Poli`ahu’s residence at Mauna Kea, but also described the creation of Lake Waiau. She wrote:

“Poliahu, the snow-goddess of Mauna-kea, was reared and lived like the daughter of an ancient chief of Hawai`i. She was restricted to the mountain Mauna-kea by her godfather Kane. She had a nurse Lihau who never left her for a moment. Kane created a silvery swimming pool for his daughter at the top of Mauna-kea. The pool was named Wai-au. The father placed a supernatural guard [Mo`o-i-nanea] at that swimming pool so that Poliahu could play at leisure without danger of being seen by a man...” (Maly & Maly 2005:53)

According to Taylor, on Mauna Kea, Poli`ahu’s attendants – Lilinoe, Lihau, and Kipu`upu`u drove away her suitor, Kūkahau`ula (the pink-tinted snow god). But Mo`o-i-nanea allowed the snow god to embrace Poli`ahu, and to this day, Taylor reports, “Ku-kahau-ula, the pink snow god, and Poliahu of the snow white bosom, may be seen embracing on Mauna-kea” (Maly & Maly 2005:53)

In modern-day accounts, Poliahu continues to be commonly referred to as “the beautiful snow goddess of Mauna Kea” while Lilinoe is called “a goddess of the mists and younger sister of the more famous Poliahu.” (Pukui & Elbert 1971:392, 396). Langlas reports that Pualani Kanaka`ole Kanahale told him that three *pu`u*—Poli`ahu, Lilinoe, and Waiau, were sister goddesses who are female forms of water and that all three of the cinder cones or *pu`u* that bear their names are important religious sites (Langlas 1999). Kealoha Piscotta also retains knowledge that Mo`o Ina`ne`a was the guardian for Poli`ahu and Lilinoe (Orr 2004:51). Today, in regards to Lake Waiau, cultural practitioner Pualani Kanaka`ole Kanahale believes that because the waters of Waiau have not “had a chance to come down to the rest of us, then it is sacred water...that water, Waiau, is the most sacred because it isn’t the water that has been spilled, it is still up there in the realm of Wākea” and in her estimation, “water is the source of life” (Maly 1999:A-368, A-370). Kealoha Piscotta believes the cultural significance of Lake Waiau rests in several facts - the Kūmulipo creation chant describes a lake that resides in the heavens, the ancient trails meet at the lake, the lake is a navigational gourd, and it is a jumping off point for ancient Hawaiian souls (Orr 2004:44-45).

5.2.4.6 Wahi Pana / Place Names

The place name evidence indicates that the “summit” was at the very least a *wahi pana*, or a legendary place in Hawaiian traditions (Pukui & Elbert 1971). As already noted in the previous section, the reference to Mauna Kea as the abode of the gods is emphasized - the word “Kea” is taken to be an abbreviated form of Wākea, the male god who procreated with Papa to form the mountain.

Into the post-Contact period, the mountain summit and some of its physiographic features continue to figure prominently into place name descriptions contained in *mele*, and in historical maps and court testimony. In an account of Queen Emma's trip to the Mauna Kea summit in 1881 or 1882, de Silva and de Silva (2006) compare eight *mele* composed about that trip and identify three place names of the mountain's summit region – Poli`ahu, Lilinoe, and Waiau. In her ethnographic study, McEldowney (1982:1.13 – 1.18) assembles and analyzes historical maps and native Hawaiian court testimony from the 1860s – 1890s that document place names of significance. McEldowney explains that various place names are included and omitted, depending upon the map source, and thus contribute to debate over name origins and meanings. For example, in an effort to formalize the Ka`ohe and Humu`ula Ahupua`a boundaries in 1862, surveyor C.S. Wiltse ascended the mountain, guided by native Hawaiians and mapped the summit region. Wiltse's map depicts the lake and named it Pond Poliahu. Yet, Wiltse's native Hawaiian guides also provided court testimonies in 1873 before the Boundary Commission, which identify the following place names Pu`u o kukahauula (the highest peak), Waiau (the lake, a gulch), and Poliahu. Subsequent survey expeditions further complicate place name designations. The 1884-1891 Lyons map designates Kukahauula, Waiau, and Lilinoe as place names of the summit area. The 1892 Alexander map names Poliahu, Waiau, and Lilinoe. Alexander apparently reports that he designated the name Poliahu for a "nameless peak." Further, in Alexander's notes he reports that the highest peak was named Kukahauula, yet this name is not upon his map. Into the early to mid 1900s, both traditional and modern place names were designated upon maps of the mountain, mixing traditional names like Poliahu, Waiau, and Lilinoe with modern Euro-American explorer and missionary surnames, as well as with physically descriptive Hawaiian words and with other purportedly traditional names (Pu`u Wekei, Pu`u Hau Kea, Pu`u Hau Oki, Pu`u Pōhaku, etc).

Today, ethnographers Maly & Maly (2005:vi) argue that:

"The name Pu`u of Kukahau`ula is the traditional name of the summit cluster of cones on Mauna Kea, appearing in native accounts and cartographic resources until c. 1932. The recent names, Pu`u Wekiu, Pu`u Hau`oki and Pu`u Haukea, have, unfortunately, been used since the 1960s (since the development of astronomy on Mauna Kea), and have displaced the significant spiritual and cultural values and sense of place associated with the traditional name, Pu`u o Kukahau`ula." (Maly & Maly 2005:vi)

5.2.4.7 Religious Practices and Beliefs

At the time of Contact, Hawaiian cultural and religious practices were inseparably intertwined. Ranging from Euro-American explorers and missionaries journal accounts to early native Hawaiian historians like David Malo, Kepelino, and S.M. Kamakau, and to later 19th and 20th century ethnologists, there is rich documentation of religious ceremonial and ritual life throughout the islands (Valeri 1985:37-44). Indeed, prior to and following significant undertakings, such as battles, dance, voyaging, the cultivation and harvesting of crops and fish, apprenticeship training, and the manufacture of tools or structures, etc., rites marked by offerings or sacrifices occurred. Propitiatory offerings were made to `aumakua, or family gods, and akua to avert disasters, like famines, volcanic eruptions and disease, or to ensure the coming of rain, success in crop fertility and fish harvest bounties, or victory in battle.

Following European contact, increasing numbers of Hawaiians converted to Christianity, while restrictions were placed upon traditional religious observances. As a result, traditional oral histories and written documentation of historic religious practices and any associated beliefs on Mauna Kea remain virtually non-existent. Because Ka`ahumanu abolished the *kapu* system in 1819 and imposed restrictions on certain traditional Hawaiian religious practices in the post-Contact period (Kamakau 1961:307, 322), in all likelihood, the voices of those practitioners were silenced, or perhaps simply muted, with traditional knowledge being passed on covertly. It is possible that close proximity to missionary settlements and Christian-converted chiefs may have, to a greater degree, influenced decline in traditional religious practice. In areas further removed from Christian centers, where new religious teachings had less appeal, traditional religious practices may have continued (Barrere et al. 1980:34).

Aside from Ka`ahumanu's restrictions, it has also been suggested that it may be culturally inappropriate for practitioners to speak aloud of their ceremonial or ritual practices and beliefs. As Jess Hannah points out when asked about the presence of *heiau* or burials upon Mauna Kea, "those days...if they know about them...they don't talk about 'em. Even Alex [Bell], he knew 'em all, they had something here and there, but they would never pin 'em down. You couldn't pin point it. Something about how they were brought up or raised, it was bad luck or hard luck to talk" (Maly & Maly 2006:A-437,438). Likewise, when Johnny Ah San was asked about burial locations on Mauna Kea, he revealed that "you take those Hawaiians, they were superstitious, and they hardly want to talk about that" (Maly 1999:A-75).

Nevertheless, modern-day oral history interviewees explain their knowledge, as well as an unfortunate lack thereof, concerning the presence of and meaning of *ahu* and burials in the summit region. And cultural practitioners also describe their knowledge of and beliefs surrounding the following contemporary religious practices - *kūahu* (family shrine) erection, the scattering of cremation remains, *piko* deposition in Waiau, pilgrimage, offerings, and prayer.

Ahu and Kūahu

Although the archaeologically-documented presence of *ahu* (shrines) within the summit region of Mauna Kea indicates that religious observances undoubtedly occurred in the Hawaiian past, no knowledge surrounding these traditional practices and beliefs exist today. In the early post-Contact period, the existence of *ahu* on Mauna Kea are reported – however, information is unavailable concerning their traditional function, be it ritual, ceremonial, or otherwise. In the 1880s – 1890s, two surveyors, J.S. Emerson and E.D. Baldwin, independently denoted various *ahu* located upon *pu`u* in the lowlands surrounding Mauna Kea and the presence of "a pile of stones on the highest point of Mauna Kea" (Maly & Maly 2005:494-502, 505).

At this point, clarification of the usage of the term *ahu* may be helpful – in a morphological sense, *ahu* are characterized as upright stones or a pile or mound of stones, yet in the functional sense, *ahu* may have served historically as altars or shrines, or as markers signifying burial locales, *ahupua`a* boundaries, or trail routes. As it was noted in the previous section, when Thomas Thrum visited Haleakala on Maui in the 1920s, he reports that *ahu* functioned as trail and way marks, memorials of traveling parties, land boundaries, burial markers, or tributes to deities (Thrum 1921:259). While Emerson and Baldwin certainly confirm the presence of *ahu* as they are defined morphologically, the surveyors do not specifically speak to the functional meanings of the *ahu* on Mauna Kea.

Likewise, oral history interviewees reveal that they have heard of or have seen the presence of *ahu* on the summit plateau and on the Mauna Kea summit (Orr 2004:47; Maly 1999:A-134, -372; Maly & Maly 2006:A-183, -335, -349, -565). Yet, little information is available about the particularities of traditional religious observances practiced in association with the *ahu*. Libert Landgraf states that he had “no idea whether they were trail markers or a grave site or something else” (Orr 2004:47). Pualani Kanaka`ole Kanahale discloses that she does not know if *ahu* “represent these *ahupua`a* markers...or whether they are actually *kūahu* [altar] or *ahu* for different families that lived in that mountainous area...or if it had to do with *konohiki* [land overseers] that were in charge of a particular *ahupua`a* and so this family went there to mark the upper regions...they could also be new ones” (Maly 1999:A-372). On the other hand, Kealoha Piscotta offers up the following explanation of the significance of *ahu* – “some of the shrines mark the birth stars of certain *ali`i*...and also birth and death” (Orr 2004:47).

Piscotta is the only cultural practitioner to describe a contemporary attempt to maintain a *kūahu* (family shrine) on Mauna Kea, which was undermined by repeated destruction and removal of the shrine. It is significant to note that in 1870 Kamakau wrote that “it was not right to trespass on someone else’s altar” (Kamakau 1964:96). This statement is the only indication of a traditional cultural practice that regulated people’s access to *kūahu* and *ahu*. Piscotta explains that she erected the *ahu*, which consists of a stone from her family, on Mauna Kea because as an employee of one of the observatories, “I thought I would put it where I’m going all the time. And also it was very beautiful and I was always attracted to that place. I prayed at that place all the time” (Orr 2004:52). Piscotta’s contemporary cultural practice of erecting *kūahu* represents continuity of a traditional practice, except that she imported her upright stone rather than selecting a local stone. Accordingly, the *ahu* and *kuahu* are recognized cultural resources with various functions, and these functions, are both historic and contemporary but, nonetheless, rooted in traditional beliefs.

Burials and the Scattering of Cremation Ashes

Concerning burial locations and practices, there are numerous historical references to human burials on Mauna Kea. The practice of burying the dead in remote, high elevation areas may have been traditional and common, based on the information collected by Thomas Thrum for Haleakala on Maui:

“The use of the craters within Haleakala as burial places, far removed from places of habitation, is quite in keeping with ancient Hawaiian practice. Distances and difficulties were no bar to faithful execution in carrying out the instruction of a dying relative or friend.” (Thrum 1921:258)

One reason, but undoubtedly not the only one, for taking the dead to remote areas was the fear that the bones might be used to make fishhooks. A person named Nainoa gave such an explanation in testimony before the Boundary Commission:

“In old times, if anyone died, could not wail, but people come and steal shin bones for fishhooks, so used to carry body secretly and bury in mountains.” (McEldowney 1982:1.9).

Other accounts suggest the placement of upper-elevation burials ensured the safekeeping of high-ranking members of the *ali`i* class. Ed Stevens maintains that “oral history and traditions

tell us that...the bones of very special personages were placed in the pu`us at or near the summit for safekeeping... they were the special ones” (Maly 1999:C-10, 13). Daniel Kaniho Sr. suggests that “they were all *ali`i*...they were kind of high-ranking people” (Maly 1999:A-169).

There are a couple of early accounts of burials having been found in the general vicinity of Pu`u Lilinoe. E.D. Preston’s account of his work at Lake Waiau, in 1892, noted that “At an elevation of nearly 13000 feet, near Lilinoe, a burying ground was found, where the ancient chiefs were laid to rest in the red volcanic sand” (Preston 1895:601). W.D. Alexander’s surveying party saw what they interpreted as graves on the top of Pu`u Lilinoe, also in 1892:

The same afternoon [July 25, 1892] the surveyors occupied the summit of Lilinoe, a high rocky crater, a mile southeast of the central hills [the ‘summit’] and a little over 13,000 feet in elevation. Here, as at other places on the plateau, ancient graves are to be found. In olden times, it was a common practice of the natives in the surrounding region to carry up the bones of their deceased relatives to the summit plateau for burial (Alexander 1892).

Kamakau indicated that Queen Ka`ahumanu, who considered Lilinoe a person, made an unsuccessful attempt to recover her bones on Mauna Kea in 1828 (McEldowney 1982:1.4). Kamakau added that the body of Lilinoe “was said to have lain for more than a thousand years in a well-preserved condition, not even the hair having fallen out” (Kamakau 1961:285). Kamakau’s description of Lilinoe’s body is probably the source of modern stories about a mummified body having been found on Mauna Kea and removed to some unknown location.

Of the many locations with confirmed and possible burial sites, Pu`u Makanaka is perhaps the best known. The 1925-26 USGS survey team found human remains on the summit of Pu`u Makanaka:

To set up Camp Four at 12,400 feet near Puu Makanaka, we had difficulty finding a small flat area for the tents. Makanaka is the largest and most perfectly formed cone in the summit area, 1,500 feet in diameter at the rim and 300 feet deep, while the base is more than 600 feet below the rim at one point. On the rim I found a partially uncovered grave, eroded by high winds, with an incomplete human skeleton. This was unknown, as far as I could discover, to anyone familiar with the area. The name Puu Makanaka means “Hill crowded with many people” and the grave must have been ancient (Kilmartin 1974:15).

Today, numerous oral history interviewees reveal that they have knowledge of burials located at a number of *pu`u* dotting Mauna Kea’s western and eastern slopes, including Ahumoa, Kemole, Papalekoki, Makanaka, Kihe, Kanakaleonui, Kaupo, and Pu`u O`o (Maly 1999:A-22, -48, -75, -165, -250, -279, -351, -395, -397).

Some cultural practitioners explain practices that relate to ancient family burials atop the mountain. Alexander Kanani`alika Lancaster reveals that he and his family members went up to Mauna Kea “for ceremonial. They go up there bless the whole mountain for all our ancestors who’s buried up there...the old folks always said, ‘Our family is up there’” (Maly 1999:240). As no documentation exists on traditional cultural practices relating to ancient Mauna Kea burials, it is unknown whether blessing ceremonies would be considered a traditional cultural practice or a contemporary cultural practice.

Other cultural practitioners reveal that they have participated in the practice of scattering the cremated remains of loved ones from atop Mauna Kea. It is noteworthy that cremation was not a common practice in traditional Hawaiian culture, and when it was done it was a punishment and meant to defile the dead person. Writing in the 1830s, native Hawaiian historian David Malo stated that “the punishment inflicted on those who violated the tabu of the chiefs was to be burned with fire until their bodies were reduced to ashes” and that cremation was practiced on “the body of anyone who had made himself an outlaw beyond the protection of the tabu” (Malo 1951:57, 20). In recent years, noted Native Hawaiian historian and ethnologist Mary Kawena Pukui explains why cremation was a defilement – “if the bones were destroyed, the spirit would never be able to join its *aumakua*” (Pukui et al. 1972:109).

The cultural practitioners who express participation in cremation-related cultural practices on Mauna Kea include Toshi Imoto, Tita Elizabeth Kauikeōlani Ruddle-Spielman, and Kealoha Piscotta. Imoto explained that in 1954, he and six others ascended to Mauna Kea’s summit, where paniolo Eben Low’s ashes were scattered from an *ahu*, which is described as an old survey marker. It is also noteworthy that at the time Low’s ashes were scattered, a commemorative cement plaque was placed at Lake Waiau in Low’s honor (Maly 1999:25-26). Ruddle-Spielman, who happens to be the granddaughter of Eben Low, explained that in 1969, she and her family members scattered her parents’ cremation ashes from the Mauna Kea summit (Maly 1999:273-274). Kealoha Piscotta also revealed that she brought her aunties’ ashes to Mauna Kea (Orr 2004:52). Finally, Theodore “Teddy” Bell says that he wants his ashes to be scattered from the mountain (Maly & Maly 2006:A-293).

Undoubtedly, the scattering of cremation ashes today is a contemporary cultural practice that has taken the place of traditional interment practices. But debate ensues over whether this practice has evolved from traditional practices and beliefs or whether it is a new practice based on modern customs and beliefs. Pualani Kanaka`ole Kanahale explains that while the scattering of cremation remains on Mauna Kea may be viewed by some as non-traditional, she counters that notion saying: “it may not be the *iwi* [bones] itself, but the ashes are the essence of what is left of the *iwi*. It doesn’t matter, it’s going back” (Maly 1999:A-377). On the contrary, in 1970, a woman identified solely as Kolokea C. testified before the Hawaiian Culture Committee of the Queen Liliuokalani Children’s Center that when her brother died, she intended to have his body cremated. However, she was told by her 73-year old great-great-grand aunt that “cremation was *puhi i ka iwi* [bone burning]” and that cremation was an expressly prohibited by Kolokea’s great-great-grandfather. This auntie recommended burial in the ground or at sea instead, as with a cremation “the body will be without peace.” In the end, Kolokea C. decided to bury her brother (Pukui et al. 1972:106-107). Ms. Kanahale explains that cremation is an evolutionary development of a contemporary practice from an earlier traditional practice, whereas Kolokea C. concluded that cremation was non-traditional in learning of the traditional prohibitions of this practice. Nevertheless, while some Hawaiian cultural studies may suggest that cremation may historically have been a sign of disrespect, those Hawaiians who choose cremation in modern times do it as a respectful commitment to the loved ones, which is a traditional cultural practice and fundamental value based upon ‘ohana’.

Piko Deposition

The cultural weight that Mauna Kea carries within the Hawaiian community is also evident in the phrase, “*piko kaulana o ka `āina*,” which translates as “the famous summit of the land” and is

used as a term of endearment (Maly 1999:A-3). However, the phrase also expresses the belief that the mountain is a *piko* (the navel, the umbilical cord) of the island and for this reason it is sacred (Maly 1999:D-20). In this context, the significance of the cultural practice of transporting and depositing a baby's *piko* on Mauna Kea may be better understood. Pualani Kanaka`ole Kanahele explains the symbolic importance of this practice, saying that:

“the *piko* is that part of the child that connected the child back to the past. Connected the child back to the mama. And the mama's *piko* is connected back to her mama and so on. So it takes it back, not only to the *wā kahiko* [ancient times], but all the way back to Kumu Lipo...So it's not only the *piko*, but it is the extension of the whole family that is taken and put up in a particular place, that again connects to the whole family line. And it not only gives *mana* or life to that *piko* and that child, but life again to the whole family.” (Maly 1999:A-376)

Other Native Hawaiian cultural practitioners illustrate that for some families the practice of *piko* deposition on Mauna Kea is a long-standing traditional cultural practice. In 1956, Kaleohano Kalihi revealed that his grandfather had taken a gourd container “the *piko* of Mauna Kea. The place of the *punawai* [spring]...” which had been filled with 40 *piko* from “all of the people that had been born into this family” (Maly 1999:A-1). Kahili also mentioned that until he took the *piko* to Lake Waiau, his grandfather had “taken care of” those *piko*. Another practitioner, Elizabeth ‘Tita’ Lindsey Kimura, describes being a *piko* caretaker for her family – “I still have some of her *piko* that she [her mother] collected. Not collected, but when she goes to my sisters that have babies and the *piko hā`ule* [a *piko* that has fallen off], she'd pick it up and bring it home. ...yes, I have it in the *ōmole* [bottle]...And I'm waiting for somebody to go up to Mauna Kea with it” (Maly & Maly 2006:A-217). One of Kimura's relatives, Irene Loeyland Lindsey-Fergerstrom, also confirms that she took her children's *piko* and the *piko* of her one of her relatives up to Mauna Kea (Maly 1999:390).

These cultural practitioners also provide insight into the proper means of practicing *piko* deposition. Irene Loeyland Lindsey-Fergerstrom recalls that “we put the *piko* in a little cotton and put ‘em in a bottle. And sometimes it's hard to come out, so *kūkū* [grandmother] Laika said all you do is take the cover off and put it on the ground and it will just deteriorate” (Maly 1999:A-392). Also, when Lindsey-Fergerstrom took *piko* to Mauna Kea, her husband “dug a little hole and put the *piko* in...the summit” (Maly 1999:A-391). Elizabeth ‘Tita’ Lindsey Kimura relates that her mother “was very particular...you don't just *hana kapulu* [to act carelessly or slovenly]...you got to treat it with respect” (Maly & Maly 2006:A-217). Kimura also says that the reason for taking the *piko* up to Mauna Kea is that the mountains is “neat” and “clean,” practitioners “don't want any *kapulu*...in the discarding of the *piko*” (Maly & Maly 2006:A-217). It is clear that maintaining cleanliness and purity is an important component in this cultural practice. Kealoha Piscotta explains that in light of some practitioners belief that Lake Waiau has become polluted, she fears that “people won't put the *piko* of the baby in there it it's polluted” (Orr 2004:45).

Pilgrimage, Prayer, Offerings, and the Spiritual Resonance of Mauna Kea

In public testimony before the Mauna Kea Advisory Committee, Ed Stevens ascribed Mauna Kea's spiritual significance to the fact that it is the highest point in Polynesia. Stevens states the mountain is significant “because it was considered to be the gateway to heaven. When the

ancient *kāula* [priests, prophets] made their treks to the summit, it was to be nearest to *akua* where prayers could be offered in the highest reverence” (Maly 1999:C-10)

Instances of the cultural importance of Mauna Kea are related in several pilgrimages made to the mountain by royalty to partake in ceremonial practices in the late pre-Contact and early post-Contact periods. During the reign of Kamehameha I, fearing dissension amongst some of his chiefs, in the company of Kekuhaupi`o, the king is reported to have traveled to Mauna Kea to make a ceremonial offering close to Lake Waiau (Desha 2000:94 in Maly & Maly 2005:50). In 1881 or 1882, Queen Emma ascended Mauna Kea and at Lake Waiau, she swam across the lake, riding on the back of Waiaulima (de Silva & de Silva 2006 in McCoy 2008:2-10; Maly & Maly 2005:158; Maly 1999:A-4, -5, -387). Queen Emma’s swim across Waiau was a cleansing ceremony initiated in an effort to prove her genealogical connection to Wākea and Papa (Kanahale & Kanahale 1997:9 in Maly 1999:D-21).

In addition, some oral history interviewees reveal seeing offerings left on Mauna Kea in recent times. Libert Landgraf recalls seeing *pu`olo* (offerings) left at Lake Waiau and on the summit of Mauna Kea, which he describes as “a gift or something wrapped in *ti* leaves. My feeling of that is it has cultural, I don’t want to go out on a limb and say religious, but it has a significant cultural significance...someone is taking a gift or presentation to a particular area.” (Orr 2004:51) Other interviewees, including Rally Greenwell, Hisao Kimura, Coco Vredenburg-Hind, and Daniel Kaniho Sr., testify that they either saw or had heard that *`opihi* shells were present in the Mauna Kea adze quarry (Maly & Maly 2006:A-37, -215; Maly 1999:A-118, -260). Archaeologists theorize that because these *`opihi* shells are too few to be interpreted as the remains of food consumption activities, it is more likely that they were offerings to the *akua* (McCoy 1990:108).

Other oral history interviewees demonstrate the spiritual resonances of Mauna Kea in the following statements:

Libert Landgraf – “I looked at sites, the area, as the church. ...In this instance maybe the summit of Mauna Kea represent to us what the church is, and the individual sites or the individual platforms is the altar.” (Orr 2004:49)

Kealoha Piscotta – “This is a really hard issue for Hawaiian people, because Hawaiian people have really no temples. [They’re] in the state or national parks....So Mauna Kea represents one of the last kind of places where the practice can continue. ...But for Mauna Kea, it’s not a temple built by man. It’s built by Akua...” (Orr 2004:49)

Pualani Kanaka`ole Kanahale – “If you want to reach *mana*, that [the summit] is where you go.” (Maly 1999:A:372)

Pualani Kanaka`ole Kanahale – “ Mauna Kea was always kupuna [an elder, ancestor] to use. ...And there was no wanting to go on top. You know, just to know that they were there...was just satisfying to us. And so it was kind of a hallowed place that you know it is there, and you don’t need to go there. You don’t need to bother it. ...And it was always reassuring because it was the foundation for our island.” (Maly 1999:A:366)

Florence La`i-ke-aloha-o-Kamāmalu ‘Coco’ Vredenburg-Hind oral history – “I don’t think I could live anywhere else. I feel like it’s right, I belong to the dirt, the soil....It just like they protect all of us. These mountains protect us.” (Maly 1999: A-117, 120)

Alexander Kanani`alika Lancaster – “My grandmother...she said, ‘When you go up there, you going feel the spirit.’ And you do feel the spirit.” (Maly 1999:A:234)

Tita Elizabeth Kauikeōlani Ruddle-Speilman – “Yes the *mana* is there. There is no question.” (Maly 1999: A-286)

Clearly, these statements demonstrate that Mauna Kea continues to be viewed as a realm of great spiritual and sacred importance, a belief rooted in Hawaiian tradition.

Adze Quarrying and Stone Tool Manufacture

The presence of ancient adze quarries and stone tool workshops on Mauna Kea is well documented in archaeological investigations conducted since the 1970s, and is discussed in the previous historic properties section. Radiocarbon dates indicate that the quarry was utilized over a period of possibly as much as 700 years between ca. A.D. 1100 and 1800 (McCoy 1986:Figure 28; McCoy 1990:Figure 4). The time period the quarry was abandoned is unknown and may never be known with any certainty, but there is some evidence that it may have occurred as late as European contact in 1778 or shortly thereafter. No ethnographic information is available concerning traditional quarrying and manufacturing practices or beliefs.

Currently, however, it appears that the modern-day practice of adze collection is on-going, although cultural practitioners appear to have differing perspectives on appropriate collection protocols and whether collection should be taking place at all. For instance, Lloyd Case does not believe adze collection should take place whatsoever. Case states:

“I think that what ever is there, should stay there. Because not only would it be a resource that people can go and see, what the old Hawaiians did and how things were. But if you take everything off of that mountain, and people keep taking things, you have nothing to show for our past.” (Maly 1999:A-352)

On the other hand, Hannah Springer believes that if it can be demonstrated that the quarries lack potential for archaeological analysis, adze quarrying could be permitted. She expresses that she does not know how access could or should be regulated, but expects that if it were stipulated that practice be done in a traditional manner, not many individuals would engage in quarrying. Springer says:

“Should there be fresh mining? I don’t know if there’s information that can still be extracted from the fragments that remain from past work done there. If already there has been tremendous removal of material, how valid is the data that remains? What sort of picture would we get from analysis of it? I cannot answer that. If it has relatively low value maybe we would want people to continue to mine an already tapped source. Hundred and eighty degrees away from that, I can’t imagine how many people would make the effort if they had to go *kālai* [carve or cut] the *pōhaku* [stone]. So that might be self regulation, right there. To identify and designate an area where people could go. And again I don’t know how you determine who’s authentic to go up there.” (Maly 1999:A-310)

Pualani Kanaka`ole Kanahale believes that adze quarrying should be permitted, but only if those quarrying can demonstrate a genealogical tradition of adze quarrying. She says:

“I have two *mana`o* [opinion, thought] for that. One is, an old site should be approached...it depends on what you are taking it for. I can only say, ‘Yes, take it if I see that you bring down the *ko`i* [adze] and you use it for something.’ It has to be functional for you, and not just a show piece or something that you want to use commercially. ...So I am thinking that if you would go to an old place to mine the *ko`i*, then you need to show some kind of genealogy where your *kūpuna* also had that kind of function. So if your *kūpuna* were some kind of *kālai ki`i* [carvers of images] or *kālai wa`a* [canoe makers] or had some kind of function with the *ko`i*, if you have that...Because then it would make us stronger to know that you still have that and that you still continue this in some form. ...So it’s not like saying, ‘Oh you cannot, first you have to show us your genealogy.’ No. ‘Show us what your genealogy is because that makes you stronger, that makes us stronger, that brings *mana* to the place.’ That it is still being continued by the *mo`opuna kuakāhi, kualua, kuakolu* [the great; great great great; and great great great grandchildren] of this *kūpuna*” (Maly 1999:A-373-374).

Modern-day adze collection and quarrying can be considered a traditional cultural practice that has been modified to include the use of contemporary methods (such as the use of steel tools).

Bird Gathering & Canoe Making

Because the majority of Mauna Kea lies within an alpine desert exhibiting sparse vegetation historically, bird gathering and canoe making were restricted to the subalpine forested regimes on the lower slopes of the mountain. These lands, except for Hale Pōhaku and the road from Hale Pōhaku to the summit, do not lie within the UH management areas. According to native Hawaiian testimony provided in Land Commission hearings and in ethnographic publications of the late 19th and early 20th centuries, within the *māmāne* and *ohi`a* forests, *kia manu* (bird catching) was practiced, with the aim of trapping various species for feather collection and for nourishment - *mamo*, *ō`ō*, *apapane*, *ī`iwi*, *ua`u*, *nēnē*, *kōloa*, *amakihī*, and *ō`ū* (Maly & Maly 2005:32-40, 278-279). Likewise, it was only in the lower forest areas that *koa* grew and could be harvested for canoe-making. For instance, Johnny Ah San tells that *Umi* cut his *koa* for canoes at Pu`u Loa and that *Umikoa* Village was named on account of this (Maly 1999:A-91).

Waiau Water & Snow Collection

Little documentation exists that Hawaiians sought to collect water or snow in ancient times, yet Lloyd Case says that “they went there because that mountain has the power to heal and it still does...I’ve heard of the old ones getting water from Waiau to use for healing...” (Maly 1999:A-353). Presently, cultural practitioners engage water and snow collection for ceremonial/medicinal purposes. Regarding the waters on the mountain, Anita Leilani Kamaka`ala Lancaster and Alexander Kanani`alika Lancaster explain that their family uses the “sacred water” of Waiau for baptisms (Maly 1999:A:246). And Kealoha Piscotta states that “its for medicine...all of these waters” (Orr 2004:45). However, concern surrounding the purity of Lake Waiau is also a factor influencing the contemporary practices of Lake Waiau water collection and snow collection on Mauna Kea. Some cultural practitioners believe that effluent from the observatories enters the aquifer and has caused the green coloration of Lake Waiau’s water. Although scientific studies disprove the theory that effluent has in fact leached into the aquifer, Kealoha Piscotta states that “we are not really trusting to take the water for the medicine anymore” (Orr 2004:45). Piscotta states that because she is unsure about the purity of the Waiau waters, she gathers snow instead. In her words, “the snow along this ridge in here and by the lake, is what I was told is the snow to collect. It’s powerful snow...” (Orr 2004:51).

Plant Gathering

Review of historic documentation does not reveal discussion of plant gathering on Mauna Kea as a traditional cultural practice. But, just as bird gathering and canoe making were restricted to the subalpine forested regimes of the mountain, any traditional plant gathering would likely have been restricted to those lower areas as well. Only one oral history interviewee reports utilizing plants in the forests on the lower Mauna Kea slopes for traditional medicinal purposes. Toshi Imoto explains that if he had a toothache, he would use leaves of the `awa plant to numb the ache. Also, Imoto says that the small blue flowers of the `owi were smashed up and applied to an area with a fractured bone (Maly 1999:A-36, 37).

Hunting

There is no evidence that hunting in the summit region was a traditional cultural practice. Available information indicates that it was not until the late 19th century and throughout the 20th century, following the introduction of numerous non-native ungulate species such as bullock (cattle), goats, and sheep, that hunting for subsistence and for sport began on Mauna Kea. Following the Māhele, livestock was deemed the property of the King and the government, although private parties could apply for license to own and brand livestock (Maly & Maly 2005:270). Interestingly, government correspondence dating from 1850-1856 shows that illegal hunting activity by individuals was becoming problematic (Maly & Maly 2005:270-273).

In 1861, a legal dispute over hunting rights led to the decision that no hunting activities could take place on Mauna Kea, except for individuals who acquired leasehold interests in the mountain lands or who gained special permission to hunt (Maly & Maly 2005:274-277). In the years that the forested slopes of Mauna Kea were controlled by cattle ranching operations, Jess Hannah contends that one benefit of being employed as a ranch hand lay in one's ability to practice subsistence hunting. He says, "If you go hunting that was the main benefit because guys could go hunt pig, sheep, and all that. You could always eat" (Maly & Maly 2006:A-428). Dave Woodside, a former government naturalist, concurs and explains that it was only after the World War II era that public hunting on Mauna Kea lands was permitted. This managed hunting policy was developed in part because non-native goats and sheep were adversely impacting the forests and in part because individuals interested in sport and subsistence hunting organized to gain the right to hunt (Maly & Maly 2006:A-323-326). Indeed, Lloyd Case explains the importance of subsistence hunting to many ranch families, "a lot of my brothers and the old timers like David Hogan Kauwē, when they went out hunting, it was basically a hunt where each family took home so much of the meat so that everybody had meat" (Maly 1999:A-345).

5.2.4.8 Trail Systems

Figure 5-7 shows known current and historic alignments of trails within UH managed areas on Mauna Kea. Although traditional accounts of trails upon Mauna Kea do not provide precise route information, they do suggest the presence of ancient trails through the summit region. A *mo`olelo* associated with chief Pili-a-Ka`aiaea, and thus dating from the 1300s, recounts the journey of two brothers, Ka-Miki and Maka-iole, who traveled around the island using ancient *ala hele* (trails). Sent up to the Mauna Kea summit, Ka-Miki was guided by the following traveling *mele*:

*The path goes to the uplands
The path goes to the lowlands
It is a lonely path to the mountain
A damp dreary path
A fire will be the wrap
Warming you along the sacred trail...*
(Maly & Maly 2005:42)

Kamakau reports on a battle that ensued between `Umi-a-Liloa and the chief of Hilo in the 1500s, wherein `Umi-a-Liloa and his warriors traveled from Waipi`o to Hilo via Mauna Kea. Kamakau states that “it was shorter to go by way of the mountain to the trail of Poli`ahu and Poli`ahu’s spring at the top of Mauna Kea, and then down toward Hilo. It was an ancient trail used by those of Hamakua, Kohala, and Waimea to go to Hilo.” (Kamakau 1961:16 in Maly & Maly 2005:453). Maly & Maly (2005:454) contend that ancient trail systems across all the mountain lands afforded travel to burial sites and facilitated travel for the collection of resources like adze stone, canoe *koa*, and bird feathers.

The ancient trails were essentially footpaths, which, by the 1840s, proved inadequate for travel with the newly-imported horses, wagons, and wagon team animals associated with cattle ranching and bullock-hunting activities; hence, formal wagon road developments, funded by the Hawaiian Kingdom, ensued in the lowland mountain slope regions (Maly & Maly 2005:454). However, the mountain’s summit region remained accessible only by trails, on foot or horseback. The difficulty of travel on the terrain by horse and on foot is well documented in historical accounts by European visitors and surveying expedition field notes. Formalized road developments continued in the lowlands into the early 20th century, with the CCC (Civilian Conservation Corps) and the U.S. Army Corps of Engineers improving existing roads, such as the Saddle Road, to accommodate vehicular traffic (Maly & Maly 2005:482). The first road from Hale Pōhaku to the Mauna Kea summit was completed in 1964 and basically consisted of a jeep road, which made access to the summit much easier.

Today there are two major named trails in the summit region of Mauna Kea, the Mauna Kea-Humuula Trail and the Mauna Kea-Umikoa Trail. The better known of the two, is the Humu`ula Trail which apparently began in the Kalaieha area where the Humu`ula Sheep Station is located. The earliest map showing the upper part of the trail was made by W.D. Alexander’s survey party in 1892 (Alexander 1892; Preston 1895). The Alexander map and the 1930 edition of the USGS Mauna Kea Quadrangle map show the trail going around the eastern flank of Pu`u Keonehehee and onward up the mountain to Lake Waiau. This alignment closely follows the modern road (Figure 5-7).

A new section of the Humu`ula trail was built by the CCC in the 1930s that took a straighter course to the west of Pu`u Keonehehee (see Figure 5-7). The new trail was described by L. Bryan in a 1939 article in *Paradise of the Pacific*:

During the past few years this lake has been visited by increasingly large numbers of visitors. Three years ago the Civilian Conservation Corp reconstructed an old trail from near the Humuula Sheep Station (Kalaieha), past Hookomo and HalePōhaku to Lake Waiau and thence to the summit. This trail is well made and carefully marked on the ground with Ahus or piles of stones

and the trip to the lake and on to the summit can easily be made by strangers without the assistance of a guide (Maly & Maly 2005:257).

The Umikoa Trail, which is labeled the Mauna Kea-Umikoa Trail on some maps, first appears as a named trail on the advance sheet of the Lake Waiau Quadrangle that was based on the mapping by J.O. Kilmartin in 1925-26. This trail, and the Mauna Kea-Humu`ula Trail are shown as terminating at Lake Waiau on the Kilmartin map. The absence of the Umikoa Trail on the 1892 map may be significant.

While many of the oral history interviewees expressed knowledge of the presence of trails upon Mauna Kea, it was only those cattle ranch employees (i.e. Toshi Imoto, Theodore Bell Sr., Sonny Kaniho, Daniel Kaniho Sr., L. "Rally" Greenwell, Kamaki Lindsey Jr., Hisao Kimura, and Jiro Yamaguchi) who demonstrated an intimate knowledge of the trail systems, which were heavily utilized for cattle drives (Maly 1999; Maly & Maly 2005). This circumstance is understandable – historically, those not in the employ of the cattle ranches were restricted from mountain slope access. As well, forest reserve employees (i.e. Johnny Ah San, David Woodside, and AhFat Lee) discussed their knowledge of the presence of the mountain trails (Maly 1999; Maly & Maly 2005).

5.2.4.9 Navigation/Orienteering

Kepā Maly notes in his collection of archival documentation on traditional practices that no specific references to *kilo hōkū* (observing and discerning the nature of the stars) upon Mauna Kea are present (Maly & Maly 2005:95). Maly speculates it is likely that *kilo hōkū* was practiced upon the mountain, as the gods and deities associated with the mountain are also embodied in the heavens, but such accounts are absent from the historical literature (Maly & Maly 2005:95). Libert Landgraf also says that he has "no personal knowledge of it," but he suspects "that it probably was a very good observation [point]" (Orr 2004:55). Lloyd Case says that he believes a platform, which he believes to have been a "navigational *heiau*" was present on the Mauna Kea summit. He states that "before the observatories were there, they had one when all the stones were piled up, kind of similar to some of the *heiau* at Mahukona" (Maly 1999:A-349).

In contrast to Maly's statement that there is an absence of evidence of traditional Hawaiian astronomical observations, cultural practitioner Kealoha Piscotta believes that "the lake [Waiau] is like the navigation gourd," a concept which she learned from her auntie (Orr 2004:45). According to Piscotta, her auntie also instructed her to the lake and when she did, Kealoha says "I could see clearly why she wanted to look into the lake. Because when you look into the lake, the whole heavens are reflected in it and it's just like the gourd that they carry on the canoe with the water and the *ane ane*" (Orr 2004:45).

Piscotta states that *mo`olelo* passed down from her auntie describe solstice alignments with Mauna Kea, thus she believes that the solstices were marked from the Mauna Kea summit. Piscotta emphasizes that she does not doubt the validity of *mo`olelo*, but she is interested in understanding how the solstice alignments work. Thus, she has concerns that the view plane from Mauna Kea has been diminished and obstructed by the leveling of pu`u and the erection of observatory domes (Orr 2004:54-55). Piscotta reveals the importance of the solstice alignments by stating that "if you do not measure the solstice and the equinox, you cannot keep track of the sacred time. And if you don't know what year you're at, you don't know part of the *wā* or the

epic period you're in, so you don't know where you are in the prophesy either" (Orr 2004:58-59). It is noteworthy that not only is Piscotta interested in validating traditional Hawaiian astronomy techniques, she also holds a degree in physics and has worked as a telescope systems specialist at a Mauna Kea observatory.

On a similar note, Tita Elizabeth Kauikeōlani Ruddle-Spielman conveys the significance of the Mauna Kea view plane, but as a landscape viewed from the sea. She says:

"It was so important when we used to go fishing with uncle Francis, I used to go with him. From Keawaiki. When we started out, he'd say 'Now watch the *pu`u* on the mountain.' And we'd go out, and that was my job to watch the *pu`u* as we went along. And as soon as a cloud came down to that certain *pu`u* we'd turn around and go right home again, because he knew that the ocean would change. It was anywhere that we went, whether we were going towards Kona or coming this side towards Kohala. He said 'You watch that *pu`u* and as soon as you see the clouds hug it, or heading towards it, let me know, because we are turning around and going home.' And he never failed.No, it was on the side, the slopes [not the *pu`u* near the summit, but on the slopes]. But he knew, and sure enough, by the time we got home, that wind would change, but we had gotten home safely. ...that is very important, this whole idea of line of sight, cultural landscape. So not only is it important close up on top, but as viewed from afar." (Maly 1999:A-282)

5.2.4.10 Kapu and Land Access Regulations

Following the settlement of the islands by Hawaiians, a system of land and resource management developed and evolved over time. Traditionally, Hawaiians divided their island landscapes into vertical management and resource zones (NASA 2005:ii; Maly & Maly 2005:12). These vertical divisions ran from mountain ridge summits to the ocean. The island of Hawai'i was vertically divided into six *moku* (districts), which were further sub-divided into *ahupua`a*, with each unit traditionally under the control of a Hawaiian *konohiki* (chief-landlords). Each *ahupua`a* was generally narrow "wedge-shaped pieces of land that radiate out from the center of the island, extending to the ocean fisheries fronting the land unit" (Maly & Maly 2005:12). Mauna Kea rested within Ka`ohe Ahupua`a (Hāmākua District) and Humu`ula Ahupua`a (Hilo District), but as Boundary Commission testimonies and surveys indicate, their boundary was contested in the post-Contact period (Maly & Maly 2005:278-392). These land divisions served to permit and regulate access to resources, following the traditional cultural code of *kapu*. The *ahupua`a* resources thus supported the *maka`āinana* (commoners) and the *ali`i* (chiefly class). Maly & Maly state that:

"as long as sufficient tribute was offered and *kapu* (restrictions) were observed, the common people who lived in a given *ahupua`a* had access to most of the resources from mountain slopes to the ocean, needed to sustain life and culture. These access rights (*pono*) were almost uniformly tied to residence on a particular land, and earned as a result of taking responsibility (*kuleana*) for stewardship of the natural environment, and supplying the needs of one's *ali`i*." (Maly & Maly 2005:12)

It is of significance that when native Hawaiians testified before the Boundary Commission regarding the disputed Ka`ohe and Humu`ula Ahupua`a boundaries, they describe landmarks representing boundaries because the consequence of trespass onto another's *ahupua`a* lands resulted in punishment. For instance, Nainoa, Waiki, Hanioa, and Kamohaiulu testified that if

bird gatherers trespassed onto *ahupua`a* other than their own and were caught taking birds, said birds would be confiscated (Maly & Maly 2005:285, 291, 293, 295).

Further, the inland reaches of the island were horizontally divided into environmental and cultural zones, according to the access rights and restrictions of the *maka`āinana*. The *wao kanaka* was a low-lying coastal area where the *maka`āinana* were free to move and inhabit. The *wao kele* was the upland forested area that the *maka`āinana* could only access for gathering purposes. The *wao akua*, which was believed to be inhabited by *akua*, was the subalpine desert region above the tree line. The *maka`āinana* were hesitant to venture into the *wao akua* and could do so only by offering prayer and displaying great respect (NASA 2005:3-18, 3-19).

Essentially, the Mauna Kea summit region lies within the *wao akua*. *Wao akua* can also be understood to mean “a remote desolate location where spirits, benevolent or malevolent, lived and people did not live. Usually these places were deep interior regions, inhospitable places such as high mountains, deserts and deep jungles. These areas were not necessarily *kapu* but were places generally avoided out of fear or respect” (PHRI 1999, 24). Indeed, when Rev. William Ellis toured the island in 1823, he noted the reluctance of native Hawaiians to venture into the summit areas of Mauna Kea.

“...numerous fabulous tales relative to its being the abode of the gods, and none ever approach the summit---as, they say, some who have gone there have been turned to stone. We do not know that any have been frozen to death; but neither Mr. Goodrich, nor Dr. Blatchely and his companion, could persuade the natives, whom they engaged as guides up the side of the mountain, to go near its summit.” (Ellis 1979:292)

Today, the *ahupua`a* system of land and resource management, with *kapu* restrictions, is no longer in existence legally, due to the collapse of the *ali`i – maka`āinana* social and cultural system. Still, knowledge of the some traditional *kapu* restrictions endures, although both traditional and contemporary cultural practices and belief are apparent. One cultural practitioner, Pualani Kanaka`ole Kanahale reveals traditional knowledge of *kapu* restrictions and her traditional cultural practice regarding entering *kapu* areas. She learned from her *kūpuna* that the forested regions are not the realm of humans; instead, the forest’s *kupa* (citizens) are the trees. Kanahale says that “when I go *maha`oi* [intrude] in their realm, I have to ask permission to be up there” (Maly 1999:A-371). In a similar sense, Irene Loeyland Lindsey-Fergerstrom reveals, in the context of taking *piko* up to the Mauna Kea summit, that her *tūtū* (grandmother) had knowledge of the *kapu* restriction that only *ali`i* were permitted on the summit. Yet, Lindsey-Fergerstrom’s *tūtū* instructed her to take her family’s *piko* to the summit anyways, saying “it’s not like we going be *ali`i*, but at least you can try...” (Maly 1999:A-390).

5.3 BIOLOGICAL RESOURCES

High elevation areas on Mauna Kea, such as those found at Hale Pōhaku and the Mauna Kea Science Reserve, can be divided into two basic types: the subalpine ecosystem (5,600 ft to 9,800 ft elevation), and the alpine ecosystem (above 9,800 ft) (Gagné and Cuddihy 1990). Hale Pōhaku occurs in the upper reaches of the subalpine ecosystem, while the Mauna Kea Science Reserve occurs in the alpine ecosystem.

Many unique species occur in the subalpine and alpine ecosystems of Mauna Kea, and there are several federal and/or state protected species that potentially occur on UH Management Areas, including 12 Endangered, one Threatened, two Candidate, and 16 Species of Concern (two of which are also listed as State Endangered on islands other than Hawai'i). A list of these species is presented in Table 5-3 below. Abundance and distribution of most of these species is currently unknown. Species currently known to be found on UH Management Areas include the wēkiu bug (Candidate for listing), the Mauna Kea silversword (Federal and State Endangered), and the Palila (Federal and State Endangered).

Table 5-3. List of Federal and State Threatened, Endangered, Candidate and Species of Concern found, or potentially occurring, at Hale Pōhaku and the Science Reserve.

Group	Scientific Name	Common Name	Legal Status ⁵
Endangered Species			
Plant	<i>Argyroxiphium sandwicense sandwicense</i>	'Ahinahina, Mauna kea silversword	FE, SE
Plant	<i>Asplenium fragile var. insulare</i>	Diamond spleenwort	FE, SE
Plant	<i>Phyllostegia racemosa var racemosa</i>	Kiponapona	FE, SE
Plant	<i>Vicia menziesii</i>	Hawaiian vetch	FE, SE
Bird	<i>Branta sandvicensis</i>	Nene (Hawaiian goose)	FE, SE
Bird	<i>Buteo solitarius</i>	'Io	FE, SE
Bird	<i>Hemignathus munroi</i>	'Akiapola'au	FE, SE
Bird	<i>Loxioides bailleui</i>	Palila	FE, SE
Bird	<i>Pterodroma sandwichensis</i>	'Ua'u (Hawaiian petrel)	FE, SE
Mammal	<i>Lasiurus cinereus semotus</i>	'Ope'ape'a (Hawaiian hoary bat)	FE, SE
Threatened Species			
Plant	<i>Silene hawaiiensis</i>	Hawai'i catchfly	FT, ST
Candidate Species			
Plant	<i>Ranunculus hawaiiensis</i>	Makou	FC, SC
Arthropod	<i>Nysius wekiuicola</i>	Wēkiu bug	FC
Species of Concern			
Plant	<i>Chamaesyce olowaluana</i>	'Akoko	HSOC
Plant	<i>Cystopteris douglasii</i>	Douglas' bladderfern	HSOC
Plant	<i>Dubautia arborea</i>	Mauna Kea dubautia, na'ena'e	HSOC
Plant	<i>Sanicula sandwicensis</i>	Hawai'i black snakeroot	HSOC, FSOC,
Arthropod	<i>Agrotis melanoneura</i>	Black-Veined Agrotis Noctuid Moth	HSOC
Arthropod	<i>Coleotichus blackburniae</i>	Koa bug	FSOC
Arthropod	<i>Hylaeus difficilis</i>	Yellow-faced bee	HSOC, FSOC,
Arthropod	<i>Hylaeus flavipes</i>	Yellow-faced bee	HSOC
Snail	<i>Succinea konaensis</i>	Succineid snail	FSOC

⁵ Legal Status: FE = Federally Endangered, FT= Federally Threatened, FC = Federal Candidate for listing, FSOC = Federal Species of Concern, SE = State Endangered, SC = State Candidate for Listing, HSOC = Hawai'i State Species of Concern, ST = State Threatened.

Group	Scientific Name	Common Name	Legal Status ⁵
Snail	<i>Vitrina tenella</i>	Zonitid snail	FSOC
Bird	<i>Asio flammeus sandwichensis</i>	Pueo	FSOC, SE ⁶
	<i>Chasiempis sandwichensis</i>	Hawai'i 'Elepaio	FSOC
Bird	<i>Hemignathus virens virens</i>	'Amakihi	FSOC
Bird	<i>Himatione sanquinea</i>	'Apapane	FSOC
Bird	<i>Pluvialis fulva</i>	Kolea (Pacific Golden Plover)	FSOC
Bird	<i>Vestiaria coccinea</i>	'Iiwi	FSOC, SE ⁷

5.3.1 Subalpine Flora and Fauna (Hale Pōhaku and Access Road)

The subalpine plant community found at Hale Pōhaku is made up primarily of clumps of māmane (*Sophora chrysophylla*) trees interspersed with open areas of bare soil or rocky outcroppings (Char 1999a). Understory plants tend to be concentrated under the māmane trees, where they receive fog drip, an important source of moisture in this dry environment (Gagné and Cuddihy 1990). Common grasses include two native grasses, alpine hairgrass (*Deschampsia nubigena*) and pili uka (*Trisetum glomeratum*), and an introduced needlegrass, *Nassella cernua* (Char 1999a). Shrub species found at Hale Pōhaku include 'āheahea (*Chenopodium oahuense*), pūkiawe (*Leptecophylla tameiameiaie*) and nohoanu (*Geranium cuneatum*). The latter two are associated with rocky areas. Three native fern species, kalamoho (*Pellaea ternifolia*), 'iwa'iwa (*Asplenium adiantum-nigrum*), and olali'i (*Asplenium trichomanes*), are also found among the rocks, along with Hawai'i catchfly (*Silene hawaiiensis*), a Federally Threatened Species (Char 1985). Two native vines, littleleaf stenogyne (*Stenogyne microphylla*) and mā'ohi'ohi (*Stenogyne rogoosa*) are found climbing into the canopy of some māmane trees (Char 1999a).

Māmane woodlands once stretched from sea level on the leeward side of Mauna Kea to the tree line, but have been greatly reduced due to habitat alteration at lower elevations and uncontrolled grazing at the higher elevations by feral sheep (*Ovis aries*), mouflon sheep (*O. musimon*), goats (*Capra hircus*) (Giffin 1982; Scowcroft and Giffin 1983; Hess et al. 1999). Although attempts have been made to control feral grazers, the forest has not fully recovered, due to continued browsing and the presence of invasive plant species that inhibit māmane regeneration (Williams 1994; Hess et al. 1996). Invasive plants include common mullein (*Verbascum thapsus*), ripgut brome (*Bromus diandrus*), orchardgrass (*Dactylis glomerata*), hairy cats-ear (*Hypochoeris radicata*), alfilaria (*Erodium cicutarium*), sheep sorrel (*Rumex acetosella*), common groundsel (*Senecio vulgaris*), and telegraph plant (*Heterotheca grandiflora*). Māmane regeneration is highest in the higher elevation areas (such as Hale Pōhaku) where grass densities are low (Hess et al. 1996).

Māmane woodlands are home to a wide variety of native arthropods (insects, spiders), the native Hawaiian hoary bat (*Lasiurus cinereus semotus*), and several native bird species, including the Palila (*Loxioides bailleui*), 'Amakihi (*Hemignathus virens*), 'Apapane (*Himatione*

⁶ State Endangered on Oahu only.

⁷ State endangered on Oahu, Lanai, and Molokai only.

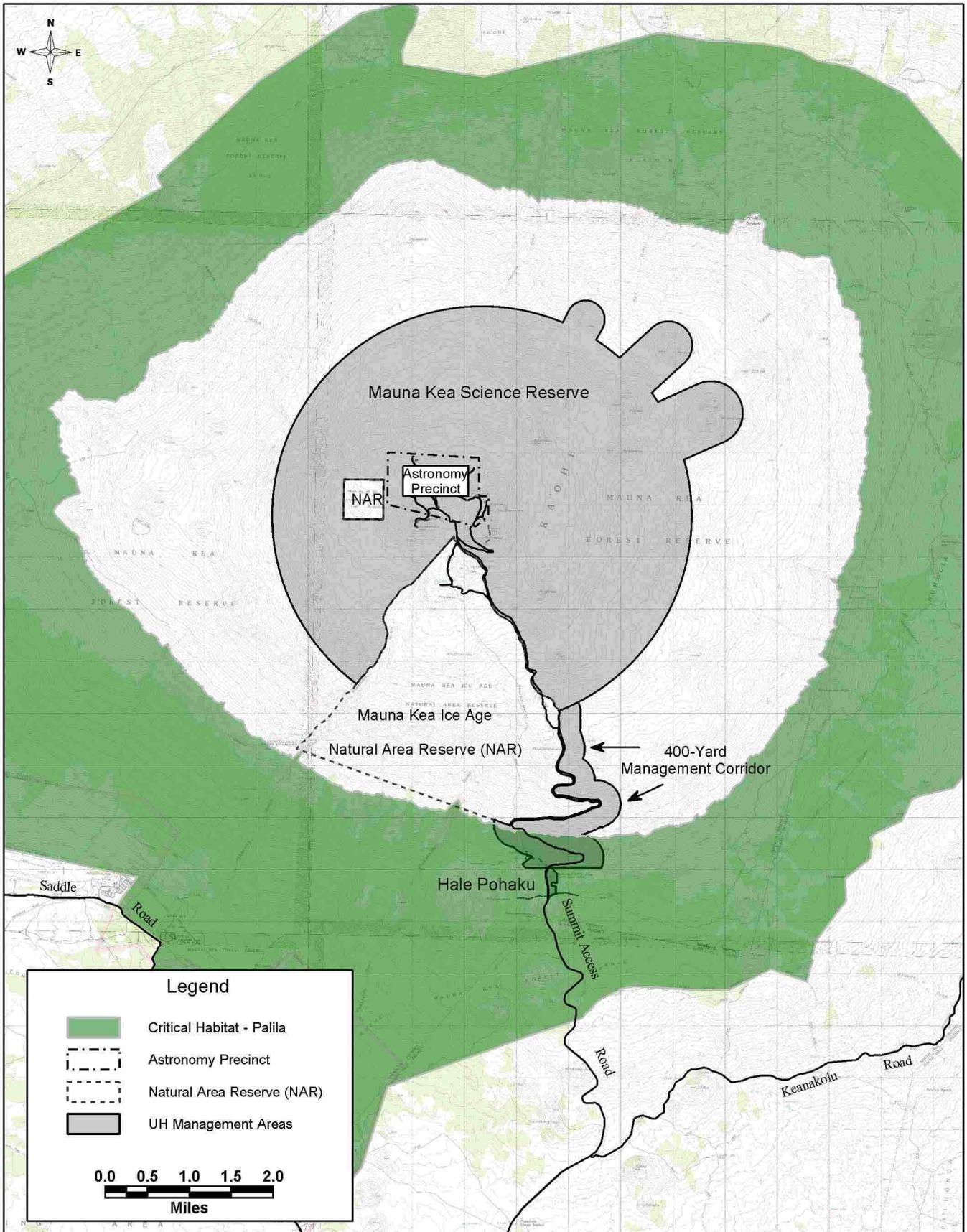
sanguinea), 'Elepaio (*Chasiempis sandwichensis sandwichensis*), 'Akiapola'au (*Hemignathus munroi*), and 'Iiwi (*Vestiaria coccinea*) (Scott et al. 1986). Of these species only the Palila, 'Amakihi, 'Apapane and 'Iiwi have been observed at Hale Pōhaku in recent times. Māmane trees are the primary food source for birds in the region, providing nectar and seeds on a seasonal basis (Hess et al. 2001). Several bird species also prey in the insects that inhabit the māmane trees. Perhaps the most notable bird species is the Federally Endangered Palila (*Loxioides bailleui*). Palila feed on the green seedpods of māmane trees, eating the seeds inside and preying on caterpillars of moth species that also feed on the seeds. Palila also eat naio fruits as well as māmane flowers, buds, and young leaves (Hawai'i Audubon Society 1997; Banko 2006). These unique endemic birds were once common in lowland dry forests on several of the Hawaiian Islands, but due to habitat alteration first by humans, and subsequently by grazing mammals, the Palila's range has decreased to a small band around Mauna Kea, in the last remaining stands of māmane woodlands. Figure 5-8 shows the lands established as critical habitat for the Palila by the U.S. Fish and Wildlife Service. Only Hale Pōhaku and a portion of the Summit Access Road 400-yard Management Corridor are located in areas designated as critical habitat for the Palila.

The māmane woodlands also are inhabited by many species of non-native birds and mammals. Invasive predators such as cats, rats, barn owls, and mongoose have a direct impact on native bird populations. Cats and mongoose eat both adult birds and chicks, while rats primarily consume eggs (and sometimes chicks). Although rats, cats, and mongoose are not abundant in māmane woodlands, they still impact Palila populations (Banko et al. 2002). Non-native birds can compete directly with native birds for resources such as food. Japanese white-eye are likely to compete directly with insectivorous and nectarivorous honeycreepers for limited resources in māmane woodlands. Non-native birds also can act as a food base for predators, which will take native birds as prey in addition to the non-natives.

5.3.2 Alpine Flora and Fauna (Mauna Kea Science Reserve)

As you travel up the mountain towards the summit, the vegetation decreases in diversity, density and size. Alpine plant communities on Mauna Kea begin just above the treeline, at approximately 9,800 ft (2,987 m), and rise to the summit of the mountain at 13,796 ft (4,205 m). The alpine plant communities can be divided into shrublands, grasslands, and stone desert. There are no sharp lines of delineation between the plant community types: the three communities grade into one another, beginning with the alpine shrubland at the treeline, grading into the alpine grasslands, and culminating with the alpine stone desert at the summit (ueller-Dombois and Fosberg 1998; Char 1999b; Conant *et al.* 2004). The three community types are all characterized as being predominantly barren rock and cinder with scattered sparse vegetation (Aldrich 2005).

Alpine shrublands are inhabited mainly by low-lying shrubby species such as pūkiawe (*Leptecophylla tameiameia*), ōhelo (*Vaccinium reticulatum*), and Mauna Kea dubautia (*Dubautia arborea*); scattered grasses such as Hawaiian bentgrass (*Agrostis sandwichensis*), and pili uka (*Trisetum glomeratum*); and native ferns such as Douglas' bladderfern (*Cystopteris douglasii*), kalamoho (*Pellaea ternifolia*), 'olali'i (*Asplenium trichomanes*), and 'iwa'iwa (bird's nest ferns, *Asplenium adiantum-nigrum*). Historically common, but now rare, species found in this community include 'āhinahina (the Mauna Kea silversword, *Argyroxiphium sandwicense* ssp. *sandwicense*), lava dubautia (*Dubautia ciliolata* ssp. *ciliolata*), 'ōhelo papa (Hawaiian



Palila Critical Habitat

strawberry, *Fragraria chiloensis*), 'ena 'ena (*Pseudognaphalium sanwicensium*), nohoanu (*Geranium cuneatum* ssp. *hololeucum*) and alpine tetramolopium (*Tetramolopium humile* ssp. *humile* var. *humile*). Several non-native plant species that have taken hold in the alpine shrublands on Mauna Kea, including hairy cat's ear (*Hypochoeris radicata*), sheep sorrel (*Rumex acetosella*), common mullein (*Verbascum thapsus*), fireweed (*Senecio madagascariensis*), and the common dandelion (*Taraxacum officinale*). Heavy grazing by feral ungulates has greatly impacted the plant communities in the alpine shrublands and grasslands (Hartt and Neal 1940; Mueller-Dombois and Fosberg 1998), and invasive plant species now compete with native plants for limited resources such as water and sheltered growing locations.

Alpine grasslands replace alpine shrublands around 11,000 ft in elevation, although pūkiawe shrubs can be found in all habitats, clear to the summit (Mueller-Dombois and Fosberg 1998). The alpine grasslands on Mauna Kea, which occur up to 12,800 ft in elevation, are dominated by two native grasses: Hawaiian bentgrass (*Agrostis sandwicensis*), and pili uka (*Trisetum glomeratum*) (Mueller-Dombois and Fosberg 1998). These grasslands are now very rare, as they have been decimated by feral ungulates (goats, sheep).

At one time, the Mauna Kea silversword, or 'āhinahina (*Argyroxiphium sandwicense* ssp. *sandwicense*) dominated the alpine landscape on Mauna Kea. 'Āhinahina is a spectacular plant with thick sword-shaped shiny silvery-green leaves growing in a giant rosette. It only flowers once, usually sometime between 3 to 50 years of age. After flowering, it dies. When it flowers, the Mauna Kea silversword grows a large stalk, up to 9 feet tall, that is covered with up to 600 pink to wine-red flowers (Wagner et al. 1990). The Mauna Kea silversword is found only on Mauna Kea, and historically occurred from 6,000 ft to 12,300 ft (Hartt and Neal 1940; Wagner et al. 1990; Robichaux et al. 2000). The population size of the Mauna Kea silversword was drastically reduced through grazing by feral sheep, goats, mouflon sheep and cattle (Hartt and Neal 1940; USFWS 1994; Robichaux et al. 2000). Although the impact of grazing ungulates on the silversword and other vegetation on Mauna Kea was recognized early on grazing animals have never been eliminated from Mauna Kea (Juvik and Juvik 1984). Recovery efforts for the Mauna Kea silversword are underway through the efforts of Federal and State agencies. Recently a new population of Mauna Kea silverswords was discovered in the Science Reserve (Nagata 2007; Tomlinson 2007).

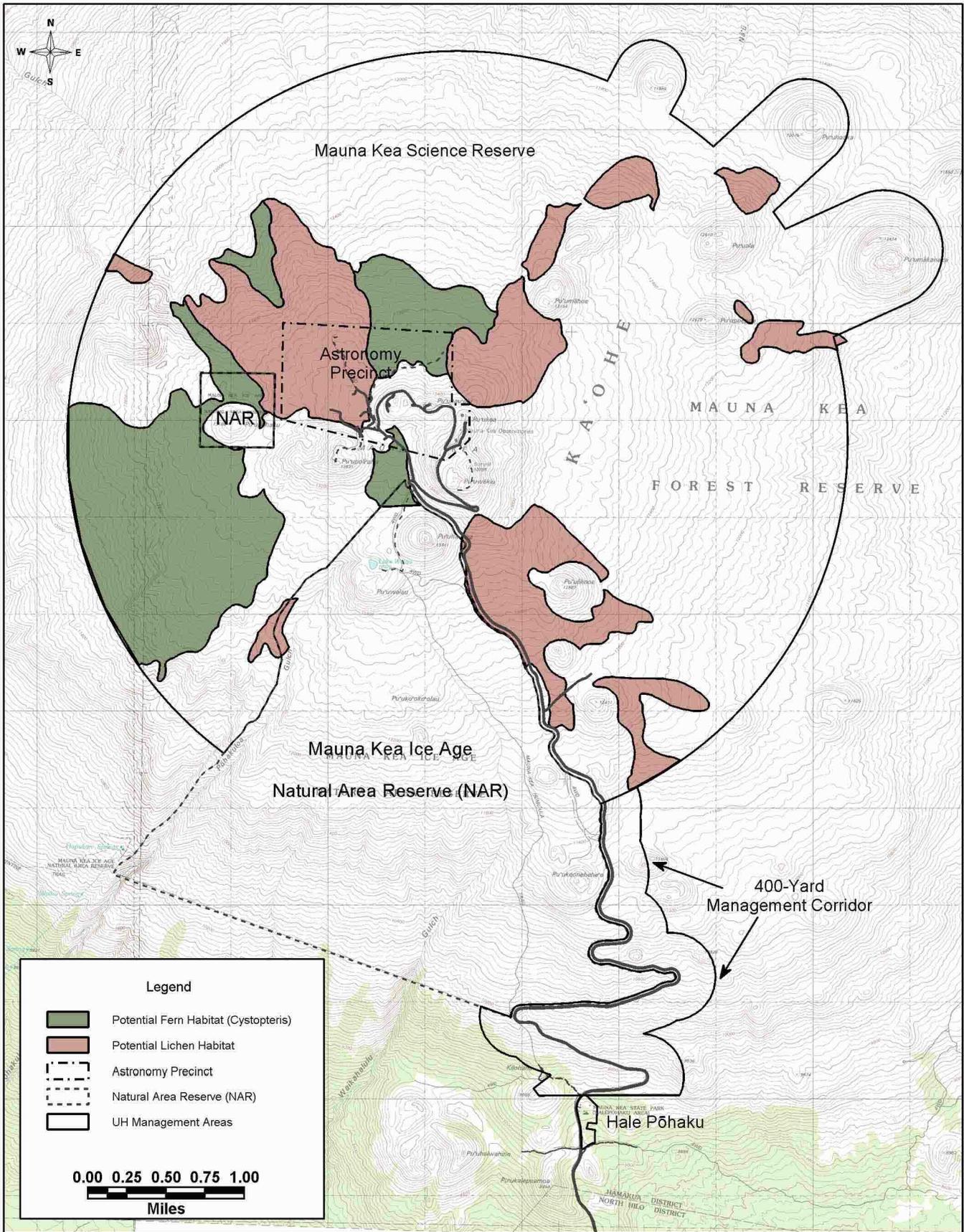
The alpine shrublands and grasslands have a fairly low diversity of vertebrate animal species that utilize it on a regular basis. One Federally Endangered bird, the Hawaiian petrel or 'Ua'u (*Pterodroma sandwichensis*), has been observed in subalpine lava flows on Mauna Loa at 8,000 – 9,200 ft elevation, and occasionally in subalpine and alpine habitats on Mauna Kea (Conant 1980; Kjargaard 1988; Hu et al. 2001). However, it has not been spotted near Hale Pōhaku or the Mauna Kea Science Reserve in recent times. Feral sheep and goats stray into the lower regions of the alpine zone and cause considerable damage to the native plant communities there.

The summit of Mauna Kea (12,800 to 13,796 ft) is considered an Alpine Stone Desert (Mueller-Dombois and Fosberg 1998). This plant community consists of several species of mosses and lichens, an unknown number of species of algae, and a limited number of vascular plants, predominantly the same species found in the alpine shrublands and grasslands (Hartt and Neal 1940; Char 1999b; Aldrich 2005). Most of the species of plants found in the region are endemic (occurring only in Hawai'i) or indigenous (native to Hawai'i but occurring elsewhere). A few non-

native plant species have also become established here, even at the summit (Hartt and Neal 1940; Char 1999b). Vascular plants are found mainly at the base of rock outcrops where there is an accumulation of soil and moisture, and some protection from wind (Char 1999b). The most abundant native plants found at this elevation are two grass species, Hawaiian bentgrass (*Agrostis sandwicensis*) and pili uka (*Trisetum glomeratum*), and two fern species, 'iwa'iwa (*Asplenium adiantum-nigrum*) and Douglas' bladderfern (*Cystopteris douglasii*). Non-native species found in the alpine stone desert include Hairy cat's ear (*Hypochoeris radicata*) and common dandelion (*Taraxacum officinale*), both of which are temperate weed species with a world-wide distribution (Smith *et al.* 1982; Char 1999b).

Lichens and mosses dominate the alpine stone desert in terms of diversity and abundance. Lichens, which are not really plants, but instead are a symbiotic relationship between a fungus and either a green alga or a blue green bacterium, or both (Hemmes and Desjardin 2002), are found throughout the summit of Mauna Kea. The highest densities and diversity of lichens tend to be found on andesite (lava) rocks, in north and west facing protected locations away from direct sun exposure (Smith *et al.* 1982). Areas to the west of the major cinder cones have a low density and diversity of lichens, most likely due to a rain shadow effect created by the cinder cones (Smith *et al.* 1982). A survey of lichens on the summit of Mauna Kea identified 21 species (plus five possible other species). Around half of the lichen species found on Mauna Kea are endemic (found only in Hawai'i), two of which (*Pseudephebe pubescens* and *Umbilicaria pacifica*) are limited to Mauna Kea alone (Smith *et al.* 1982; Char 1999b). *Pseudephebe pubescens* has not been recorded anywhere else in Hawai'i, or any other tropical island, as this species is primarily found in high altitude and alpine regions of the world (Smith *et al.* 1982). The remaining species are indigenous to the Hawaiian Islands. *Lecanora muralis* is the most abundant lichen on Mauna Kea, and is found throughout the summit on all substrate types including cinders and colluvial material on the cinder cones up to the summit of Pu'u Wēkiu (Smith *et al.* 1982). Other common species on the summit are *Lecidea skottsbergii* and *Candelariella vitellina*, both of which are found on rocks "larger than a small fist" (Smith *et al.* 1982). Figure 5-9 shows the potential extent of fern and lichen habitat.

Mosses at the summit occur in protected places where water availability is more consistent, such as under overhanging rocks and in shaded crevices or caves where snow melts slowly (Smith *et al.* 1982). Mosses are predominantly found on the north-northeast and south-southeast facing sides of rocky mounds, generally in association with runoff channels from snow melt (Smith *et al.* 1982). Moss cover is much lower in the rain shadow region west of the summit cone, due to the more arid conditions (Smith *et al.* 1982). Mosses have not been observed in loose cinders or on the aeolian or colluvial fields (Char 1999b). A survey of the mosses on the Mauna Kea summit area (above 13,000 ft) identified approximately 12 species (some could not be identified with certainty to the species level), most of which are indigenous to the Hawaiian Islands. Two moss species, *Bryum hawaiiicum* and *Pohlia mauiensis*, are endemic (Smith *et al.* 1982). All the moss species found at the summit are related to temperate species. The most common species of moss were a previously undescribed species of *Grimmia* and *Pohlia cruda* (Smith *et al.* 1982). *Grimmia* are silvery-gray mosses that form



Potential Extents of Fern and Lichen Habitat

Source: Winona Char, 1999

clumps in run-off channels and semi-exposed rock faces (Smith et al. 1982). *Pohlia cruda* is a bright green moss found in well-protected, deeply shady locations, and are so well hidden they are unlikely to be seen by the casual observer (Smith et al. 1982). The remaining moss species were not as abundant and tended to occur in habitats intermediate between the somewhat exposed *Grimmia* habitats and the protected *Pohlia* habitats (Smith et al. 1982).

Although it may appear barren to the casual observer, the summit of Mauna Kea supports an interesting variety of species, many of which are found nowhere else in the world. The animal community at the summit is dominated by arthropods (invertebrates such as insects and spiders): there are only a few vertebrate species (other than man) that venture this high, and these are primarily non-native mammals such as mice that reside in and around the observatories. The arthropod community on the summit of Mauna Kea can be divided into two parts: those species that are blown up the mountain from lower elevations by the wind and die there in the cold (referred to as aeolian drift), and those cold-adapted species that are permanent residents, that feed on the dead and dying arthropods found in the aeolian drift or on one-another (Howarth and Montgomery 1980; Howarth and Stone 1982). The arthropod community on the summit is highly unusual in that it is mostly made up of predators and scavengers, and there are very few species that rely on plants as their sole food source.

Through the various studies conducted at the summit of Mauna Kea, 21 resident species, and 14 species of undetermined origin (unknown if they are resident or aeolian) have been recorded as occurring in the alpine stone desert. Native resident species include the wēkiu bugs (*Nysius wekiuicola*), a noctuid moth (*Agrotis* sp.), a hide beetle (*Dermestes maculatus*), a large wolf spider (*Lycosa* sp.), two sheet web spiders (*Erigone* species), an unidentified Linyphiid sheet web spider (Family Linyphiidae), two unknown Entomobryid springtails (Family Entomobryidae), a Collembolla springtail (Class Collembola, family and species unknown), two species of mites (Families Anystidae and Eupodidae), a bark louse (*Palistreptus inconstans*) and a centipede (*Lithobius* sp.). Non-native resident species include a book louse (*Liposcelis divinatorius*), big-eyed bug (*Geocoris pallens*), a hunting spider (*Meriola arcifera*), a sheet web spider (*Leptyphantus tenuis*), and an unidentified jumping spider (family Salticidae).

The wēkiu bug (*Nysius wekiuicola*) is the best-studied invertebrate at the summit. The wēkiu bug is a Federal Candidate species, meaning that it is being considered for listing as Threatened or Endangered, but has not yet been listed. The wēkiu bug was first recognized as a new species in 1979. It is a true bug in the family Lygaeidae (order Heteroptera), and is approximately the size of a grain of rice (Ashlock and Gagne 1983; Richardson 2002). The wēkiu bug, and its sister species, the Mauna Loa bug (*Nysius aa*), which resides on the summit of Mauna Loa, differ from other species in the genus *Nysius* in being scavengers and predators of dead and dying arthropods, while all other known species in the genus are seed and/or plant feeders (Ashlock and Gagne 1983; Polhemus 1998). Wēkiu bugs reside in the cinders on the summit of Mauna Kea, where they use their straw like beaks to suck the hemolymph (blood) from dead and dying insects blown up the mountain from lower elevations (Howarth and Montgomery 1980; Ashlock and Gagne 1983; Howarth 1987; Richardson 2002). They do not appear to feed on healthy/living individuals of the other resident arthropod species (Ashlock and Gagne 1983).

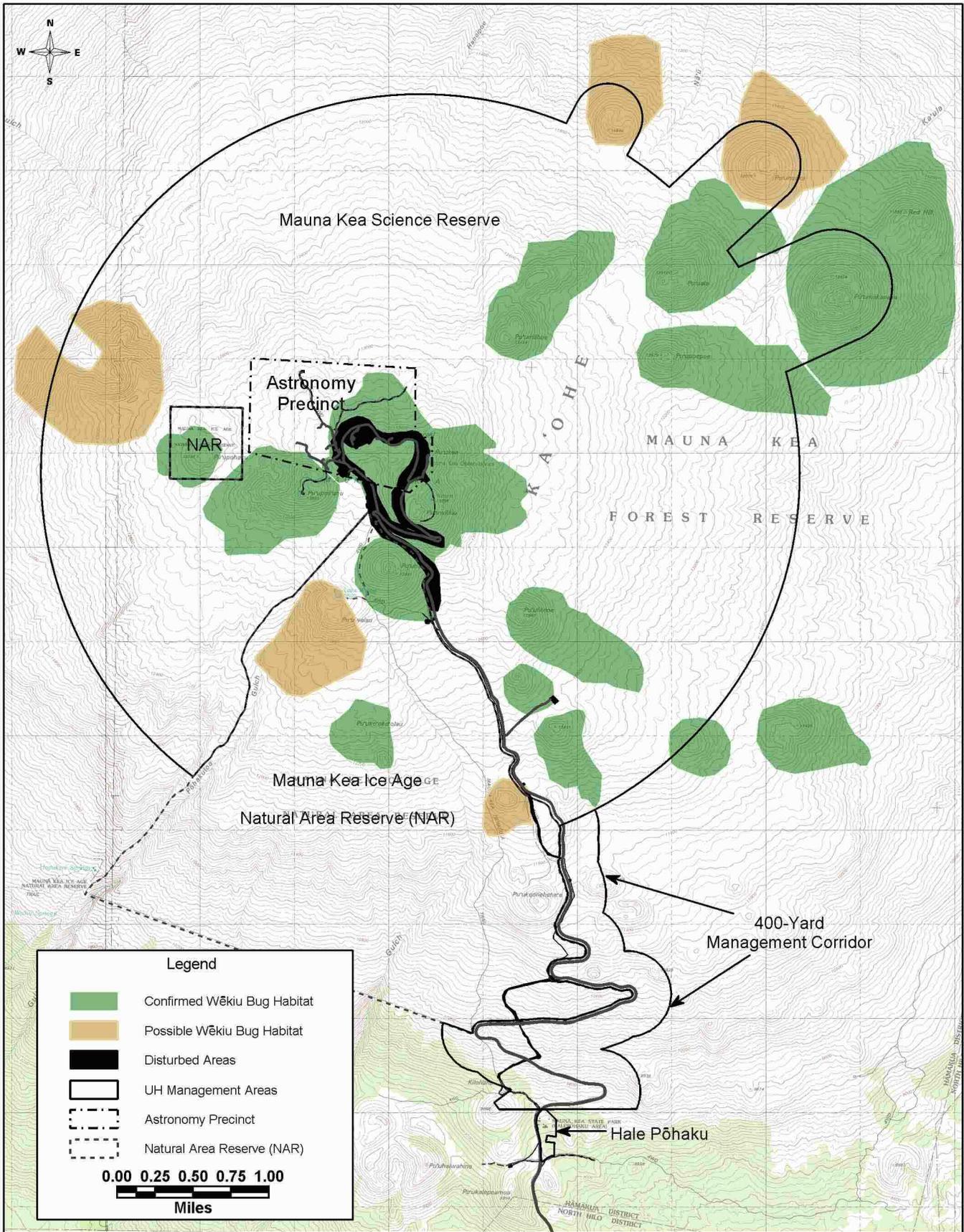
Wēkiu bugs are most abundant on or near the crater rims of cinder cones that formed nunataks (ice free areas rising above the surrounding glacier) or that lay at the glacier limit during the last glaciation, especially on the north- and east-facing slopes (and on slopes shaded by local topography), where seasonal snow remains the longest (Porter and Englund 2006). They can also be found on the flanks and at the bases of the cones where cinders have accumulated to sufficient depths (Eiben 2008). Snowfields may be important to the scavenger species on the summit, as they chill and store insects in the aeolian drift for later consumption. Wēkiu bugs can often be seen foraging on the edge of snow banks (Englund et al. 2006). Crests of glacially overridden cones and inter-cone expanses of glacial till appear to lack suitable wēkiu bug habitat (Porter and Englund 2006). Figure 5-10 shows the potential and known wēkiu bug habitat in the Mauna Kea Science Reserve, as determined by Jesse Eiben (2008).

There has been some discussion about whether wēkiu bug populations have decreased, increased, or remained the same over time since the first survey in 1982 (Howarth et al. 1999; Polhemus 2001; Englund et al. 2002). Many insect populations naturally undergo cycles of low and high abundance over long periods of time (Howarth et al. 1999). Most of the studies were not designed to calculate population densities of wēkiu bugs, and instead measured activity levels. Wēkiu bug capture rates appear to be heavily influenced by climactic conditions such as presence of snow (Englund et al. 2006; Porter and Englund 2006; Englund et al. 2007), which makes it difficult to compare capture rates across studies that were conducted during different conditions or time of year. However, ten years of study following the 1997-98 surveys suggest that wēkiu bugs are still abundant on Mauna Kea, and that they are able to reside in both undeveloped and developed areas at the summit (Polhemus 2001; Englund et al. 2002; Englund et al. 2005; Englund et al. 2006; Porter and Englund 2006; Englund et al. 2007).

5.4 VISUAL ENVIRONMENT

Views of Mauna Kea from the lowlands, along with views from the summit region are one of the mountain's resources that has been valued for generations. When skies are clear, the summit region and observatories can be seen from Hilo, Honoka'a, Waimea, Kilauea summit, sections of the Mauna Kea Summit Access Road and much of Puna. On cloud-free days, views from the summit region include Mauna Loa to the south, Hualālai to the west, the flanks of summit cinder cones to the east, and other islands in the Hawaiian chain to the north-northwest. Hilo is visible unless it is blocked by the inversion cloud layer. Existing observatories have impacted the viewscape in some locations, both from the summit and of it, and they do obscure portions of the 360-degree view from the summit area. Trails that become etched into the cinder from repeated use also impact the viewscape.

It is well known that the "seeing" ability from the summit region, as it relates to astronomy, is very high, and it has been well documented that the Science Reserve is a premier location for astronomical activities (Walker 1983; Businger et al. 2002; Wainscoat 2007). Dark skies, generally favorable weather, and clean, clear air permit almost year-round un-obscured conditions for optimal night seeing. These attributes of seeing ability result directly and indirectly from four primary factors: the site's remote location, its elevation, topography, and climate (Businger et al. 2002). Managing these attributes for optimal influence on night sky viewing will be essential to the continued success of astronomy at the Science Reserve.



Source: Jesse Eiben, PhD Candidate, UH Manoa, Insect Systematics and Biodiversity 2008

Wēkiu Bug Habitat

5.5 TRAFFIC

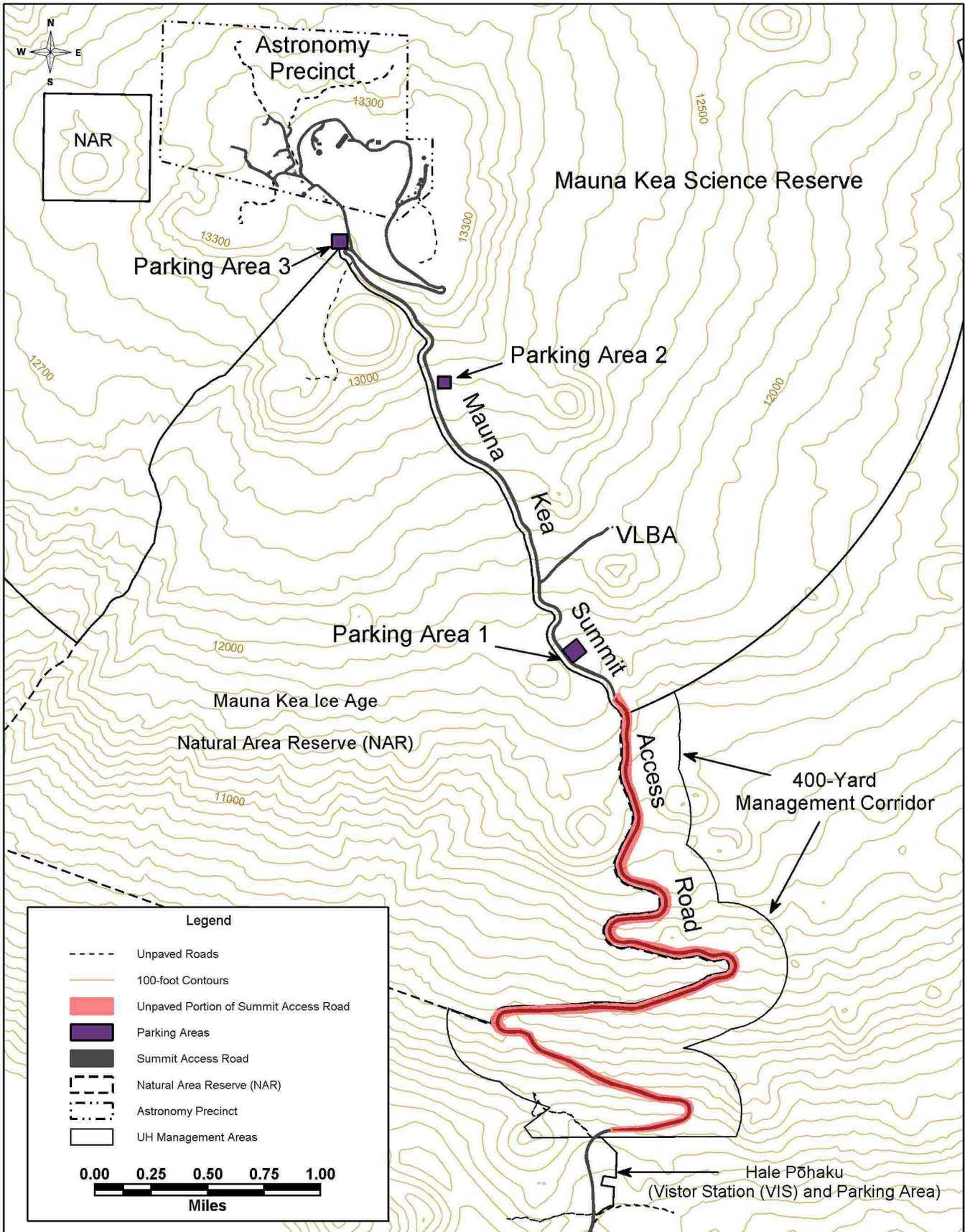
Hale Pōhaku and the summit of Mauna Kea are accessible from Saddle Road (Route 200). The Summit Access Road extends 16.3 mi (26.2 km) from its intersection with Saddle Road to the summit, with an average width, including cuts and fills beyond the main route, of 45 ft (14 m) (NASA 2005). Figure 5.11 shows the Mauna Kea Summit Access Road. The road is paved along its entire length except for a 4.6 mile unpaved, gravel section that extends from Hale Pōhaku to the summit area. Future plans may include paving the unpaved portion of the summit access road and the remainder of the summit spur road, from the SMA building, past the Subaru Telescope to the Keck Observatory; however, concerns related to cost, environmental impacts, and facilitating access to the summit need to be evaluated.

There are three visitor parking areas along the Summit Access Road: Parking Area 1, located just after the paved road begins; Parking Area 2, near the trailhead to Lake Waiau; and Parking Area 3, just past the junction of the access road and the summit loop. These areas are depicted on the map included in the safety brochure made available to workers and visitors, but are not identified by signage on-site. At the summit many visitors park near the UH 2.2m telescope if they plan to hike the summit trail. During the winter, before roads are fully cleared of snow and when there are large numbers of private vehicles in the summit area, parking becomes congested and visitors park their vehicles along the road wherever there is space. Commercial tour vehicles usually park in the area around the UH 2.2m telescope and Gemini Telescope during the sunset viewing times. For evening stargazing, there are designated parking areas for tour vehicles on lower portions of the mountain. Observatory vehicles park in designated areas near their buildings. Most parking areas are graded but unpaved.

Observatory vehicles and visiting 4-wheel drive vehicles represent, by far, the largest percentage of total vehicles on the mountain, with just over 13,000 of the former and over 10,500 of the later, in 2007 (OMKM, unpublished data). Ranger estimates indicate an average of about 30 non-commercial visitors a day to the summit, most of them staying less than 30 minutes (OMKM Rangers 2007). It is anticipated that as tourism on the Big Island continues to grow, and with the ongoing improvements to Saddle Road, more tourists and recreational visitors will visit Mauna Kea in coming years. Currently OMKM rangers estimate that most recreational visitors are from the mainland or overseas, but there is no official tracking of visitor demographics (OMKM Rangers 2007).

5.6 AIR QUALITY

Although there is no active monitoring for air quality at the Mauna Kea summit, its geographic and meteorological isolation results in excellent air quality, well known throughout the



UH Management Area Roads and Parking Areas

astronomy community.⁸ The summit is above the altitude of temperature inversions, and pollutants such as smoke, dust, and smog that are generated below the inversion layer generally do not affect the air quality at the summit of Mauna Kea. Locally generated contributors to air pollution at the summit include vehicle exhaust and fugitive dust. Dispersion of the pollutants is aided by strong winds.

5.7 INFRASTRUCTURE AND UTILITIES

The following section includes a discussion of the communications, power, and water infrastructure located in the UH Management Areas.

5.7.1 Communications and Power Supply

Underground power and communication lines supply Hale Pōhaku and summit facilities. Installation of the underground system to transmit electricity to the summit facilities began in 1985 and was completed in 1995. Rather than on-site generators, the facilities are now powered from a sub-station below Hale Pōhaku that is connected by overhead lines to the Humu'ula Radio Site. In the mid-1990s, underground fiber optic lines were installed to provide high speed communications capability to the observatories. One benefit of these lines was a reduction in personnel needed on-site at some of the observatories, as they can now be controlled remotely.

5.7.2. Water

Mauna Kea Support Services (MKSS) contracts with a trucking company to deliver potable water from Hilo to Hale Pōhaku and the summit observatories, in 5,000-gallon-capacity (18,900 l) tank trailers owned by MKSS. Each observatory stores its own water and is responsible for maintenance of their water tanks. Data from MKSS indicates that the Hale Pōhaku facilities (food, lodging, VIS) currently require approximately 30,000 gallons (113,500 l) of water weekly (Nahakuelua 2008). Water is trucked to the summit about twice a week for an annual total of approximately 502,500 gallons (1,902,000 l) (Koehler 2008).

5.8 FLOOD HAZARD

The Federal Emergency Management Agency has not prepared Flood Insurance Rate Maps for the project area. Precipitation rates average 7 to 18 inches per year within the Science Reserve and 12 to 20 inches per year at Hale Pōhaku. These low precipitation rates, coupled with the relative high porosity of volcanic soils, result in minimal runoff or precipitation accumulation. Water flow in the gulches and streams of the Science Reserve is ephemeral, and occurs only during periods of rapid snow melt and during infrequent, high magnitude rainfall events. There are no recorded flood events on UH leased lands on Mauna Kea.

⁸ Data for the summit of Mauna Loa, collected by the NOAA Mauna Loa Observatory, indicate that the air quality at Mauna Loa is excellent. Given the similarities between the two locations, it has been suggested that the overall air quality at Mauna Kea is excellent, as well (NASA 2005; Barnes 2008).

5.9 GROUND AND SURFACE WATER RESOURCES

The science of hydrology revolves around the properties, distribution, and circulation of water. The following discussion presents the most current understanding of the mountain's upper watershed surface and ground water features. Figure 5-12 illustrates the hydrological features in the Mauna Kea summit region.

5.9.1 Surface Water

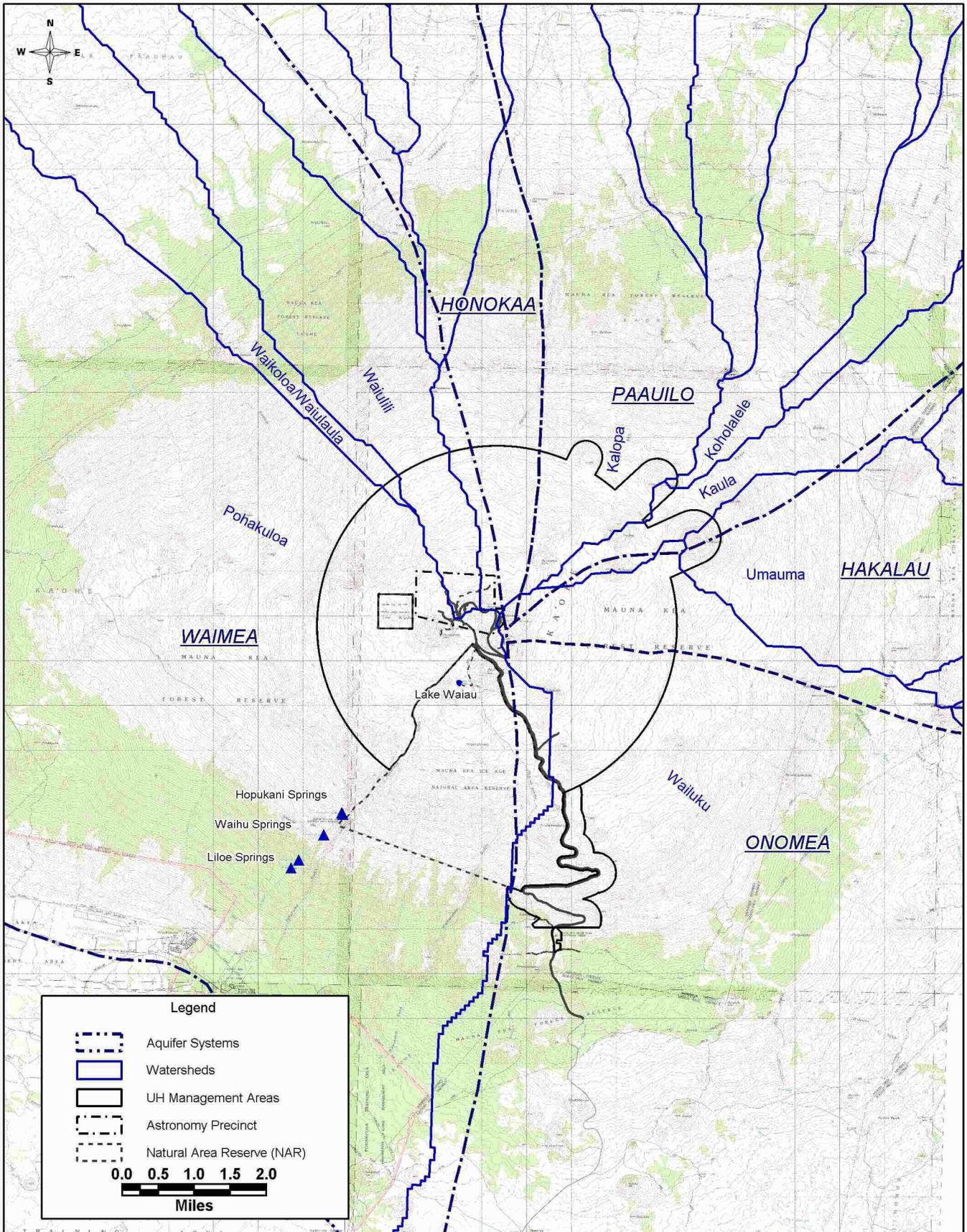
The summit area and upper flanks of the mountain are dissected by very small ephemeral rills and gullies, which are only moderately incised and do not have hydraulic geometries that would convey much water. Pōhakuloa and Waikahalulu Gulches are the most developed drainage channels along the upper slopes of the mountain. Unlike the rills and gullies, the gulches originate in higher elevation areas covered in lava and cinder. These channels likely formed following large-scale scouring of and movement of materials down the present day gulch alignment from a process initiated by melting glaciers (Macdonald et al. 1983; Lockwood 2000; Porter 2005). These melt waters are also thought to be responsible for first filling Lake Waiau (Sherrod et al. 2007).

According to the DLNR Commission on Water Resource Management, the State agency that defines stream flow status, none of the streams in Mauna Kea's watersheds are perennial in the summit region (having continuous flow all year).⁹ The Wailuku River is the only river whose numerous gulches extend along the upper flanks of Mauna Kea, and where these coalesce, downslope near the 10,000 ft elevation (3,048 m), stream flow is considered to be perennial.

Lake Waiau is located within the Mauna Kea Ice Age NAR. Located at the bottom of Pu'u Waiau, the lake freezes almost entirely during colder times of the year and has never been known to dry up. Lake Waiau is one of Hawai'i's few confined surface water bodies (Massey 1979) and one of the highest alpine lakes in the United States (Laws and Woodcock 1981). Lake Waiau is revered by many Hawaiians as a pool created for the snow goddess Poli'ahu by her father, Kane (Melvin 1988). The lake is heart-shaped, 300 ft in diameter (91 m) and reaches approximately 7.5 ft deep (2.3 m) at capacity (Woodcock et al. 1966; Laws and Woodcock 1981). Lake Waiau is believed to have formed approximately 15,000 years ago, following the last glacial retreat (Woodcock 1974). The primary source of the lake's water is now thought to be precipitation, rain and, snow melt, collected within Pu'u Waiau's approximately 35 ac (14.2 ha) watershed and not from relic layers of ice or permafrost within the ground as previously thought (Woodcock 1980; Ehlmann et al. 2005; Lippiatt 2005).

Subsurface fluvial processes feed seeps and streams found between 8,500 and 11,000 ft (2,591 and 3,353 m), near Pōhakuloa and Waikahalulu Gulches (Woodcock 1980; Arvidson 2002). While the precise hydrologic connection of water from the summit to these seeps and streams is unknown, there is evidence associating it with "current summit rainfall and snow melt"

⁹ Perennial/Significant Streams as defined by the Hawai'i Stream Assessment Project, 1993



Hydrologic Features

(Arvidson 2002; Ehlmann et al. 2005), and it is not derived from remnant buried permafrost or ice, as previously suggested (Woodcock 1980).

5.9.2 Groundwater

Groundwater transportation rates in the summit region of Mauna Kea are unknown, and no flow paths have been identified. It is generally believed that groundwater flows along the direction of the ground surface slope, although the presence of variable subsurface features, such as dikes and sills, with low hydraulic conductivity, likely alter groundwater flow rates and flow paths. Groundwater flow-paths are important to understanding the potential movement of leachate from underground waste water systems. Very little information was found discussing the fate and transport of leachate from the summit region,¹⁰ and it is unknown how much, if any, of the total volume of leachate from these systems enters the mountain's aquifers.

The Science Reserve is located above five State of Hawai'i delineated aquifer systems, while Hale Pōhaku is over one, the Waimea Aquifer. The Waimea Aquifer system also underlies the western half of the Science Reserve, including both NAR parcels. The southeast portion of the Science Reserve, approximately one-quarter of its surface area, lies on top of the Onomea Aquifer. The three other aquifers, Hakalau, Pa'auilo and Honoka'a, lie beneath the lands comprising the east and northeast areas of the Science Reserve. The Astronomy Precinct is located entirely above the Waimea Aquifer.¹¹ It is possible, but unconfirmed, that water infiltrating into the substrate from the Astronomy Precinct flows out of the Waimea Aquifer boundary along preferential flow paths that route water to the other aquifer systems.

5.9.3 Water Budget Analysis

A water budget describes the movement of water on, above and below the earth's surface. For Mauna Kea, inputs come in the form of rainfall and snow, and to a lesser extent fog condensation,¹² and losses occur through infiltration, evapotranspiration, and sublimation ("evaporation" directly from snow or ice).

On Mauna Kea, above 9,000 ft (2,743 m), mean annual precipitation is low and evaporation rates are high. Anecdotal evidence and published literature agree that there is considerable annual variability in the amount of water input from rain and snow. Snow's contribution to the total precipitation of the upper slopes and summit area was found to be significant (Ehlmann et al. 2005). The scarcity of vegetation means that very little rainfall is intercepted by vegetation or evaporated from leaves or other plant surfaces. However, the broken rocky surfaces that cover many areas increase overall surface area and trap and hold water, exposing it to evaporation. Although the amount of precipitation that infiltrates into the ground is unknown, it is generally accepted, and is reported by the NRCS, that infiltration rates in the summit region are high, and that during heavy precipitation events, water reaching the ground surface infiltrates quickly.

¹⁰ A limited investigation on groundwater transmission between Lake Waiau and existing and proposed septic systems located in the Astronomy Precinct was conducted by Nance (NASA 2005). His conclusion was that leachate from septic systems would not flow into or toward Lake Waiau.

¹¹ The Astronomy Precinct is the 525 acre (212 ha) area within the Science Reserve reserved for astronomical development.

¹² On Mauna Kea, fog drip is associated with vegetated areas below 9,000 ft (2,743 m) and is not a contributing source of water for upper elevation watersheds (Arvidson 2002).

5.9.4 Water Quality

Water quality parameters of Lake Waiau investigated by Massey (1978) and others in 2003 indicated a slightly alkaline water and very low levels of dissolved constituents (NASA 2005). A turbid look and greenish tint to the lake water has been noted by observers for many years (Bryan 1939; Neal 1939; Wentworth and Powers 1941; Maciolek 1969; Group 70 1982; Arvidson 2002) and is attributed to algae mats growing on the bottom of the lake (Woodcock et al. 1966; Massey 1978; Dillon 1979). There are, however, accounts from visitors to the lake in which a green tint was not mentioned (Raine 1939). In 1977, a severe reduction in lake water levels with concomitant elevations in phytoplankton biomass was identified and classified as hypereutrophication (a significant increase in nutrients, including nitrogen and phosphorus) (Laws and Woodcock 1981). Fecal coliform and bacteria parameters obtained from samples from Hopukani Spring were found to be negligible (NASA 2005). Similar investigations into well water found at much lower elevations were also found to be negligible (NASA 2005).

5.10 CLIMATE

At the upper elevations of Mauna Kea, the prevailing conditions are dry, windy, and cool, with high visibility and low surface albedo; it has been designated as semi-arid, barren alpine desert tundra (Ugolini 1974).

There are two seasons in Hawai'i, winter (October–April), and summer (May–September), with the trade winds blowing approximately 80 percent of the time in the summer and 50 percent of the time in the winter (Giambelluca and Sanderson 1993). On the windward sides of the islands, trade wind showers are common, with the highest trade wind rainfall rates occurring in an elevation band between 2,500 and 7,000 feet (762 and 2,133 m). At 7,000 ft (2,133 m), however, when the trade winds are blowing, the inversion caps upward migration of the clouds, and above this level, rainfall decreases with elevation, keeping Mauna Kea dry and cool from roughly 7,000 ft (2,133 m) upwards (da Silva 2006).

As evidenced from reported data, the mean precipitation in the summit region varies significantly from year to year. Data collected in the summit region by the National Weather Service (NWS) from 1969-2000 reports an average annual precipitation of 7.41 in (188 mm), though it is unknown if the value includes the contribution of water from snow fall. Mean annual precipitation based on data collected by the Subaru Telescope from 1999-2005 was estimated at 15.5 in (393 mm) (Miyashita et al. 2004), including the contribution from snowfall, although the efficiency of snow capture by the recording instrument is unknown. Ehlmann et al. (2005) reports annual precipitation as a range of 4.7 to 17.7 inches (12 to 45 cm) recorded at the VLBA, located below the summit area.

Although no data on average snowfall, snowpack volumes, or patterns of ice formation for the Science Reserve was found in the literature, it is known that varying amounts of snow and ice regularly occupy the summit during the months of November–March (Laws and Woodcock 1981), and snowpack volumes fluctuate from year to year (da Silva 2006) as does, most likely, the formation of ice.

Particularly during the winter, storms reach the upper slopes and summit of Mauna Kea. Storms can include cold-front storms, upper-level and surface low-pressure systems (including kona lows), tropical depressions, and hurricanes. These storm systems bring most of the annual precipitation to the areas above the trade wind inversion, including Mauna Kea (Giambelluca and Sanderson 1993). No records were located documenting the number of storms that affect Mauna Kea annually, but it is presumed to be highly variable, with a range of two to ten storms a year.

Approximately 80 percent of the time, wind direction at the upper elevations of Mauna Kea is from the west. This typically changes during warmer months, and for the remaining 20 percent of the time, wind comes from the east (Juvik and Juvik 1998; da Silva 2006). On occasion, unstable upper atmospheric conditions bring southerly winds, often accompanied by in storm fronts and large amounts of rain (Birchard 2008). Wind speeds at Mauna Kea's summit normally vary between a maximum of 23 miles per hour (10 meters per second) in January and a minimum of 11 miles per hour (5 meters per second) in September (da Silva 2006); however, higher speeds have been noted during storm events (NASA 2005). The dry and breezy conditions facilitate high rates of evaporation at the summit and maintain the cool, dry atmosphere (da Silva 2006; Birchard 2008). Wind direction and speed across the summit area play a large role in the aeolian environment on Mauna Kea, transporting small debris, including bugs, from lower elevations up to the summit area. Average wind speeds at 8,530 ft (2,600 m) at Pu'u La'au, near Hale Pōhaku, range between 2.7 to 3.6 miles per hour (1.2 to 1.6 meters per second) (Nullet et al. 1995).

Mean monthly temperatures above the inversion layer generally range between 24.8°F and 32.9°F (-4°C and 0.5° C) in January, one of the coldest months, and between 38.3°F and 42.8°F (3.5°C and 6.0°C) in September, considered a warm summer month (da Silva 2006). Even though variability between annual mean lows and highs is minimal, temperature ranges recorded at the summit area are quite large, ranging from 2°F to 61°F (-16.6°C to 16.1°C). Average temperatures at Hale Pōhaku, at 9,000 ft (2,743 m), range between 30°F and 70°F (-1°C and 21°C) throughout the year (Group 70 International 1999).

5.11 GEOLOGY AND TOPOGRAPHY

The Hawaiian Archipelago exists due to the west-northwest movement of the Pacific Plate, over a "hotspot" (mantle plume) that is the source of magma creating the Hawaiian Islands. As the Pacific Plate moves slowly over the mantle plume, volcanoes spring up, formed by the repeated discharge of magma. The advance of the plate eventually moves the volcano off the plume, cutting off the source of magma, but at a rate so slow that the deposited cooled magma creates a mountain we identify as a volcano. About 129 different Hawaiian volcanoes have been formed this way, stretching 3,800 miles (6,000 km) across the Pacific Plate (Walker 1990; Juvik and Juvik 1998).

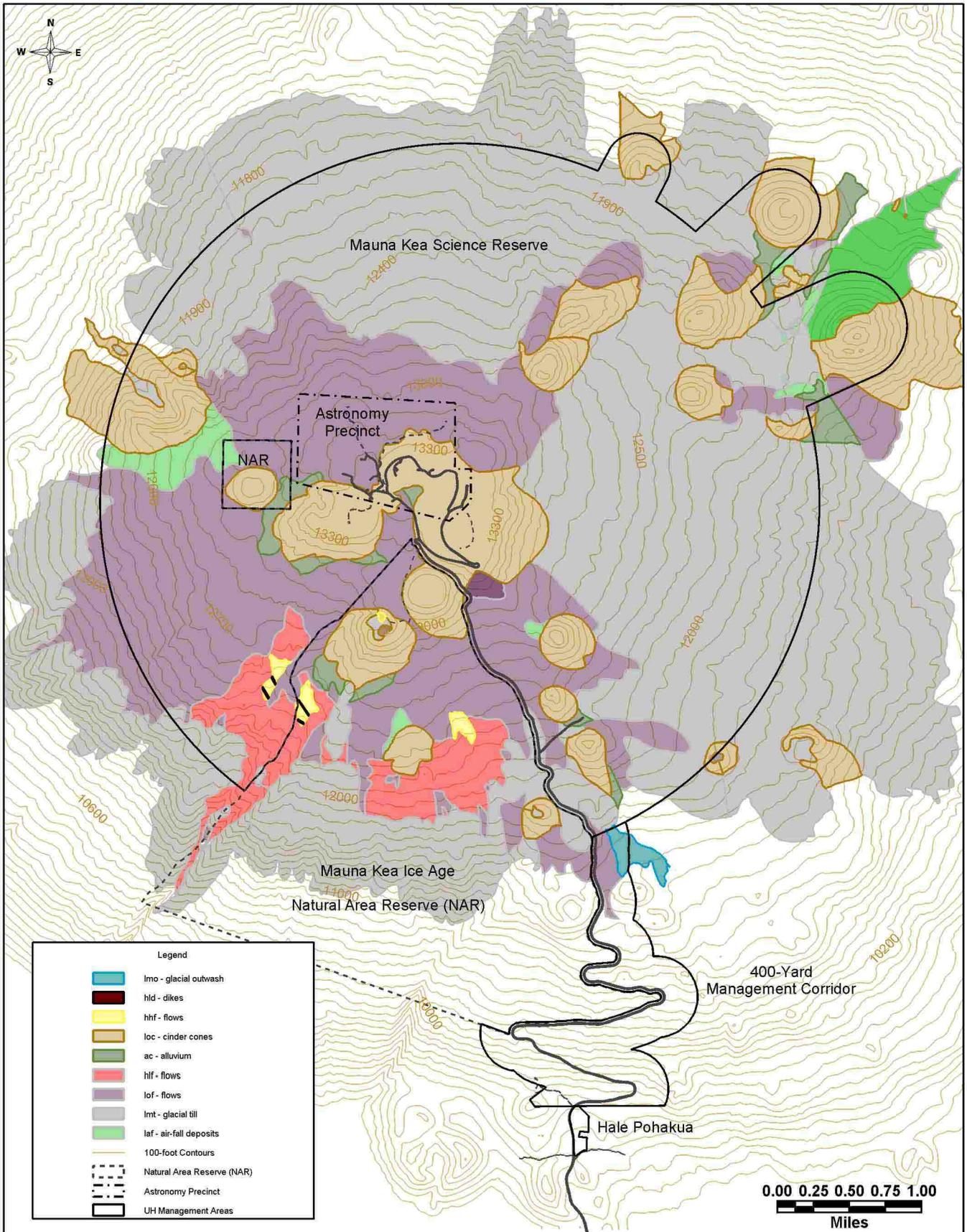
Hawai'i's volcanoes do not usually erupt explosively, and instead produce relatively slow-moving lavas that build up locally, forming rounded peaks. These are called shield volcanoes. Mauna Kea is the second oldest, and highest, of the five volcanoes composing the Island of Hawai'i.

Mauna Kea has completed the submarine, emergent, and shield building stages of the Hawaiian volcanoes life cycle and is now in the post-shield stage (Wolfe et al. 1997). Close to 95 percent of Mauna Kea's mass was generated during the shield stage, and comprises primarily tholeiitic basalts, none of which are visible at Mauna Kea's summit, today (Sherrod et al. 2007). Lavas and other ejecta discharged during the current post-shield stage are primarily alkalic in composition and have been divided into two sub-stages, the Hāmākua and the Laupāhoehoe Volcanics, the Hāmākua being the earlier of the two (Macdonald et al. 1983; Wolfe et al. 1997; Sherrod et al. 2007). The Laupāhoehoe, and to a lesser extent the Hāmākua lava and tephra deposits, are the most visible on the surface of the summit area and cover the older shield-stage basalts (Porter 1979b; Sherrod et al. 2007). The post shield stage also included an explosive period producing highly vesicular materials such as ash, lapilli and cinder (often termed scoria). Once ejected, finer particles such as ash were transported downwind, falling on the landscape in layers of significant depth (Porter 1997). Heavier and denser products such as lapilli and cinder, falling close to the source, formed the massive cinder cones seen today across Mauna Kea's surface.

Mauna Kea is currently estimated to be between 600,000 and 1.5 million years old (Moore and Clague 1992; DePaolo and Stolper 1996; Wolfe et al. 1997; Sharp and Renne 2005) and is considered by the U.S. Geological Survey (USGS) to be an active post-shield volcano (U.S. Geological Survey 2002). While there has been no recent volcanic activity at Mauna Kea, volcanologists believe that it "is likely to erupt again" (Walker 1990; U.S. Geological Survey 2002). It is expected, however, that any future volcanic activity at Mauna Kea will be prefaced by seismic activity and that erupted materials will resemble the thick and sticky lava flows of its more recent past (Lockwood 2000).

The formation of cinder cones, the movement of ice sheets, and the interaction of lava and ice has shaped much of the summit area. Probably the most significant naturally-occurring geomorphic contributor to alteration of the summit landscape since the decline of post-shield activity has been the series of glacial events that occurred between approximately 180,000 and 13,000 thousand years ago (Porter 1979a, 2005; Sherrod et al. 2007). Within the last several hundred thousand years, the summit of Mauna Kea is believed to have been covered by three glaciers (Lockwood 2000). Evidence of these glacial events includes till and moraines, glacially polished rock surfaces, lava-ice contact zones, and hydrologic features such as Pōhakuloa Gulch. These can be seen throughout the Science Reserve and within the neighboring Mauna Kea Ice Age NAR. Today, erosional processes are occurring across the landscape. In addition, Mauna Kea's significant mass induces subsidence at a rate of approximately 0.12 in/yr (3 mm/yr), or 1,312 ft (400 m) in 130,000 years (Wolfe et al. 1997; Sharp and Renne 2005). Figure 5-13 shows the area topography and geologic structures forming Mauna Kea.

Mauna Kea formed through the accumulation of large volumes of lava from a series of volcanic eruptions. The morphology of the upper flanks and summit area of Mauna Kea was subsequently altered by the post-shield eruptions of the Hāmākua and Laupāhoehoe Volcanics. Explosive eruptions that deposited tephra more or less symmetrically around the vents were typical of this volcanic period and formed the pu'u that dot the landscape. This period of volcanism also coincided with the presence of glaciers on the upper mountain. When ejected lavas met the glacial ice, they were cooled immediately, creating an explosive eruption called a pyroclastic event. Products of these events included extremely fine particles (tuff) and ash.



Source: The Geology and Petrology of Mauna Kea Volcano, Hawaii USGS Professional Paper 1557

Topography and Geologic Features

Lava and ice interaction is also responsible for the lava outcrops associated with the adze quarries (Bayman and Nakamura 2001; Bayman 2004), as well as the massive volumes of melt water believed to have carved features such as Pōhakuloa Gulch (Macdonald et al. 1983; Lockwood 2000; Porter 2005). The combination of these factors resulted in the unique and varied geomorphic features of Mauna Kea, none of which would have been formed had the glaciers not been present.

5.11.1 Mauna Kea Science Reserve

The Science Reserve encompasses 11,288 acres (4,568 hectares), from its boundary, which encircles the mountain at approximately 11,500 ft (3,505 m) to the summit of Pu‘u Wēkiu, at 13,796 ft (4,205 m).

Classified as semi-arid, barren alpine-desert tundra (Mueller-Dombois and Krajina 1968; McCoy 1977; McCoy and Gould 1977; Ziegler 2002), and dotted with lonely lava outcrops and boulders, the upper slopes and summit area are sparse, rough landscapes dominated by exposed rock with little soil cover or vegetation. A combination of coarse gravel to cobble-sized pieces of cinder and lava covers the ground surface of most of the summit area. Lava flow outcrops are scattered throughout the Science Reserve, poking out from layers of cinder, till, and a slowly increasing coating of finer particles as one descends the mountain. Many of these outcrop formations are the result of lava erupting under the icecaps of the glacial periods.

The summit area, which includes elevations from approximately 12,800 ft (3,900 m) to the tops of the highest cinder cone, encompasses a large, nearly flat plateau of remnant lava flows that were subsequently sculpted by glaciers. Cinder cones of various sizes jut up above the upper reaches of the mountain and dominate the summit landscape (Wolfe et al. 1997). Cinder cones typically have steep slopes, averaging approximately 25–27 degrees along both their outer and inner faces (Porter 1972). The largest cone, Pu‘u Makanaka has a basal diameter greater than 4,000 ft (1,219 m) and is more than 600 ft (183 m) high (Macdonald et al. 1983); however, most of the cones are between 656–1,969 ft (200–600 m) wide and 98–328 ft high (30–100 m) (Porter 1972). Cinder is the dominant component of the cinder cones forming the summit, including the outer slopes (Porter 1972; Wood 1980; Wolfe et al. 1997). Areas that were capped by lava flows at the summit plateau are relatively flat and dark grey to black in color, with a low albedo (surface reflectivity). Exposed outcrops of moraine and till from glacial icecaps are composed of poorly sorted cobbles, rocks, and boulders (Wolfe et al. 1997). Rills and small gullies incising the flanks of Pu‘u Poli‘ahu, Pu‘u Waiau, and other cones indicate a naturally altered layer that is less porous and more prone to erosion than cones that do not contain less-porous layers of ash or other material (Wolfe et al. 1997).

The cool, dry climate, a general lack of vegetation, and the high elevation topography limit soil formation in the summit region of Mauna Kea. The Department of Agriculture Natural Resources Conservation Service (NRCS), which houses the national soil survey, does not list any soils at the summit of Mauna Kea (Sato et al. 1973).¹³ However, formations that may be considered soils, that have soil-like properties, or both, have been found within the summit region. Deposits of volcanic lavas, ash, glacial till, and other materials have been weathered in-situ, making them soil-like.

¹³ See also: <http://www.hi.nrcs.usda.gov/soils.html>

5.11.2 Hale Pōhaku

The approximately 19-acre Hale Pōhaku parcel, located at 9,200 ft (2,804 m) is situated at the base of Mauna Kea's upper slopes. There are three pu'u in the vicinity of Hale Pōhaku: Pu'u Kilohana, Pu'u Hawaihine and Pu'u Kalepeomoa. The slopes of cinder cones near Hale Pōhaku contain larger fragments than those on the summit and are dusted with fine-grained aeolian particulates. The ground surface of the lower-elevation Hale Pōhaku facilities area is covered with small cinder and lava rock particles that have accumulated to several centimeters deep in some locations.

5.11.3 Unique Geologic Features

Five types of geomorphic processes created the unique geologic features we see today on Mauna Kea: volcanic, glacial, fluvial, aeolian, and meteorological, with the most significant being volcanism, glaciations—and the interaction of the two, some 10,000 years ago. These processes resulted in a landscape whose surface textures range from relatively smooth and free of large particles, to areas of broken lavas composed of a'ā chunks and other large rock material, to cinder cones with uniform surface particle size and relief.

5.11.3.1 Cinder Cones

Mauna Kea contains more than 300 large cinder cones (Porter 1972). Wolfe and others (1997) mapped 23 cinder cones within the area of the Science Reserve, including four within the Mauna Kea Ice Age NAR boundaries; Porter (1979b) shows 25. Cinder features most commonly formed during both the basaltic Hāmākua and the younger alkali Laupāhoehoe post-shield eruptions (Macdonald et al. 1983; Juvik and Juvik 1998). In many instances, extremely thick, sodium-rich flows of 'a'ā (Macdonald et al. 1983; Wolfe and Morris 1996) erupted from cinder cones, often emerging through lower portions of the cone (Porter 1972). Lava dikes that did not reach the surface would form part of the cone's inner structure (Macdonald et al. 1983). Subsurface investigations during construction in Pu'u Hau'oki revealed deposits of cinder at least 130 feet (40m) below the surface (University of Hawai'i Institute for Astronomy 2002). This gives the impression that for at least some cones, a large portion of the volume may be composed of only light-weight pyroclastic material and not lava flows.

5.11.3.2 Hawaiiite Outcrops

Hundreds of outcroppings of hawaiiite, the highly prized tool-making material of the Mauna Kea adze quarries were formed approximately 70,000 to 150,000 years ago as a result of the interaction of glacial ice and hot lava (Porter 1979a; Sherrod et al. 2007). The outcrops lie between elevations of 8,600 and 11,130 ft (2,622 and 3,393 m) (McCoy 1977; Bayman and Nakamura 2001). They are not continuous, and not all outcroppings are of similar adze-making quality (Bayman and Nakamura 2001).

5.11.3.3 Till and Moraines¹⁴

Glaciers slowly eroded large amounts of lava and tephra material from their upper reaches on Mauna Kea and transported this material down slope. Most of this eroded debris (till) is deposited at the bases of the glaciers as an uneven ridge called a terminal moraine. Moraines stretch over acres of land around the summit and mark the extent of glacier advance (Wentworth 1935; Wolfe et al. 1997; Porter 2005). Till blankets much of Mauna Kea's summit above 11,000 ft (3,353 m), while some terminal moraines are found as low as 9,842 ft (3,000 m) (Porter 1979a) and are as thick as 130 ft (40 m) (Wolfe et al. 1997).

5.11.3.4 Glacially Polished Rock Surfaces

Glacially polished lava outcrops are found throughout the Science Reserve and Mauna Kea Ice Age NAR. Marks on rock outcrops, such as ground-in striations and "chatter marks" (fine-scaled curved cracks), as well as smooth-polished rock, tell of the immense weight and force of the ice sheets as they moved across the summit plateau.

Lava and ice contact zones: Interactions of lava and glacial ice have been documented at several summit locations within the Science Reserve and in the Mauna Kea Ice Age NAR (Porter et al. 1977; Wolfe et al. 1997). Some of these events produced fine-grained flow margins at the lava-ice interface and the fine-grained adze material found within the Mauna Kea Adze Quarry (Bayman and Nakamura 2001; Bayman 2004). The large pillow lavas, gas spiracles, and hyaloclastic deposits (quenched glass) also created by these sub-glacial eruptive events are normally found in submarine environments (Lockwood 2000).

5.11.3.5 Sorted Stones

Found on the inner rim of Pu'u Waiau and on the southwestern slopes of Pu'u Poli'ahu, particulates of ash and pebble-sized materials are neatly sorted into parallel lines by freeze and thaw events that capture and then release the particles. The lines follow the in-situ slope (Lockwood 2000).

5.11.3.6 Permafrost

Permafrost has been documented in two locations at the summit of Mauna Kea. The largest patch is approximately 98 ft (30 m) wide and 33 ft (10 m) thick and has inundated a matrix of boulders, cinder, and ash found at the base of the south slope of the Pu'u Wēkiu crater (Woodcock et al. 1970). The second patch is found on the southeast rim of Pu'u Hau Kea (Woodcock et al. 1970). Despite the fact that the ambient air temperature is often far above freezing, it is believed that the permafrost forms due to a combination of very high evaporation rates, low angle of sunlight, and the presence of cool air trapped at the bottom of the cinder cone, directly above the ground cover at these locations (Woodcock 1974).

¹⁴ *Moraine* is any deposit, consolidated or unconsolidated displaced by a glacier, that is deposited within a fairly discrete area usually parallel (lateral) to the direction of or at the end (terminal) of the glaciers movement. *Till* is any deposit, transported in the glacier and deposited along broad areas either adjacent to, but predominantly at the toe of the glacier.

5.11.3.7 Nieve Penitentes

Not a common occurrence, nieve penitentes (also called sunspikes or suncups) often several feet high have been spotted for brief periods at Mauna Kea (Wentworth 1940; Cooper 2008). These jagged pinnacles of snow form through a combination of meteorological conditions favoring differential melting and evaporation.

5.12 HAZARDOUS MATERIALS, SOLID WASTES AND WASTEWATER

This section describes the hazardous materials used within UH Management Areas and the waste products generated.

5.12.1 Hazardous Materials and Fuels

Hazardous materials are used at Hale Pōhaku and at the summit observatories for a variety of maintenance and cleaning operations. Fuels are also stored for use in motor vehicles and emergency generators.

Table 5-4 identifies the hazardous materials used and stored within UH Management Areas, together with the quantities of those materials normally stored or used. Use of some of these materials results in the generation of small quantities of wastes. All hazardous wastes generated on UH Management Areas are placed in containers and removed from the mountain by licensed transport, treatment and disposal contractors. No hazardous wastes are disposed of within UH Management Areas.

Hale Pōhaku has three underground storage tanks: one housing 11,500 gal (43532 l) of diesel and two housing 2,000 gal (7570 liters) and 4,000 gal (15,140 liters) of gasoline. Tanks are located underground in front of the maintenance utilities shop and are believed to be approximately 25 years old. Due to the lack of secondary containment, in 1997 the tanks were retrofitted with a 24-hour a day sensor monitoring system that is checked daily (Nahakuelua 2008). No releases have been reported from any of these USTs (DOH, 2009).

5.12.2 Solid Wastes

Trash is generated and collected at summit observatories and Hale Pōhaku facilities. All trash containers are required to be covered and secured to prevent providing a food source for invasive fauna and to reduce the possibility of escaping debris, which can occur during periods of high winds that occur regularly. The observatories are responsible for removing their trash from the summit. Trash from Hale Pōhaku and the dormitories is taken off the mountain daily by the MKSS housekeeping staff and brought to the main Hilo office where it is removed by sub-contractors (Wilson 2008).

Table 5-4. Hazardous Materials Used and Stored on UH Management Areas

Observatory	UH (0.6-m) (24-in) and 2.2-m (88-in))	Hale Pōhaku Mid-Elevation Support Facilities	SMA	Subaru Telescope	Gemini North	W.M. Keck	VLBA	JCMT	CSO	UKIRT	NASA IRTF	CFHT
Hydraulic Fluid	400 gal (1,500 l) in use, 150 gal (570 l) in storage; replaced every 5 years	Normally has less than 55 gal (208 l) on hand; recycle 760 l (200 gal) yearly	100 gal (380 l) in use, 40 gal (150 l) in storage	690 gal (2,600 l) reservoir, 55 gal (208 l) in storage	400 gal (1,500 l) in use; replaced as needed every several years	1,200 gal (4,500 l) in use, 55 gal use, (208 l) in storage	28 gal (106 l) in use, 20 gal (76 l) in storage; replaced yearly	Less than 30 gal (114 l) in use in both UKIRT and JCMT; less than 5 gal (19 l) in storage	100 gal (380 l) in use, 5 gal (19 l) in storage; added to equipment as needed	Less than 30 gal (114 l) in use in both UKIRT and JCMT; less than 5 gal (19 l) in storage	90 gal (340 l) in use, 5 gal (19 l) in storage; replaced as needed	300 gal (1,135 l) in use, 600 gal (2,100 l) in storage; systems replenished once in past 10 years
Paint and Related Solvents	About 38 10 gal (38 l) on site, mostly spray cans; several used per month as needed	Solvent, 50 gal (190 l) mostly in parts washer; recycled.	Paint and primer 12 gal (45 l) in use and storage; mineral spirits 2 g (7.6 l) in use and storage	None on site.	About 20 gal (76 l) in storage; thinner, several liters in storage; used maybe once per week.	Various amounts on site; used as needed	Acrylic roof coating 5 gal (19 l), spot repairs, once per year.	Less than 5 gal (19 l) onsite	Paint, 22 gal (83 l) on site for cosmetic touch up; thinner, 2 gal (7.6 l) on site	Less than 5 gal (19 l) onsite	50 gal (189 l) on site; used on monthly, basis depending on job requirements	10 gal (38 l) paint on site, used for occasional touch up
Oil and Lubricant	Lube, 20 to 30 gal (76 to 114 l)	Oil, less than 100 gal (380 l) in storage	Engine oil, 9 gal (34 l) in use, 10 gal (38 l) in storage; lubricant 10 lb (4.5 kg) in use, 10 lb (4.5 kg) in storage	Lubricant for periodic service of backup generator, none stored onsite	Grease, about 50 lb (23 kg), and oils about 100 gal (380 l) in storage	Oil, 1,000 gal (3,800 l) in use, 100 gal (380 l) in storage	Gear lube 5 gal (19 l) grease, 15 gal (57 l), and motor oil 2 gal (7.6 l)	Between UKIRT and JCMT, about 20 gal (76 l) stored on site	Grease, about 50 lb (23 kg) and lubricants, 12 gal (45 l) stored on site	Between UKIRT and JCMT, about 20 gal (76 l) stored on site	30 gal (114 l) stored on site.	Oil and lube, 25 gal (95 l) in storage
Mercury	Primary mirror support for 2.2-m (7.2-ft) only, 30 lb (13.6 kg) in use, 20 lb (9.1 kg) in storage	No mercury used	No mercury used	No mercury used	No mercury used, other than a few thermometers	1.4-m (4.6-ft) secondary mirror support; 13 lb (5.9 kg) in use, 17 lb (7.7 kg) in storage	No mercury used	No mercury used	No mercury used	No mercury used	About 112 lb (51 kg) in support tube for primary mirror, none held in reserve	Mercury used in radial support tube for secondary mirror: 17 lb (7.7 kg) in use, 21 lb (9.5 kg) in reserve

Source: NASA 2005

5.12.2 Wastewater

Each observatory owns an individual wastewater system (e.g., septic tank, cesspool) that has been permitted by the Hawai'i State Department of Health (DOH)(see Table 5-5). Since initial construction, many of the summit facility cesspools have been upgraded to a septic tank with associated leach field or seepage pit.

Table 5-5. Wastewater Treatment and Disposal Systems at MKSR Facilities

Observatory	Average Wastewater Flow Rate (gpd)	Treatment and Disposal System
UH 0.6-m (24-in) & 2.2-m (88-in)	115	2,500-gal (5-kl) septic tank and leach field
CFHT	295	Septic tank and leach field
NASA IRTF	50	1,450-gal (5-kl), two-compartment septic tank and leach field (90 linear ft (27 m))
UKIRT	111	1,130-gal (4-kl), two-compartment septic tank and leach field (75 linear ft (23 m))
CSO	65	7-ft (2-m) diameter, 10-ft (3-m) deep cesspool
JCMT	109	8-ft (2-m) diameter, 13-ft (4-m) deep cesspool
VLBA	31	7-ft (2-m) square-shaped, 10-ft (3-m) deep cesspool
W.M. Keck I & II	399	1,000-gal (4-kl) septic tank and 12-ft (4-m) deep seepage pit
Gemini	122	1,000-gal (4-kl) septic tank and 10-ft (3-m) deep seepage pit
Subaru Telescope	360	1,250-gal (5-kl) septic tank and two seepage pits
SMA	118	1,000-gal (4-kl) septic tank and leach field (265 linear ft (81 m))

Source: NASA 2005

Hale Pōhaku has eight cesspools and six septic systems (see Table 5-6). The systems at the old construction camp and utilities buildings have not been upgraded and still use the original cesspools for wastewater disposal. At Hale Pōhaku's main common building, dormitories B, C, and the VIS, the wastewater systems have been upgraded to septic tanks that use the old cesspools instead of leach fields to capture effluent discharges. Dormitory D was constructed with a septic system and no modifications have been made. A septic tank with a leach field is used at the new construction camp.

Restroom facilities at the summit available for visitor use include four portable toilets and the restrooms located in the Keck Observatory. The portable toilets are located at two different parking areas and can be moved between the sites depending upon need. Portable toilets are serviced weekly and pumping is done on-site.

Table 5-6. Wastewater Treatment and Disposal Systems at Hale Pōhaku Facilities

Location	Septic Tank Volume (gal)	Septic Tank Pumping Schedule	Number of Cesspools	Cesspool Use	Current Flow (gpd)	Design Use (gpd)
Main Common Building	2,500	Every 3 months	2	Overflow leach fields	1,200	1,500
VIS	2,000	Every 3 months	1	Overflow leach field	1,200	1,250
Dormitory A (cook staff only)	None	None	1	Primary waste	100	500
Dormitory B	1,500	Every 9 months	1	Overflow leach field	750	1,600
Dormitory C	1,250	Every 12 months	1	Overflow leach field	600	1,000
Dormitory D	1,250	Every 12 months	0	N/A	400	1,000
NEW Construction Camp	2,000	Every 1.5 years (due to low usage); has only been pumped once	0	N/A	150	1,600
OLD Construction Camp	None	None	1	Primary waste	0	1,000
Utilities	None	None	1	Primary waste	100	500

Five observatories (Keck, CFHT, Gemini, Subaru, and UH 2.2m) have their own facilities to conduct mirror washing activities (stripping aluminum from the reflecting surface of the mirror) at the summit. The other observatories bring their mirrors to one of those five for washing and recoating activities (McNarie 2004). All mirror washing effluent is collected and trucked off the mountain for off-site treatment and disposal (McNarie 2004).

5.13 NOISE

Ambient noise levels at Mauna Kea are low, with vehicle traffic and wind providing the dominant background noise. Observatory operations create minimal noise, while construction activities create intermittent, though sometimes significant, disruptions. The primary receivers that might be disrupted by excessive noise are the human users of the mountain including scientists, cultural practitioners, and recreational users. There is also the potential that noise generated by certain activities or systems would have an impact on biological resources. The main activities that produce noise include vehicle travel, observatory operations, and construction operations (e.g., heavy equipment use, drilling, and excavation).

5.14 SOCIO-ECONOMICS

The UH Management Areas on Mauna Kea are located in the Hamakua District of Hawaii County. The Hamakua District is a relatively sparsely populated area (6,108 residents in 2000), and represented approximately 4% of the county's total population of 148,677 in 2000 DBET

2007). Less than 10,000 residents live within 25 miles of the UH Management Areas (Helber Hastert & Fee 2006). Hawai'i County is experiencing a population growth rate of approximately 2.4% per year. This growth rate is projected to decline steadily, reaching a rate of 1.2% by 2030, when the county's population is expected to be 261,030 (DBET 2007).

The nearest urban center is the town of Hilo, located approximately 30 miles to the southeast. Hilo had a population of 40,759 in 2000 (DBET 2007).

In 2000, the average Hawai'i County household consisted of 2.75 persons. Approximately 23% of the county's population is under 18 years of age, 64% is between 18 and 64 years of age, and 13% is over 64 years of age (DBET 2007).

Hawai'i County had an estimated labor force of 86,300 individuals in 2007, of which 3.3% were unemployed. Annual wages in the county averaged \$33,960 in 2006. It was estimated that 13.5% of the county's population were below the poverty level in 2005 (DBET 2007).

Activities occurring in the UH Management Areas that generate revenues within the county are limited primarily to astronomy and tourism. A 2005 survey found that observatory operations on Mauna Kea employed 610 personnel in the following job classifications (John M. Knox & Associates 2007):

- Scientific Researchers 160 (26%)
- Technicians 302 (50%)
- Administrative Personnel 116 (19%)
- Maintenance Personnel 32 (5%)

The technical and scientific personnel (76% of the employees) are the most highly paid, with salaries ranging from \$50,000 to \$150,000 (NASA 2005). Direct wages generated by observatory operations are estimated to represent approximately 1.3% of the total wages earned in Hawai'i County.

The total economic activity (direct, indirect and induced) resulting from observatory operations on Mauna Kea has been estimated to be \$130.9 million annually in Hawai'i County and \$141.7 million statewide (Helber Hastert & Fee 2006).

6 ENVIRONMENTAL IMPACTS

6.1 INTRODUCTION

This section evaluates the anticipated effects of the Proposed Action and of the No Action Alternative. Prepared in accordance with HRS § 343 and HAR § 11-200-10, it considers short-term, long-term, direct, indirect, and cumulative impacts. Short-term impacts are effects that occur as and/or immediately after an action is taken and can be anticipated to disappear within a given period of time after the action occurs. Long-term impacts are those that persist so long as the measures recommended in the CMP remain in place. The terms “impacts” and “effects” are synonymous, as are the terms “secondary” and “indirect.” Indirect effects are those effects caused by the action that occur later in time or occur outside of the UH Management Areas, or both. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

In presenting the findings of the assessment process in this DEA, the statement “no environmental impacts are anticipated” is used. In the context of this DEA, the statement should be interpreted as meaning that the action described has been evaluated with regards to potential direct short-term impacts, direct long-term impacts, indirect short-term impacts, and indirect long-term impacts, and is anticipated not to result in any of these impact types.

Section 6.2 of this DEA assesses those Management Actions that can be reasonably anticipated to have no potential for adverse environmental impact. The Management Actions that do not meet these criteria are identified and evaluated in Sections 6.3 through 6.15. Cumulative impacts are addressed in Section 6.16.

6.2 ACTIONS WITHOUT A POTENTIAL TO SIGNIFICANTLY AFFECT THE ENVIRONMENT

The 103 separate Management Actions included in the CMP fall into two groups encompassing eight broad categories. Because they do not require any commitment of environmental resources, Management Actions in the first group, consisting of 88 Management Actions, does not present any potential for significant direct or indirect adverse impacts on environmental resources. They are Management Actions that: (1) call for future planning or studies; (2) recommend communication programs; and (3) describe management processes and goals to be adopted by UH. The second group, consisting of 15 Management Actions is comprised of five categories of actions that do have some potential for environmental effect. They include recommendations that pertain to: (4) managing cultural practices, (5) controlling access, (6) erecting signage, (7) hiring staff, and (8) pursuing legislative action. The potential environmental effects of actions in each of these eight categories are discussed below.

6.2.1 Planning and Studies

A total of 35 of the CMP Management Actions recommend some type of plan development or study. Table 6-1 identifies the actions that fall into this category.

Table 6-1. CMP Management Actions: Planning and Studies

CMP Location	Management Action	Category
7.1.1 Culture and History		
CR-1	Kahu Kū Mauna shall work with families with lineal and historical connections to Mauna Kea, cultural practitioners, and other Native Hawaiian groups, including the Mauna Kea Management Board’s Hawaiian Culture Committee, toward the development of appropriate procedures and protocols regarding cultural issues.	Planning
CR-2	Support application for designation of the summit region of Mauna Kea as a Traditional Cultural Property, per the National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq. in consultation with the larger community.	Planning
CR-4	Establish a process for ongoing collection of information on traditional, contemporary, and customary cultural practices	Study
CR-10	Develop and implement a historic property monitoring program to systematically monitor the condition of the historic district and all historic properties, including cultural sites and burials	Planning
CR-11	Complete archaeological survey of the portions of the Summit Access Road corridor under UH management	Study
CR-12	Consult with Kahu Kū Mauna about establishing buffers (preservation zones) around known historic sites in the Astronomy Precinct, to protect them from potential future development	Planning
CR-13	Develop and implement a burial treatment plan for the UH Management Areas in consultation with Kahu Kū Mauna Council, MKMB’s Hawaiian Culture Committee, the Hawai’i Island Burial Council, recognized lineal or cultural descendants, and SHPD	Planning
7.1.2 Natural Resources		
NR-2	Limit damage caused by invasive species through creation of an invasive species prevention and control program	Planning
NR-3	Maintain native plant and animal populations and biological diversity	Planning
NR-7	Delineate areas of high native diversity, unique communities, or unique geological features and consider protection from development	Planning
NR-8	Consider fencing areas of high native biodiversity or populations of endangered species to keep out feral ungulates (applies to areas below 12,800 ft elevation)	Planning
NR-9	Increase native plant density and diversity through an outplanting program	Planning
NR-10	Incorporate mitigation plans into project planning and conduct mitigation following new development	Planning
NR-11	Conduct habitat rehabilitation projects following unplanned disturbances	Planning
NR-12	Create restoration plans and conduct habitat restoration activities, as needed	Planning
NR-15	Conduct baseline inventories of high-priority resources, as outlined in an inventory, monitoring, and research plan	Study
NR-16	Conduct regular long-term monitoring, as outlined in an inventory, monitoring, and research plan	Study
NR-17	Conduct research to fill knowledge gaps that cannot be addressed through inventory and monitoring.	Study
7.1.3 Education and Outreach		
EO-5	Develop interpretive features such as self-guided cultural walks and volunteer-maintained native plant gardens	Planning
7.2.1 Activities and Uses		
ACT-2	Develop parking and visitor traffic plan	Planning
ACT-5	Implement policies to reduce impacts of recreational hiking	Planning
ACT-8	Coordinate with DLNR in the development of a policy regarding hunting in the UH Management Areas	Planning
7.3.1 Infrastructure and Maintenance		
IM-4	Evaluate need for and feasibility of a vehicle wash station near Hale Pōhaku, and requiring that vehicles be cleaned	Planning

Table 6-1. CMP Management Actions: Planning and Studies

CMP Location	Management Action	Category
IM-5	Develop and implement a Debris Removal, Monitoring and Prevention Plan	Planning
IM-6	Develop and implement an erosion inventory and assessment plan	Planning
IM-7	Prepare a plan, in collaboration with the Department of Defense, to remove military wreckage from a remote area of the UH Management Areas, while ensuring protection of natural and cultural resources	Planning
IM-8	Assess feasibility of paving the Summit Access Road	Planning
IM-9	Evaluate need for additional parking lots and vehicle pullouts and install if necessary	Planning
IM-10	Evaluate need for additional public restroom facilities in the summit region and at Hale Pōhaku, and install close-contained zero waste systems if necessary	Planning
IM-13	Conduct feasibility assessment, in consultation with Hawaii Electric Light Company, on developing locally-based alternative energy sources	Planning
7.3.4 Considering Future Land Use		
FLU-2	Develop a map with land-use zones in the Astronomy Precinct based on updated inventories of cultural and natural resources, to delineate areas where future land use will not be allowed and areas where future land use will be allowed but will require compliance with prerequisite studies or analysis prior to approval of Conservation District Use Permit	Planning
FLU-7	Require use of close-contained zero-discharge waste systems for any future development in the summit region, from portable toilets to observatory restrooms, if feasible	Planning
7.4.1 Operations and Implementation		
OI-5	Update and implement emergency response plan.	Planning
7.4.2 Monitoring Evaluation and Updates		
MEU-2	Conduct regular updates of the CMP that reflect outcomes of the evaluation process, and that incorporate new information about resources	Planning
MEU-3	Revise and update planning documents, including the master plan, leases, and subleases, so that they will clearly assign roles and responsibilities for managing Mauna Kea and reflect stewardship matters resolved with DLNR	Planning

Each of these actions involves the study and evaluation of information, but does not propose any action that requires the use or commitment of natural or cultural resources within UH Management Areas. As such, these actions do not have a potential adverse environmental impact, either individually or collectively.

The future actions that may result from the planning and study efforts listed in Table 6-1 cannot be identified at this time. Should any of the plans and study efforts recommend subsequent actions not already approved under existing permits applicable to UH Management Areas. Appropriate permits will be sought and environmental review may be required.

As an example, the recommendation to evaluate a vehicle wash stations (IM-4) does not have any anticipated impacts to cultural and natural resources. Implementing the Management Action would involve tasks such as estimating costs, evaluating possible locations for the wash station and assessing the benefits and potential effects of constructing the wash station. The end result of such a planning study would be a recommendation to proceed or not proceed, possibly accompanied by a budget, schedule and implementation requirements. At that point, before constructing a vehicle wash station, UH would obtain any necessary permits or approvals from BLNR/DLNR, and would comply with any applicable requirements in Chapter 343.

The preceding example illustrates the distinction between the planning and study Management Actions contained in the CMP and the possible outcomes if recommendations contained in those plans and studies are implemented. Approval and implementation of the CMP will not constitute approval of later actions that may be proposed in response to recommendations resulting from the planning or study efforts contained in the CMP; it will only approve conducting the studies. Any specific actions identified at a later date for implementation will be evaluated separately under the Chapter 343 environmental assessment process, if applicable.

6.2.2 Communications

Eight of the CMP Management Actions recommend increased communication between UH and its employees, the public, observatory staff, regulatory agencies, surrounding landowners and other stakeholders. The recommended communications involve developing internal UH programs that facilitate the exchange of information with these groups. Table 6-2 identifies the Management Actions that fall into this category.

Table 6-2. CMP Management Actions: Communications-Related

CMP Location	Management Action	Type of Recommendation
7.1.1 Culture and History		
CR-3	Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape	Communications
7.1.3 Education and Outreach		
EO-1	Develop and implement education and outreach program.	Communications
EO-3	Continue to develop, update, and distribute educational materials	Communications
EO-6	Engage in outreach and partnerships with schools	Communications
EO-7	Increase opportunities for community members to provide input to cultural and natural resources management activities	Communications
7.2.2 Permitting and Enforcement		
P-4	Educate management staff and users of the mountain about all applicable rules and permit requirements	Communications
7.4.1 Operations and Implementation		
OI-3	Maintain and expand regular interaction and dialogue with stakeholders to provide a coordinated approach to resource management	Communications
7.4.2 Monitoring Evaluation and Updates		
MEU-1	Establish a reporting system to ensure that the MKMB, DLNR, and the public are informed of results of management activities in a timely manner.	Communications

None of the recommended communications actions have the potential to result in adverse impacts on environmental resources. Several of the measures, if successful, are anticipated to have positive impacts on environmental awareness and/or environmental protection by educating and engaging users in natural and cultural resource protection efforts.

Most of the communications recommendations involve creating formal, interactive programs to promote outreach and dialog, such as partnerships with schools or staff training. Others rely on static processes, such as having informational brochures available to visitors. All of the Management Actions establish goals for the various communications efforts but do not specify the exact manner in which the communications will actually occur.

A typical communications Management Action will require researching the specific subject matter to be conveyed, identifying suitable methods for transferring essential information, and developing the selected communications tools. The CMP recommends communications methods that embrace a variety of media, including printed literature, audio recordings, video recording, web-based information and personal communications. None of the communications methods that are anticipated to be used require the use or commitment of significant environmental resources in the UH Management Areas or elsewhere. With the community advisory system that is/will be in place, the communications that are disseminated through this process are likely to reflect broad community values and be supportive of the plan's objectives.

The majority of the communications Management Actions are intended to convey information to potential visitors and users concerning the importance of Mauna Kea's natural and cultural resources and ways to protect and preserve those resources. Successful implementation of those communications programs will have a positive impact on environmental resources by helping visitors avoid unintentional damage during activities such as hiking and snow play.

6.2.3 Management Processes and Goals

The CMP Management Actions include 45 recommendations that describe processes that will be adopted to incorporate environmental stewardship into management of UH management areas. An additional four recommendations identify goals or standards to be used in decision-making processes. Table 6-3 lists the Management Actions in this category.

Table 6-3. CMP Management Actions: Management Processes and Goals

CMP Location	Management Action	Type of Recommendation
7.1.1 Culture and History		
CR-14	Immediately report any disturbance of a shrine or burial site to the rangers, DOCARE, Kahu Kū Mauna Council, and SHPD.	Management Process
7.1.2 Natural Resources		
NR-1	Limit threats to natural resources through management of permitted activities and uses	Management Process
NR-4	Minimize barriers to species migration, to help maintain populations and protect ecosystem processes and development	Goals
NR-5	Manage ecosystems to allow for response to climate change	Goals
NR-6	Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea's unique natural resources	Management Process
NR-13	Increase communication, networking, and collaborative opportunities, to support management and protection of natural resources	Management Process
NR-14	Use the principles of adaptive management when developing programs and methodologies. Review programs annually and revise any component plans every five years, based on the results of the program review.	Management Process
NR-18	Develop geo-spatial database of all known natural resources and their locations in the UH Management Areas that can serve as baseline documentation against change and provide information essential for decision-making.	Management Process
7.1.3 Education and Outreach		
EO-8	Provide opportunities for community members to participate in stewardship activities	Management Process

Table 6-3. CMP Management Actions: Management Processes and Goals

CMP Location	Management Action	Type of Recommendation
7.1.4 Astronomical Resources		
AR-1	Operate the UH Management Areas to prohibit activities resulting in negative impacts to astronomical resources	Goals
AR-2	Prevent light pollution, radio frequency interference and dust	Goals
7.2.1 Activities and Uses		
ACT-9	Maintain commercial tour permitting process; evaluate and update permits annually	Management Process
ACT-10	Ensure OMKM input on permits for filming activities	Management Process
ACT-12	Ensure input by OMKM, MKMB, and Kahu Kū Mauna on all scientific research permits and establish system of reporting results of research to OMKM	Management Process
7.2.2 Permitting and Enforcement		
P-1	Comply with all applicable federal, state, and local laws, regulations, and permit conditions related to activities in the UH Management Areas	Management Process
P-2	Strengthen CMP implementation by recommending to the BLNR that the CMP conditions be included in any Conservation District Use Permit or other permit	Management Process
P-5	Continue coordinating with other agencies on enforcement needs	Management Process
P-7	Develop and implement protocol for oversight and compliance with Conservation District Use Permits	Management Process
P-8	Enforce conditions contained in commercial and Special Use permits	Management Process
7.3.1 Infrastructure and Maintenance		
IM-1	Develop and implement an Operations Monitoring and Maintenance Plan	Management Process
IM-2	Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	Management Process
IM-3	Conduct historic preservation review for maintenance activities with potential adverse effect on historic properties	Management Process
IM-11	Encourage existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations	Management Process
IM-12	Conduct energy audits to identify energy use and system inefficiencies, and develop solutions to reduce energy usage	Management Process
IM-14	Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations	Management Process
7.3.2 Construction Guidelines		
C-1	Require an independent construction monitor who has oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements	Management Process
C-2	Require use of Best Management Practices Plan for Construction Practices.	Management Process
C-3	Develop, prior to construction, a rock movement plan	Management Process
C-4	Require contractors to provide information from construction activities to OMKM for input into OMKM information databases	Management Process
C-5	Require on-site monitors (e.g., archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agency	Management Process
C-6	Conduct required archaeological monitoring during construction projects per SHPD approved plan	Management Process
C-7	Education regarding historical and cultural significance	Management Process
C-8	Education regarding environment, ecology and natural resources	Management Process
C-9	Inspection of construction materials	Management Process
7.3.3 Site Recycling, Decommissioning, Demolition and Restoration		
SR-1	Require observatories to develop plans to recycle or demolish facilities once their useful life has ended, in accordance with their sublease requirements, identifying all proposed actions	Management Process

Table 6-3. CMP Management Actions: Management Processes and Goals

CMP Location	Management Action	Type of Recommendation
SR-2	Require observatories to develop a restoration plan in association with decommissioning, to include an environmental cost-benefit analysis and a cultural assessment	Management Process
SR-3	Require any future observatories to consider site restoration during project planning and include provisions in subleases for funding of full restoration	Management Process
7.3.4 Considering Future Land Use		
FLU-1	Follow design guidelines presented in the 2000 Master Plan	Management Process
FLU-3	Require cataloguing of initial site conditions for use when conducting site restoration	Management Process
FLU-4	Require project specific visual rendering of both pre- and post-project settings to facilitate analysis of potential impacts to view planes	Management Process
FLU-5	Require an airflow analysis on the design of proposed structures to assess potential impacts to aeolian ecosystems.	Management Process
FLU-6	Incorporate habitat mitigation plans into project planning process	Management Process
7.4.1 Operations and Implementation		
OI-1	Maintain OMKM, MKMB, and Kahu Kū Mauna in current roles, with OMKM providing local management of the UH Management Areas, and MKSS providing operational and maintenance services.	Management Process
OI-2	Develop training plan for staff and volunteers.	Management Process
OI-4	Establish grievance procedures for OMKM, to address issues as they arise.	Management Process

Management goals and processes identify a set of standards or methods to be applied in dealing with situations expected to be encountered on a routine basis. None of the Management Actions in Table 6-3 commit to actions that would adversely affect cultural and natural resources. Instead, they establish protocols designed to minimize impacts, either through proactive measures or through the application of resource-protective strategies.

The five Management Actions in Table 6-3 related to future development projects (FLU-1 and FLU-3 through FLU-6) provide typical examples of CMP management processes. They provide processes to mitigate possible environmental impacts when considering future land use changes. FLU-1 refers a project reviewer to design standards contained in the 2000 Master Plan to ensure that renovations and new construction blend into the landscape and surrounding features. FLU-3 through FLU-6 identify specific processes that should be required of the applicant to help mitigate potential natural resource impacts. These Management Actions serve to formalize and strengthen the process for incorporating resource protection measures into management processes. They do not constitute approval or commitment to any new action. Rather, they require that any development project that is approved incorporate specific natural resource protection measures that exceed typical regulatory and permit requirements.

The CMP management processes and goals in Table 6-3 adopt and formalize many of the methods that will be applied by agencies discharging their management responsibilities. Some of the Management Actions adopt current roles and responsibilities, while others add new requirements. For example, Management Actions ACT-9 and ACT-10 adopt and maintain current policies regarding commercial tours and filming. In addition, they add new requirements for periodic review of those policies.

In addition to the specific Management Actions in the CMP, UH is adopting several of the controls contained in the existing 1995 Management Plan. The controls being adopted from the 1995 Management Plan that are management processes with no potential environmental impacts are:

- Establishing hours of operation
- Establishing authority to require a Waiver of Liability from visitors
- Requiring compliance with historic preservation laws
- Authorizing UH to manage aspects of observatory tours.

Taken collectively, the Management Recommendations in Table 6-3 and the management processes adopted from the 1995 Management Plan reflect an increased commitment to improved environmental stewardship on Mauna Kea, while protecting visitor safety. There are no anticipated adverse impacts to cultural or natural resources associated with implementation of these management goals and processes.

6.2.4 Recommended Management Actions With Some Potential to Affect the Environment

Table 6-4 identifies the remaining 15 Management Actions contained in the CMP for which some potential for environmental effect exists.

Table 6-4. CMP Management Actions Evaluated Individually

CMP Location	Management Action	Type of Recommendation
7.1.1 Culture and History		
CR-5	Develop and adopt guidelines for the culturally appropriate placement and removal of offerings	Cultural Practices
CR-6	Develop and adopt guidelines for the visitation and use of ancient shrines	Cultural Practices
CR-7	Kahu Kū Mauna shall take the lead in determining the appropriateness of constructing new Hawaiian cultural features	Cultural Practices
CR-8	Develop and adopt a management policy for the UH Management Areas on the scattering of cremated human remains	Cultural Practices
CR-9	Develop a management policy for the cultural appropriateness of building ahu or “stacking of rocks” will need to be developed by Kahu Kū Mauna who may consider similar policies adopted by Hawai’i Volcanoes National Park	Cultural Practices
7.1.3 Education and Outreach		
EO-2	Require orientation of users, with periodic updates and a certificate of completion, including but not limited to visitors, employees, observatory staff, contractors, and commercial and recreational users	Access Control
EO-4	Develop and implement a signage plan to improve signage throughout the UH Management Areas (interpretive, safety, rules and regulations)	Signage
7.2.1 Activities and Uses		
ACT-1	Continue and update managed access policy of 1995 Management Plan	Access
ACT-3	Maintain a presence of interpretive and enforcement personnel on the mountain at all times to educate users, deter violations, and encourage adherence to restrictions	Staffing
ACT-4	Develop and enforce a policy that maintains current prohibitions on off-road vehicle use in the UH Management Areas and that strengthens measures to prevent or deter vehicles from leaving established roads and designated parking areas	Access Control
ACT-6	Define and maintain areas where snow-related activities can occur and	Access Control

Table 6-4. CMP Management Actions Evaluated Individually

CMP Location	Management Action	Type of Recommendation
	confine activities to slopes that have a protective layer of snow	
ACT-7	Confine University or other sponsored tours and star-gazing activities to previously disturbed ground surfaces and established parking areas.	Access Control
ACT-11	Seek statutory authority for the University to regulate commercial activities in the UH Management Areas.	Legislative Action
7.2.2 Permitting and Enforcement		
P-3	Obtain statutory rule-making authority from the legislature, authorizing the University of Hawai'i to adopt administrative rules pursuant to Chapter 91 to implement and enforce the Management Actions	Legislative Action
P-6	Obtain legal authority for establishing, and then establish, a law enforcement presence on the mountain that can enforce rules for the UH Management Areas on Mauna Kea	Legislative Action

In addition, the following controls adopted from the existing 1995 Management Plan have some potential to produce environmental effects:

- Establishing Science Reserve access controls for visitor safety
- Prohibiting alcohol consumption
- Prohibiting outdoor fires
- Establishing commercial tour operator requirements
- Prohibiting off-road vehicle use
- Prohibiting commercial hunting tours

The remainder of Section 6 assesses the extent to which the above controls adopted from the 1995 Management Plan and those listed in Table 6-4 have the potential to affect environmental resources.

6.3 IMPACT ON LAND USE

6.3.1 Proposed Alternative's Effects on Land Use

No land use changes or impacts are anticipated under the Proposed Action. The CMP is not a land use plan and does not recommend any actions that would change or alter current land uses. Any proposed changes in currently approved land use on UH Management Areas would require DLNR consideration and approval in accordance with HAR § 13-5 requirements.

6.3.2 No Action Alternative's Effect on Land Use

No land use changes or impacts are anticipated under the No Action Alternative.

6.4 IMPACT ON CULTURAL RESOURCES

This section evaluates potential impacts on cultural resources associated with the CMP and the No Action Alternative in accordance with *Guidelines for Assessing Cultural Impacts* as adopted by the Hawai'i Environmental Council. Within each of those subsections, separate impact evaluations are provided for historic properties and for cultural practices and beliefs. The analyses are based on the information contained in Section 5.2 of this DEA.

6.4.1 Proposed Action's Effects on Cultural Resources

The Proposed Action is anticipated to have beneficial impacts on cultural practices and beliefs associated with Mauna Kea, as well as historic properties located within UH Management Areas. No adverse impacts on cultural resources are anticipated to result from the Proposed Action.

6.4.1.1 *Impacts of the Proposed Action on Historic Properties*

For reasons explained below, the Management Actions listed in Table 6-4 that relate to historic properties are anticipated to have positive effects on those resources. No adverse impacts to historic properties are anticipated to result from the Proposed Action.

Management Actions P-3 and P-6 recommend that UH obtain rulemaking and enforcement authority from the State Legislature. UH has determined that those authorities are critical to carrying out its goal of environmental stewardship, as they will allow UH to create and enforce rules needed to better-protect historic properties located on UH Management Areas. Granting UH this authority will not diminish the authority that DLNR has to oversee uses within the Conservation District; neither will it lessen BLNR's power to approve or deny proposed uses of State Land. It will, however, allow UH to be a more effective partner and decrease the probability that inappropriate uses will occur within the UH Management Areas. Management Action ACT-3 commits UH to maintaining an enforcement presence within the UH Management Areas to help ensure compliance with applicable historic property protection rules.

The rules that UH wishes to create to protect and preserve historic properties are described by Management Actions EO-2, ACT-4, ACT-6 and ACT-7. Those Management Actions involve managing certain activities that have a potential to damage or degrade historic properties and ensuring that visitors are aware of the importance of protecting those resources.

Management Action EO-2 (as well as ACT-1) would require mandatory orientation for visitors to UH Management Areas. The orientation (which would also cover natural resource issues) would provide participants descriptions of historic properties present on the mountain, the legal protection afforded those sites, the ethical responsibilities that every individual who uses the mountain assumes, and the expectations and requirements incumbent on visitors to avoid damaging resources. UH intends and expects that this orientation program will reduce damage to historic properties from hikers, staff, and other visitors who may otherwise be unaware of the historic properties that are present, their significance, and the legal protections afforded those properties.

Management Action ACT-4 continues the current prohibition on off-road vehicle use that is contained in the 1995 Management Plan. This prohibition is intended to reduce the potential for direct physical impacts on historic properties associated with off-road vehicle use.

Management Action ACT-6 would allow UH to restrict snow play to areas and conditions that do not pose a threat to historic properties, a power not expressly granted to it now. This recommendation does not identify the areas that would be affected by snow play restrictions. Currently, there are no specific restrictions on where snow play activities can occur, and it is difficult to oversee the existing limits on activities that historic preservation laws and regulations theoretically provide. Unrestricted access for sledding, skiing and similar activities creates a potential for inadvertent damage to historic properties that this action seeks to mitigate.

Management Action ACT-7 would allow UH to restrict tours and star-gazing activities to previously disturbed areas and parking areas. This restriction would reduce the potential for inadvertent damage to historic properties by members of tour groups or amateur astronomers visiting the mountain.

Collectively, the effect of the preceding Management Actions (obtaining rule-making and enforcement authority and creating and enforcing new rules protecting historic properties) would have a positive, long-term impact by allowing UH to effectively manage activities that threaten historic properties.

In addition to the Management Actions that provide specific access restrictions to be adopted by UH after obtaining rule-making authority, the CMP recommends developing and adopting guidelines for: culturally appropriate placement and removal of offerings (CR-5); the visitation and use of ancient shrines (CR-6); constructing new cultural features (CR-7); and stacking rocks or *ahu* construction (CR-9). One purpose of those guidelines would be to provide visitors and cultural practitioners with detailed, tailored guidance concerning appropriate and allowable uses near historic properties, thereby reducing the potential for damaging those features.

Management Action EO-4 calls for UH to develop and implement interpretive signage. This recommendation adopts a condition of the 1995 Management Plan. Signage would identify threatened historic properties and allowable hiking trails, as well as describing prohibited activities that could degrade historic properties. This action would have the effect of reducing the potential for inadvertent damage to historic properties.

These Management Actions (CR-5, CR-6, CR-7, CR-9 and EO-4) further strengthen the proposed historic property protection program. Individually and collectively, they are anticipated to have beneficial impacts on the long-term preservation of historic properties located in UH Management Areas, as well as surrounding areas accessed through UH Management Areas.

None of the additional controls adopted from the 1995 Management Plan would result in adverse effects on historic properties. Those controls deal with activities that do not involve historic properties. They address visitor safety and commercial tour operations.

6.4.1.2 Impacts of the Proposed Action on Cultural Practices and Beliefs

The Proposed Action will not have any adverse impacts on cultural practices or beliefs related to Mauna Kea. Rather, it is anticipated that implementing the CMP will have beneficial impacts on cultural practices. The CMP promotes developing a better understanding of Hawaiian practices and beliefs and integrating the protection of those practices and beliefs into management and decision-making processes.

Under the CMP, Kahu Kū Mauna and the MKMB Hawaiian Cultural Committee, in consultation with families with lineal and historic connections to Mauna Kea, cultural practitioners, and other Native Hawaiian organizations, will provide guidance related to issues involving Native Hawaiians. The CMP tasks those groups with developing new guidelines or protocols regarding cultural practices on UH Management Areas, including: leaving offerings (CR-5); shrine visitation and use (CR-6); constructing new cultural features (CR-7); scattering of cremation remains (CR-8); and stacking of rocks, or *ahu* construction (CR-9).

The CMP promotes cultural awareness through programs such as Hawaiian Studies, interpretive and educational literature and employee training. Such programs will have a positive impact by reducing culturally insensitive and offensive behavior by visitors and employees.

State and federal laws and the 1995 Management Plan already prohibit or restrict some traditional and customary Native Hawaiian practices from occurring on Mauna Kea. Specifically:

- Human remains may not be buried on State lands without State permission
- Historic properties cannot be damaged or altered, including the rebuilding of protected shrines or the addition of new materials to protected shrines
- Resources may not be extracted from the slopes of Mauna Kea without a Conservation District Use Permit (CDUP).

Land uses that are allowed within a Conservation District are described in HAR §13-5. Under those rules and the 1995 Management Plan, any cultural practices that involve a physical impact within UH Management Areas are prohibited.

Management Action CR-5 recommends developing guidelines for the culturally appropriate removal of offerings. This action does not restrict the cultural practice or result in an adverse effect on the practice.

Management Action CR-6 recommends that UH and Kahu Kū Mauna, in consultation with families with lineal and historic connections to Mauna Kea, cultural practitioners, and other Native Hawaiian organizations, develop guidelines for the visitation and use of ancient shrines. Guidelines for the visitation and use of ancient shrines are necessary to provide a mechanism that allows for access and use by modern cultural practitioners yet preserves their integrity and the underlying meaning they had for the ancestors that built them. Guidelines will include the provision that access not be denied or unduly restricted for any Native Hawaiian wanting to visit the shrines within the UH Management Areas. No restrictions will be placed on any observance or practice that is deemed culturally appropriate as long as the practice does not violate HRS Chapter 6E, which prohibits the alteration of historic properties. Practitioners

will be informed of the same general rules and precautions as are all public users. A program to regularly monitor the condition of ancient shrines shall be established and if effects of heavy use become apparent, measures will be considered to control access. These measures described in CR-6 will not result in an adverse effect on cultural practices.

Management Action CR-7 calls for guidelines on the construction of new cultural features. It includes development of guidelines on what is appropriate by UH in consultation with Kahu Kū Mauna and other Native Hawaiian organizations, and with families with lineal and historic connections to Mauna Kea, cultural practitioners, and other Native Hawaiian organizations. It also calls for describing the process through which individuals or organizations wishing to construct new cultural features can obtain legal authority to do so. It calls for guidelines to be adopted to assist in formulating culturally appropriate protocols (e.g., to determine which kinds of features and locations are appropriate or inappropriate, as well as if and when a regulatory review process is necessary). New construction not complying with the applicable protocols, the conditions imposed by guidance provided by Kahu Kū Mauna, MKMB, and/or the MKMB Hawaiian Cultural Committee or administrative rules, if/when adopted, will be dismantled. This Management Action does not result in an adverse effect on cultural practices. Rather, it provides a mechanism for allowing the continuation of a traditional and customary cultural practice in accordance with applicable State rules and requirements.

Management Action CR-8 recommends establishing a system for permitting the scattering of cremated human remains on UH Management Areas, and provides suggested guidelines intended to respect the traditional cultural beliefs related to Mauna Kea during such activities. CR-8 recognizes that further study is required and that Kahu Kū Mauna, in consultation with families with lineal and historic connections to Mauna Kea, cultural practitioners, and other Native Hawaiian organizations will develop a system that is culturally appropriate and can be conducted in accordance with applicable State rules and requirements. This recommended action would not have an adverse effect on this contemporary cultural practice.

Management Action CR-9 recommends developing a management policy for dealing with stacked rocks or *ahu*. CR-9 does not restrict this practice, although it does note that new rock piles will be removed in a culturally appropriate manner. Management Action CR-7 (discussed separately above) is intended to provide a mechanism for the construction of new cultural features. CR-9 would not have an adverse effect on cultural practices.

Management Action EO-2 (as well as ACT-1) would require mandatory orientation for visitors to and users of UH Management Areas. The orientation would include descriptions of the cultural practices and beliefs associated with Mauna Kea and would instruct visitors on culturally respectful behavior expected of them while visiting the mountain. In addition to the orientation program, interpretive signage may be placed on UH Management Areas regarding sacred sites and appropriate behavior (Management Action EO-4). The orientation and interpretive signage programs are anticipated to result in increased awareness of and respect for Native Hawaiian cultural practices and beliefs by hikers, staff, and other visitors. No adverse effects on cultural practices or beliefs are associated with either action.

Management Actions establishing access restrictions on off-road vehicle use (ACT-4), snow play activities (ACT-6), extreme sports (ACT-1), allowing pets out of vehicles (ACT-1) and tours and amateur astronomy (ACT-1 and ACT-7) do not affect cultural activities, as the restricted activities are not considered cultural practices.

The controls contained in the existing 1995 Management Plan that are being adopted by the CMP would not result in an adverse effect on cultural practices or beliefs. Those controls are addressed below.

Controlling Access to the Summit Area

UH will continue to be allowed to restrict access to the summit area when road construction, weather conditions, heavy traffic, or other safety issues create an undue risk. The ability to close the upper reaches of the Summit Access Road for safety and maintenance purposes does not create an adverse effect on cultural practices.

Prohibiting Alcohol Consumption

Alcohol consumption is not a cultural practice. Controlling alcohol consumption on UH Management Areas does not have an adverse effect on cultural practices.

Prohibiting Outdoor Fires

The prohibition on outdoor fires is necessary to protect natural resources and historic properties from damage and degradation. This prohibition does not adversely effect cultural practices.

Establishing Commercial Tour Operator Requirements

The controls on commercial tour operations reflect measures to protect public safety and ensure resource protection during commercial activities taking place within the UH Management Areas. These controls do not adversely affect cultural practices.

Prohibiting Commercial Hunting Tours

Commercial hunting tours are not cultural practices. Prohibiting this activity does not adversely affect cultural practices.

6.4.2 No Action Alternative's Effects on Cultural Resources

The No Action Alternative is anticipated to result in less protection for historic properties located within UH Management Areas, when compared to the Proposed Alternative. In the absence of the Management Actions contained in the CMP that aid in protecting historic properties, the No Action Alternative will permit the continued degradation of historic properties.

The continued degradation of historic properties under the No Action Alternative could have detrimental, long-term, secondary impacts on cultural practices associated with those properties.

6.4.2.1 *Impacts of the No Action Alternative on Historic Properties*

The No Action Alternative represents continuation of current practices and procedures on UH Management Areas. Under the No Action Alternative, adverse impacts to historic properties can be expected to continue at their present rate.

Archaeological studies and fieldwork on UH Management Areas between 1976 and 2008 have identified impacts to historic properties not attributable to natural processes. It is evident that some ancient shrines have been intentionally or inadvertently altered or dismantled. Observed alterations include the presence of culturally inappropriate items added to ancient shrines; the replacement of fallen uprights; and the removal of ancient stone artifacts left as offerings to the gods of adze manufacture. This has occurred despite existing regulations protecting historic properties and despite the best efforts of DLNR and OMKM.

At present, violations of State law protecting historic properties cannot be enforced by UH. Although OMKM has a staff of on-site Rangers, they have no enforcement authority. If the Rangers observe actions that impact historic properties, such as off-road vehicle activity, their authority is limited to warning the violators and referring the violation to DLNR for enforcement.

6.4.2.2 *Impacts of the No Action Alternative on Cultural Practices and Beliefs*

Under the No Action Alternative, without the Management Actions proposed in the CMP, the ongoing degradation of historic properties is anticipated to continue, which could result in adverse effects on the ability to engage in cultural practices or beliefs involving those historic properties, such as shrine visitation.

6.5 IMPACTS ON BIOLOGICAL RESOURCES

6.5.1 Proposed Action's Effect on Biological Resources

The CMP is expected to result in beneficial long-term effects on biological resources. No adverse effects on biological resources are anticipated to result from the Proposed Action.

Management Actions P-3 and P-6 recommend that UH obtain rulemaking and enforcement authority from the State Legislature. UH has determined that those authorities are critical to carrying out its goal of environmental stewardship, as they will allow UH to create and enforce rules needed to protect biological resources located on UH Management Areas. Management Action ACT-3 commits UH to maintaining an enforcement presence within the UH Management Areas for enforcing applicable natural resource protection rules. As DLNR's existing regulatory and management authority will remain undiminished, this additional enforcement presence is expected to reduce activities that adversely affect the mountain's biological resources.

The rules that UH wishes to create to protect and preserve natural resources are described by Management Actions EO-2, ACT-1, ACT-4, ACT-6 and ACT-7. Those Management Actions focus on restricting access for certain activities that have a potential for damaging or

degrading biological resources and ensuring that staff and visitors who do enter sensitive areas are aware of the importance of protecting those resources.

Management Action EO-2 (as well as ACT-1) would require mandatory orientation for everyone entering the Mauna Kea Management Areas (e.g., visitors, scientists, commercial drivers, observatory support staff, etc.). The orientation would include descriptions of the natural resources present on the mountain, the protection afforded those resources, and the expectations and requirements to avoid habitat damage. This orientation program is anticipated to result in decreased damage to biological resources by people who are unaware of the presence of those resources, of their significance, or the legal protections they are afforded.

Management Action ACT-4 would adopt the current prohibition on off-road vehicle use that is contained in the 1995 Management Plan. This prohibition is intended to reduce the potential for direct physical impacts on biological resources associated with off-road vehicle use.

Management Action ACT-6 would allow UH to restrict snow play to areas and conditions that do not pose a threat to biological resources. This recommendation does not identify the areas that would be affected by snow play restrictions. Currently, there are no restrictions on where snow play activities can occur. The current unrestricted access for sledding, skiing and similar activities creates a potential for inadvertent damage to biological resources that this action seeks to mitigate.

Management Actions ACT-1 and ACT-7 would allow UH to restrict tours and star-gazing activities to previously disturbed areas and parking areas. The previously disturbed areas where these activities could occur are not identified in the CMP. This restriction would reduce the potential for inadvertent damage to biological resources by members of tour groups or amateur astronomers visiting the mountain.

Management Action ACT-1 would also prohibit extreme sporting events, which present a risk to biological resources and/or their habitats.

Collectively, the effect of the preceding Management Actions (obtaining rule-making and enforcement authority and creating and enforcing rules protecting natural resources) would have a positive, long-term impact by allowing UH to manage activities that threaten biological resources more effectively. When applied in conjunction with the continuing limits imposed by the DLNR, these would help maintain a healthy ecological balance.

Management Action EO-4 calls for development and implementation of interpretive signage. This recommendation adopts a condition of the 1995 Management Plan. Signage would identify sensitive habitats, protected plant species and allowable hiking trails, as well as describing prohibited activities that could degrade biological resources. This action is anticipated to have an overall beneficial effect on biological resources.

Under Management Action CR-5, leaving traditional offerings on UH Management Areas would be allowed to continue unrestricted for all persons who have completed the required orientation. Culturally appropriate guidelines for removing offerings to protect natural resources would be developed.

Additional controls adopted from the 1995 Management Plan that serve to improve the protection afforded biological resources include prohibiting outdoor fires and commercial hunting tours. None of the adopted 1995 Management Plan controls would have an adverse effect on biological resources.

6.5.2 No Action Alternative's Effect on Biological Resources

The No Action Alternative is anticipated to be less protective of biological resources found within UH Management Areas than would the Proposed Alternative.

At present, OMKM staff cannot take enforcement action when they observe violations of State law protecting biological resources and sensitive habitats. Although UH has a staff of on-site Rangers, they have no enforcement authority. If the Rangers observe actions that could effect biological resources, such as off-road vehicle activity, their authority is limited to warning the violators and referring the violation to DLNR for enforcement.

6.6 IMPACTS ON VISUAL ENVIRONMENT

6.6.1 Proposed Action's Effect on the Visual Environment

Minor long-term changes in the visual environment are associated with the Proposed Action. These are discussed below.

Under Management Action CR-5, leaving traditional offerings on UH Management Areas would be allowed to continue unrestricted. Culturally appropriate guidelines for removing offerings to protect the visual landscape would be developed and implemented. Periodically removing visual clutter from the landscape would result in minor positive impacts to visual resources.

Management Action ACT-4 would adopt the current prohibition on off-road vehicle use that is contained in the 1995 Management Plan. This prohibition would reduce the scarring associated with off-road vehicle travel in wilderness areas, thereby protecting visual resources associated with Mauna Kea's landscape.

Management Action EO-4 calls for developing and implementing interpretive signage. This recommendation adopts a condition of the 1995 Management Plan. Per HAR § 13-5-24 requirements, UH would be required to develop a site plan and obtain DLNR approval before implementing this action. Signage would identify certain natural and cultural resources, allowable hiking trails, as well as describing restrictions and prohibited activities. Signs, particularly in natural settings, have an inherent minor adverse visual impact, as they can detract from the "naturalness" of an outdoors setting.

Signage standards will be developed that minimize the visual impact of signage while ensuring that it attains its desired function. Signage related to safety issues will, necessarily, be designed to attract attention to ensure that appropriate warnings are noted by users. In general, safety signage should be limited to developed areas and to undeveloped areas that pose an immediate safety risk to visitors. Interpretative signs, trail markers and other educational signage will be designed to blend into the landscape when viewed from a

distance. The colors, materials of construction and dimensions should be standardized and constrained to achieve these goals. These planned mitigation measures will reduce the impacts of Management Act EO-4 on the visual environment.

6.6.2 No Action Alternative's Effect on the Visual Environment

The No Action Alternative is anticipated to allow continued minor degradation of visual resources, when compared to the Proposed Action.

Absent the authority to enforce prohibitions on off-road vehicle use (Management Actions ACT-4 and P-6), this prohibition has no effect in practice. The No Action Alternative would provide no improvement in current conditions. Impacts to visual resources would continue to accrue, as no enforcement of off-road vehicle use would be available to deter this activity.

6.7 IMPACTS ON TRAFFIC

6.7.1 Proposed Action's Effect on Traffic

The Proposed Action is anticipated to result in minor, long-term increases in vehicle-traffic along the Summit Access Road due to increased resource management staffing.

Management Action ACT-3 recommends that UH maintain an enforcement presence on Mauna Kea. In addition, implementation of the studies and management programs recommended in the CMP can be reasonably expected to result in additional staff or contractor visits. Enforcement staffing at Hale Pōhaku and visits by UH and contractor staff involved in implementing the CMP are estimated to result in an additional five round-trips per day along the Summit Access Road from current levels. This anticipated increase in vehicle trips is not anticipated to impact traffic movement or result in congestion, as the current traffic on UH Management Areas and surrounding roads is relatively light and the roads are devoid of congestion.

This minor increase in vehicle trips can be mitigated by encouraging car-pooling. It is recommended that OMKM develop a program to encourage car-pooling by employees.

6.7.2 No Action Alternative's Effect on Traffic

The No Action Alternative would have no impacts on traffic on UH Management Areas or surrounding roadways.

6.8 IMPACT ON INFRASTRUCTURE AND UTILITIES

6.8.1 Proposed Action's Effect on Infrastructure and Utilities

The Proposed Action is not anticipated to have any significant impacts on infrastructure or utility requirements or require expansion of infrastructure on UH Management Areas from current capacities.

The Proposed Action is anticipated to have a minor secondary impact by increasing potable water use at Hale Pōhaku. Management Action ACT-3 recommends that UH maintain an enforcement presence on Mauna Kea. In addition, implementing the studies and management programs recommended in the CMP can be expected to result in additional employee and contractor activities within the UH Management Areas. Enforcement staffing at Hale Pōhaku and increased visits by UH and contractor staff involved in implementing the CMP are estimated to result in a minor increase in the rate of water use at Hale Pōhaku. Increased facility use resulting from CMP implementation is estimated to result in a one percent increase in water use rates from current levels.

6.8.2 No Action Alternative's Effect on Infrastructure and Utilities

The No Action Alternative would have no impact on infrastructure or utilities.

6.9 IMPACT ON FLOOD HAZARD

6.9.1 Proposed Action's Effect on Flood Hazards

The Proposed Action will not impact flood hazard conditions, as none of the actions proposed involve any ground disturbance or alteration of drainage patterns.

6.9.2 No Action Alternative's Effect on Flood Hazards

The No Action Alternative will not impact flood hazard conditions.

6.10 IMPACT ON GROUNDWATER AND SURFACE WATER RESOURCES

6.10.1 Proposed Action's Effect on Groundwater and Surface Water Resources

Because the University will continue to adequately treat domestic wastewater produced by staff, the Proposed Action is not anticipated to result in any impact to groundwater or surface water resources within UH Management Areas or surrounding areas.

6.10.2 No Action Alternative's Effect on Groundwater and Surface Water Resources

The No Action Alternative will not impact groundwater or surface water resources.

6.11 IMPACT ON GEOLOGY AND TOPOGRAPHY

6.11.1 Proposed Action's Effect on Geology and Topography

The Proposed Action will not impact geology or topography within UH Management Areas or surrounding areas, as none of the actions proposed involve any ground disturbance. Minor decreases in the occurrence of localized erosion may result from improved enforcement of the prohibition on off-road vehicle use.

6.11.2 No Action Alternative's Effect on Geology and Topography

Minor increases in the occurrence of localized erosion are associated with the No Action Alternative resulting from the lack of improved enforcement of the prohibition on off-road vehicle use.

6.12 IMPACT ON CLIMATE AND AIR QUALITY

6.12.1 Proposed Action's Effect on Climate and Air Quality

The Proposed Action will not have any significant impacts on climate or air quality within UH Management Areas or surrounding areas.

To the extent that there is a net increase in vehicular traffic on the Mountain, estimated at five round trips per day, the Proposed Action may have a secondary, long-term impact on pollutant emission rates resulting from enforcement staffing at Hale Pōhaku and contractor visits. Hawai'i is in an attainment area for all regulated air pollutants associated with motor vehicle emissions. The increase in tailpipe emissions and particulate matter resulting from the projected increase in traffic is small and does not have the potential to significantly affect air quality. Therefore, the secondary impact of the Proposed Action on air quality is anticipated to be insignificant. There is no anticipated impact on climate.

As noted in the discussion of traffic, this increase in vehicle emissions can be mitigated by encouraging ride sharing and car pooling. It is recommended that OMKM develop a program to encourage car-pooling by employees.

6.12.2 No Action Alternative's Effect on Climate and Air Quality

The No Action Alternative will not impact air quality.

6.13 IMPACT ON HAZARDOUS MATERIALS, SOLID WASTES AND WASTEWATER

6.13.1 Proposed Action's Effect on Hazardous Materials, Solid Wastes and Wastewater

The Proposed Action will not increase the use of hazardous or regulated materials in UH Management Areas or result in increases in the amount of hazardous wastes generated. Enforcement staffing and increased staff and contractor visits associated with CMP implementation is anticipated to result in minor increases in the generation of solid waste and domestic wastewater at Hale Pōhaku.

The increase in solid waste and domestic wastewater generation associated with CMP implementation is estimated to be approximately one percent, when compared to current generation rates. These increases will not exceed the design capacity of existing systems or require expansion of those systems. Therefore, the impacts of the Proposed Action on hazardous materials use, hazardous waste generation, solid waste generation and wastewater generation are anticipated to be insignificant.

6.13.2 No Action Alternative's Effect on Hazardous Materials, Solid Wastes and Wastewater

The No Action Alternative will not impact the use of hazardous and regulated materials or the generation and treatment of wastewater.

6.14 IMPACTS ON NOISE

6.14.1 Proposed Action's Effect on Sound Levels

The Proposed Action will not have any significant impacts on sound levels in UH Management Areas or surrounding areas.

The Proposed Action may have a minor secondary impact resulting from enforcement staffing and increased staff and contractor visits at Hale Pōhaku. The enforcement staffing may result in a greater number of vehicle trips to the UH Management Areas and increases in transient noise levels. Enforcement staffing and visits resulting from full CMP implementation could increase the number of vehicle-trips to Hale Pōhaku and the summit area by up to five round-trips per day if mitigation measures aimed at encouraging car-pooling are unsuccessful. Even under this "worst-case" outcome, the resulting increase in low-level, transient noise would be insignificant.

As described in the Traffic section, the increase in the transient noise levels associated with increased traffic can be mitigated by encouraging ride sharing and car pooling. It is recommended that OMKM develop a program to encourage car-pooling by employees.

6.14.2 No Action Alternative's Effect on Sound Levels

The No Action Alternative will not impact noise levels.

6.15 IMPACTS ON SOCIO-ECONOMICS

6.15.1 Proposed Action's Effect on Socio-Economic Conditions

The Proposed Action is not anticipated to have any adverse socio-economic impacts.

The Proposed Action may have long-term, indirect, minor beneficial effects on employment, income and commerce. Long-term employment levels may increase as the result of additional staff and contract hiring required to implement the CMP. Between four and ten additional staff or contract hires are anticipated to be required on a long-term basis to conduct visitor orientations and staff training, provide enforcement support, conduct environmental and archaeological studies, and provide administrative and management support related to CMP implementation. Some of the anticipated employment needs would be expected to be contracted to local firms on an intermittent as-needed basis, while others would be permanent, new UH hires. Additional direct expenditures of approximately \$1 million annually are anticipated to result from CMP implementation.

This modest increase in employment would generate a corresponding increase in direct spending which, in turn, would generate further economic activity in Hawai'i County and statewide. Minor beneficial impacts to the existing socio-economic environment at the local and regional level are anticipated to result.

6.15.2 No Action Alternative's Effect on Socio-Economic Conditions

The No Action Alternative will not impact the local or regional socio-economic environment.

6.16 CUMULATIVE IMPACTS

Cumulative impacts are those that result from the incremental impact of the Proposed Action when added to other past, present and reasonably foreseeable future actions. The CMP presents a framework of management strategies that protect, preserve, and enhance Mauna Kea's resources. However the CMP does not authorize any changes to current land uses, and adoption of the CMP will not constitute approval of future development actions within the UH Management Areas. Therefore, the Proposed Action is not anticipated to result in significant incremental environmental impacts when added to other past, present and reasonably foreseeable future actions. The Proposed Action, when considered in a cumulative framework, is anticipated to result in beneficial environmental effects for all reasonably foreseeable future actions.

In considering the cumulative impacts of the Proposed Action, projects described in the 2000 Master Plan were considered to be reasonably foreseeable future actions. The 2000 Master Plan describes all current land uses for the UH Management areas and identifies future development plans. The 2000 Master Plan is still in effect and is not altered by the CMP. The Final EIS (FEIS) prepared for the 2000 Master Plan was accepted in 1999. That FEIS thoroughly addressed the environmental impacts of constructing and operating observatory and support facilities within the UH Management Areas. The FEIS considered the cumulative effects of all past and planned development within the UH Management Areas. It is anticipated that several individual projects put forth for areas covered by the Master Plan and that are consistent with the overall development scheme laid out in that document will be the subject to additional HRS Chapter 343 review.

On September 23, 2008, the University issued a Preparation Notice for an Environmental Impact Statement (PNEIS) for the Thirty Meter Telescope (TMT), which is being considered for construction in the Astronomy Precinct of Mauna Kea or at a location in Chile. If sited in Hawai'i, the TMT project would involve the construction and operation of an optical/infrared telescope on an estimated four acres of presently undeveloped land within the 525-acre Astronomy Precinct. The 2000 Master Plan included the possibility of locating such a telescope, then referred to as the Next Generation Large Telescope (NGLT), within the Astronomy Precinct of the Mauna Kea Science Reserve and considered its impacts in a cumulative impact analysis presented in the FEIS.

The second specific project that UH is aware of is the Panoramic Survey Telescope & Rapid Response System (Pan-STARRS). In December 2006, the University's IfA published a PNEIS for the Pan-STARRS project. This new telescope is proposed to replace the existing

UH 2.2m telescope on Mauna Kea. An alternative site in Maui is also being considered. If sited on Mauna Kea, the existing UH 2.2m facility would be dismantled and the Pan-STARRS facility would be constructed in its location. This project was also considered in the 2000 Master Plan as one of the potential redevelopment or “recycling” projects foreseen for Mauna Kea and was considered in the cumulative impact analysis presented in the Master Plan FEIS.

The Proposed Action will not have any significant adverse incremental environmental impacts when added to other development projects identified in the 2000 Master Plan that may be proposed for construction within UH Management Areas, including the TMT and Pan-STARRS projects, as the CMP provides a mechanism for integrated and coordinated management of Mauna Kea's cultural and natural resources during future development projects.

The Proposed Action will enforce new, stricter environmental considerations on any future development project than would occur under the No Action Alternative. Management Actions C-7 and C-8 require that all workers accessing UH Management Area who are involved in the construction or operation of new facilities receive training that includes:

- The historical and cultural significance of Mauna Kea;
- Culturally sensitive and respectful behavior;
- The environment, ecology and natural resources of Mauna Kea; and
- Protecting natural resources.

Management Actions C-1 through C-5 and C-9 contain conditions that would be required in all future development project permits. Those conditions establish strict environmental process and performance requirements to help protect natural and cultural resources.

In considering possible future land uses, the CMP developed additional standards to be imposed on future projects. These include:

- FLU-1 adopting the design guidelines in the 2000 Master Plan
- FLU-3 requiring that initial site conditions be cataloged for use in restoring a site upon decommissioning
- FLU-4 requiring project specific visual rendering of both pre- and post-project settings to facilitate analysis of potential impacts to view planes
- FLU-5 requiring an airflow analysis on the design of proposed structures to assess potential impacts to aeolian ecosystems
- FLU-6 incorporating habitat mitigation plans into project planning processes
- FLU-7 requiring use of close-contained zero-discharge waste systems for any future development in the summit region, from portable toilets to observatory restrooms, if feasible.

Individually and collectively, these requirements will reduce the environmental impacts of future development, including all projects planned for in the 2000 Master Plan. Therefore, the Proposed Action can be reasonably anticipated to result in beneficial cumulative impacts when added to potential future development projects. No detrimental cumulative impacts are anticipated to result from the Proposed Action.

7 ANTICIPATED DETERMINATION

7.1 PROPOSING AGENCY

University of Hawai'i

7.2 APPROVING AGENCY

University of Hawai'i

7.3 DESCRIPTION OF THE PROPOSED ACTION

Title: *Mauna Kea Comprehensive Management Plan (CMP)*

The proposed action is the implementation of management strategies within UH Management Areas. The CMP provides a management framework to address existing and future astronomical, recreational, commercial, scientific research and cultural activities in the UH Management Areas. More importantly, the CMP provides a guide for protecting Mauna Kea's cultural and natural resources. The CMP, once approved by the BLNR, will be the guiding management plan for University decisions. All activities within the UH Management Areas will have to be consistent with the provisions of the CMP, as well as with applicable laws and regulations.

The CMP was derived from previous plans, experience gained through many years of management efforts on Mauna Kea and input gathered during consultation with community members and other stakeholders. The primary management goal of the CMP is the protection and preservation of the mountain's many cultural and natural resources.

The leased lands covered by the CMP begin at approximately 9,200 ft (2,804 m) on Mauna Kea and extend to the summit, at 13,796 ft (4,205 m), encompassing three distinct areas: the Mauna Kea Science Reserve (Science Reserve), the mid-level facilities at Hale Pōhaku, and the Summit Access Road and management corridor. These areas are collectively referred to as the "UH Management Areas."

7.4 ANTICIPATED DETERMINATION

Based on the information contained in this DEA the University has determined that the proposed action will not have a significant impact on the environment. Accordingly, it anticipates that it will issue a FONSI for the proposed action. This anticipated determination will be reviewed after all comments on the DEA are received. At that time, the University will either issue a FONSI or will publish an EISPN.

7.5 REASONS SUPPORTING THE DETERMINATION

HAR § 11-200-12 details the specific significance criteria that must be used to determine if a potential environmental effect of a proposed action constitutes a "significant effect."

1) Involves an irrevocable commitment to loss or destruction of any natural or cultural resource

The Proposed Action will not cause an irrevocable commitment to loss or destruction of any natural or cultural resources in the UH Management Areas. The CMP is a framework for improved management and protection of Mauna Kea's unique natural and cultural resources and will have positive long-term effects on these resources. The CMP is expected to result in more effective education, management and enforcement of State historic/cultural protection and environmental regulations in the UH Management Areas, ultimately improving resource protection.

2) Curtails the range of beneficial uses of the environment

The Proposed Action is intended to improve the management of activities and uses within the UH Management Areas. The potential effects of the Proposed Action will not curtail the range of beneficial uses of the environment in the UH Management Areas. It is intended to ensure that beneficial uses of the UH Management Areas can continue.

3) Conflicts with the state's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS and any revisions thereof and amendments thereto, court decisions, or executive orders

Chapter 344, HRS states, it shall be the policy of the State, through its programs, authorities, and resources to:

(1) Conserve the natural resources, so that land, water, mineral, visual, air and other natural resources are protected by controlling pollution, by preserving or augmenting natural resources, and by safeguarding the State's unique natural environmental characteristics in a manner which will foster and promote the general welfare, create and maintain conditions under which humanity and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of the people of Hawaii. (HRS § 344)

The Proposed Action and its potential effects do not conflict with the State's long-term environmental policies or goals and guidelines, court decisions, or executive orders. The primary objective of the CMP is to improve the management and protection of natural and cultural resources in the UH Management Areas. The potential effects of Proposed Action include improved education, management, and enforcement of State environmental and historic preservation regulations. These effects support the stated goals of Chapter 344, HRS.

4) Substantially affects the economic welfare, social welfare, and cultural practices of the community or State

The Proposed Action will not substantially affect the economic and social welfare of the community or State.

Similarly, the potential effects of the Proposed Action will not substantially affect cultural practices in the community or State. The Proposed Action will not restrict access to the UH Management Areas for cultural practitioners nor will it restrict the exercise of cultural and

religious practices, except where safety, resource management, cultural appropriateness, and legal compliance considerations require reasonable restrictions on access.

5) Substantially affects public health

The Proposed Action and its potential effects will not substantially affect public health.

6) Involves substantial secondary impacts, such as population changes or effects on public facilities

The potential effects of the Proposed Action do not involve substantial secondary impacts. Secondary or indirect impacts of the Proposed Action are restricted to minimal increases in staffing, vehicle traffic and emissions, water use, solid waste generation, and waste water generation on the mountain.

7) Involves a substantial degradation of environmental quality

For reasons described in previous sections of this DEA, the Proposed Action will not involve a substantial degradation of environmental quality. The Proposed Action is intended to improve the protection of natural and cultural resources in the UH Management Areas.

8) Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions

The proposed CMP creates a management framework for the UH Management Areas and does not have potential effects that will result in cumulative impacts when reviewed with other past, present and reasonably foreseeable future projects. The CMP mandates increased education, management, and enforcement of existing regulations and does not involve a commitment for future larger actions.

9) Substantially affects a rare, threatened, or endangered species, or its habitat

The Proposed Action will not adversely affect rare, threatened, or endangered species, or their habitats. Potential effects of the Proposed Action include improved natural resource management planning and enforcement of existing State regulations. There are no direct effects to rare, threatened, or endangered species or their habitats from the Proposed Action.

10) Detrimentially affects air or water quality or ambient noise levels

Minor increases in air emissions, wastewater generation and vehicle noise emissions are anticipated to result from the small increase in enforcement staffing needed to better manage the UH Management Areas. The increases are too small to have a significant adverse effect on these environmental parameters.

11) Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters

Since the proposed CMP is principally a series of planning and management actions and it does not propose any land use or development of any structures or facilities, it will not affect an environmentally sensitive area. The increased oversight will provide enhanced protection of Mauna Kea's natural and cultural resources.

12) Substantially affects scenic vistas and viewplanes identified in county or state plans or studies

The only physical changes that may occur as a result of the CMP consist of the posting of additional educational and warning signage. The number, size, and design of the signs will be appropriate to the setting and they are not expected to have a significant adverse effect.

13) Requires substantial energy consumption

The Proposed Action does not include actions that will substantially increase energy consumption in the UH Management Areas.

7.6 CONTACT INFORMATION

For more information contact:

University of Hawai'i
Office of the President
2444 Dole Street
Bachman 202
Honolulu, HI 96822
Telephone: (808)956-8207
Facsimile: (808)956-5286

8 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED

Chapter 343, HRS and HAR § 11-200-9 stipulate that the proposing agency shall consult with the general public, citizen groups and government agencies, in particular the County agency responsible for implementing the County's general plan, which the proposing agency reasonably believes to be affected by the proposed action. This section includes a discussion of consultation process conducted for the CMP and DEA. Section 4 of the CMP describes the complete Community Engagement Process.

8.1 CONSULTATION PROCESS

Community consultation was an integral component of the CMP process. The University sought to re-establish a meaningful community relationship with the range of stakeholders involved with the UH Management Areas, and it undertook a multi-faceted consultation process to achieve this goal. The University engaged with a wide variety of stakeholders and "listened" to them in a setting or forum of their choosing. It used individual and small group "talk story" sessions, traditional public meetings, a statewide survey, direct newsletter mailings, workshops, and a CMP website to establish a meaningful dialogue with community members and agencies. Table 8-1 lists the names and affiliations of the individuals who participated in the process.

Table 8-1. List of Parties Participating in the CMP Process

LAST	FIRST	AFFILIATION
Abercrombie	Neil	Congressman
Abreu	Al	Individual
Agor	Ron	BLNR Member
Akaka	Moanikeala	Individual
Armandroff	Taft	Outrigger Telescopes
Baybayan	Chad Kalepa	Kahu Kū Mauna
Bergin	Billy	Waimea resident / former UH BOR
Bergin	Pat	Mauna Kea Management Board
Bracken	Sherry	Island Issues - Radio Show
Brock	Daniel	West Hawai'i Today - Reporter
Burnett	John	Individual
Callejo	Sam	UH - VP for Administration
Carlson, Jr.	Carl	UH BOR
Carter	Yvonne	Cultural practitioner / Waimea resident
Carter	Keoki	Cultural practitioner / Waimea resident

Table 8-1. List of Parties Participating in the CMP Process

LAST	FIRST	AFFILIATION
Case	Lloyd	Subsistence hunter - Wildlife Conservation of Hawai'i
Catterall	Lee	Star Bulletin - Editorial Board
Chang	Jerry	Representative
Chinn	Linda	Department of Hawaiian Home Lands
Cho	Henry	Former DHHL Commissioner
Chu	Roberta	Sr. VP & Manager BOH
Cody	Nicole	Student
Coleman	Paul	IFA - Manoa
Colley	Steve & Carmen	Individual
Cordell	Susan	Environmental Committee of MKMB
Crabbe	Moses	Individual
Cross	John	MKMB
David	Reggie	Former MKMB
DaMate	Leimana	Aha Kiole
DeMello	Gerald	Relations Director
Dillard	Orpheus	Individual
Edlao	Jerry	BLNR Member
Evans	Cindy	Representative
Evans	Kim	Individual
Fergerstrom	Blaine	Individual
Fergestrom	Hanalei	Temple of Lono
Fisher	Scott	Gemini Telescopes
Flickinger	Reed	West Hawai'i Today - Editor
Flores	Miliaka & Joe	Individual
Flynn	Rory	Kukuipahu Energy LLC (w/ John Ray)
Freitas	Rockne	Hilo Community College Chancellor
Fujihara	Gary	IFA - Hilo
Gaines	James	UH - VP for Research
Gon	Sam	The Nature Conservancy / BLNR Member
Green	Josh	Representative
Ha	Richard	Hamakua Springs Country Farms
Hamabata	Matt	The Kohala Center
Hanabusa	Colleen	Senator
Hanoa	Pele	Kūpuna – Hawai'i Island Burial Council
Hanohano	Faye	Representative
Hapai	Marlene	UH BOR; Former Executive Director of Imiloa

Table 8-1. List of Parties Participating in the CMP Process

LAST	FIRST	AFFILIATION
Hardaway	Lisa	Department of Land and Natural Resources
Harden	Cory	Sierra Club
Hayashi	Masa	Subaru Telescope
Heen	Walter	Office of Hawaiian Affairs
Helfrich	Paula	Individual
Herkes	Bob	Representative
Heyer	Inge	Individual
Hiura	Arnold	OMKM media relations specialist
Hoke	Arthur	Kahu Kū Mauna _ Hilo Hawaiian Civic Club
Hong	Lea	Hawai'i Trust for Public Lands
Hoover	Jacqui	Hawai'i Leeward Planning Conference
Ikawa	Allan	Big Island Candies - Former Board of Regent
Ishibashi	Wally	ILWU - Hilo
Ito	Ken	Representative
Johns	Tim	BLNR Member
Kahawaiola'a	Patrick K.	Kea`aukaha Hawaiian Homesteads
Kakalia	Tiffnie	Kahu Kū Mauna
Kalamau	Jo-Ann	Individual
Kalua	Herring	MKMB - former Hawaiian Homes Commissioner
Kamakawiwoole	Reynolds	Hawaiian cultural practitioner
Kamakawiwoole	Kalei	Individual
Kanahele	Pua	Cultural practioner - Kumu Hula - Hilo Community College
Kanehailua III	Ernest	Royal Order of Kamehameha
Kaneha'ilua	Brenda	Individual
Kanui	John	Individual
Kapono	Eric	Individual
Kauhikaua	Jim	MKMB – Hawai`i Volcanoes National Park
Kennedy	Jim	MKMB
Kenoi	Billy	Mayor
Kikuchi	Bill	Individual
Kim	Harry	County of Hawai`i - Mayor, Hawai`i County
Kim	Millie	Individual
Kimura	Ka'iu	Imiloa
Kimura	Larry	Kahu Kū Mauna - University of Hawai`i at Hilo
Kinchla	Joan	Kona Hiking Club
Kinimaka	Kaniu	Alternative Technologies in Power

Table 8-1. List of Parties Participating in the CMP Process

LAST	FIRST	AFFILIATION
Kitamura	Mike	Senator Akaka's State Director
Kokubun	Russell	Senator
Kudritzki	Rolf-Peter	IFA - Manoa
Landrum	Vivian	Kona-Kohala Chamber of Commerce
Lee	Nani	Individual
Leialoha	Julie	Environmental Committee of MKMB
Lemmo	Sam	Department of Land and Natural Resources
Levine	Andy	County of Hawai'i - Mayor's Assistant
Lindsey	Robert	OHA Trustee
Lovell	Kawika	IFA - Hilo
Lucas	Carolyn	West Hawai'i Today - Reporter
Lyon	Kendal	Individual
Maberry	Mike	IFA - Maui
Mahi	Arthur	Kūpuna
Mallow	Antoinette	Kahu Kū Mauna
Marks	Barry	Individual
Masuda	Robert	UH - Special Assistant
Matthews	Amy	Individual
McClain	David	University of Hawai'i President
McDonald	Ruby	Office of Hawaiian Affairs - Hawaiian Civic Club
McGuffie	Mark	Hawai'i Island Economic Development Board
McKeague	Kawika	Group 70 consultant
McLaren	Robert	IFA - Manoa
McLoud	Pablo	Former Ranger OMKM
McNett	Mark	Individual
Mercier	Tyler	Individual
Mills	Peter	Individual
Moon	Alice	Consultant
Nagata	Stephanie	Associate Director - Office of Mauna Kea Management
Naleimaile	Sean	Kahu Kū Mauna
Namuo	Clyde	Administrator Office of Hawaiian Affairs
Nelson	Dickie	I Mua Group - Hawaiian Homestead Association
Nishimura	Tetsuo	Subaru Telescope
Oi	Cynthia	Star Bulletin - Editorial Board
Omphroy	Leilehua	Kahu Kū Mauna
Oshiro	Marcus	Representative

Table 8-1. List of Parties Participating in the CMP Process

LAST	FIRST	AFFILIATION
Ostrander	Gary	UH - VP for Research
Ota	John	Individual
Pacheco	Robert	BLNR Member
Panoke	Kaho'onei	Hawaiian Civic Club
Pisciotta	Kealoha	Mauna Kea Anaina Hou
Poole	Mary	Star Bulletin - Editorial Board
Putland	Stuart	Individual
Ray	John	Waimea resident / Kukuipahu Energy LLC
Rice	Koa	Gemini Telescopes
Rogers	Helen	UH Hilo
Sabas	Jennifer Goto	U.S. Senator Daniel K. Inouye's Office
Sakamoto	Norman	Senator
Salmol	Derrick	Individual
Say	Calvin	Representative
Schaefer	Barbara	Individual
Sherlock	Ululani	Former Kahu Kū Mauna and OMKMB
Sing	David	Na Pua No`eau
Spencer	Margie	Kūpuna
Springer	Hannah	Kahu Kū Mauna - cultural practitioner
Stanton	Chas	Individual
Steffey	Eric	Individual
Stevens	Ed	Kahu Kū Mauna - cultural practitioner
Stevens	Mercedes	Individual
Stone	Fred	Individual
Stormont	Bill	Former Director OMKM
Sur	Peter	Hawai'i Tribune Herald
Tajiri	Harvey	UH Board of Regent
Takami	Hideki	Individual
Takamine	Dwight	Representative
Tam	William	Attorney
Taniguchi	Barry	MKMB - KTA Super Stores
Terry	Ron	MKMB
Thielen	Laura	Chairperson of Board of Land and Natural Resources
Thomas	Don	MKMB Environmental Committee
Tolentino	Mabel	Kūpuna
Tseng	Rose	UH Hilo Chancellor

Table 8-1. List of Parties Participating in the CMP Process

LAST	FIRST	AFFILIATION
Tsuji	Clift	Representative
Tzimeas	Ruby	Kona Hiking Club
Veillet	Christian	MKMB - Canada France Telescopes
Walker	Alice	Kona Hiking Club
Ward	Deborah	Sierra Club
Warren	DeeDee	Individual
Watts	Joy	Individual
Wilson	Ross	Consultant
Wuddell	Alan	Individual
Yeh	Thomas	Attorney

<u>Hawaiian Agencies Organizations</u>
Kanaka Council
Ahahui Ka`ahumanu Society
Royal Order of Kamehameha
Hawaiꞌi Island Economic Development Board, Gov't Affairs
Mauna Kea Observatory Directors
Kona-Kohala Chamber of Commerce, Gov't Affairs Committee
OHA Beneficiary Advocacy and Empowerment Committee
University of Hawaiꞌi at Hilo - Hawaiian Studies Faculty/Students
OHA's Native Hawaiian Historic Preservation Council
Association of Hawaiian Civic Clubs

The consultation process elicited a broad range of concerns and issues. Included among them were statements regarding religious and spiritual beliefs, cultural practices, cultural and natural resources, legal matters, education, economic development, social justice, land use, management, and communication. Given the diversity of comments received, an effort was made to identify recurrent issues or concerns that would foster the formulation of the CMP management recommendations. Issues were evaluated in the context of the CMP scope, the current lease between the University and DLNR, existing statutes and rules, and other similar parameters regarding the University's use and stewardship of the UH Management Areas. Comments were received from some individuals who believe that all astronomy on Mauna Kea should be halted, all telescopes removed, and that Mauna Kea should be restored and preserved solely for cultural and religious purposes. While such perspectives are

understandable, they were not consistently held across the community; in fact, they were put forth by relatively few individuals.

One of the most consistent viewpoints was that science (astronomy) can co-exist within the cultural and natural resource setting of the UH Management Areas. This perspective was held across nearly all groupings and individuals ranging from families that have a lineal or a historic connection to Mauna Kea to individuals who reside on neighbor islands. Beyond this generally held belief however, perspectives varied with regard to how such uses should occur and be managed. It was from that perspective that the Management Recommendations for the CMP were established.

8.2 Organizations and Individuals Sent Copies of the Draft EA

Table 8-2 is a list of all the organizations and agencies that will be sent a copy of this DEA and asked to comment on it.

Table 8-2. List of Agencies and Organizations Sent the DEA for Comment

Organization
Dept. of Agriculture
UHM Water Res. Research Ctr
Dept. of Design & Construction
Comptroller, Dept. of Accounting & General Services
Region IX Administrator, US EPA
Dept. of Community Services
Dept. of Defense
Manager, EPA -- PICO
Superintendent of Educ. Dept. of Education
Directorate of Facilities Engineer U.S. Army Support Command Hawaii Attn: Environmental Management Office
Chairman, Hawaiian Homes Comm. Dept. of Hawaiian Home Lands
Commander, Naval Base Pearl Harbor Attn: Base Civil Engineer
Dept. of Health Env. Planning Office
State Conservationist Resources Conservation Service U.S. Dept. of Agriculture
Dept. of Facility Maintenance
Dept. of Land & Natural Resources
Commander & Division Engineer U.S. Army Corps of Engineers Pacific Ocean Division
State Historic Preservation Officer Dept. of Land & Natural Resources
Commander, U.S. Coast Guard 14th Coast Guard District
Dept. of Business, Economic Development & Tourism

Organization
Pacific Islands Administrator Dept. of the Interior Fish & Wildlife Services
Dept. of Business, Econ. Dev. & Tourism Energy, Resources & Technology Division
District Chief Dept. of the Interior US Geological Survey
Executive Director Housing Finance & Development Corp.
Honolulu Star-Bulletin
Dir. Environmental Health American Lung Association
Dept. of Transportation
Editor, Hon. Advertiser
Hawaii Electric Light Company (HELCO)
Office of Planning
Administrator Office of Hawaiian Affairs
UHM Environmental Center
UHM Hamilton Library Hawaiian Collection
UHM Marine Programs
Legislative Reference Bureau State Capitol
HI County Planning Dept.
HI Co. Dept. of Research & Dev.
Editor, Hawaii Tribune Herald
HI Co. Dept. of Parks & Rec. 25
HI Co. Dept. of Water Supply
Editor, West Hawaii Today
HI Co. Dept. of Public Works
Librarian, UHH Library
Bond Memorial Public Library
Laupahoehoe Public & School Library
Hilo Public Library
Mountain View Public & School Library
Holualoa Public Library
Naalehu Public Library
Honokaa Public Library
Pahala Public & School Library
Kailua-Kona Public Library
Pahoa Public & School Library
Keaau Public & School Library
Thelma Parker Memorial Public & School Library
Kealahou Public Library

8.3 SUBMISSION OF COMMENTS

Individuals wishing to submit comments on this DEA may submit them to:

To:

University of Hawai'i
Office of the President
2444 Dole Street
Bachman 202
Honolulu, HI 96822

With Copies To:

Pacific Consulting Services, Inc.
720 Iwilei Road, Suite 424
Honolulu, Hawaii 96817
Attention Doug Hazelwood

Katherine Puana Kealoha, Director
OEQC
235 South Beretania Street, Suite 702
Honolulu, HI 96813

9 REFERENCES

- Aldrich, P. 2005. Biological information for Mauna Kea. Prepared for the Office of Mauna Kea Management by Patrick Aldrich, Zoology Department, University of Hawaii Honolulu, HI.
- Alexander, W.D. 1892 The Ascent of Mauna Kea, Hawaii. *The Hawaiian Gazette* 27(38):7.
- Arvidson, R. E. 2002. Draft environmental assessment for the Outrigger Telescopes Project published by NASA in December 2000; Response to comments concerning the hydrology of Mauna Kea. Outrigger. St. Louis, MO, McDonnell Center for the Space Sciences, Dept. of Earth and Planetary Sciences, Washington University.
- Ashlock, P. D. and W. C. Gagne. 1983. A remarkable new micropterous Nysius species from the aeolian zone of Mauna Kea, Hawaii Island (Hemiptera: Heteroptera: Lygaeidae). International Journal of Entomology 25(1): 47-55.
- Banko, P. C. 2006. Palila Restoration: Lessons from Long-term Research. USGS FS 2006-3104. USGS Pacific Island Ecosystems Research Center.
- Banko, P. C., P. T. Oboyski, J. W. Slotterback, S. J. Dougill, D. M. Goltz, L. Johnson, M. E. Laut and T. C. Murray. 2002. Availability of food resources, distribution of invasive species, and conservation of a Hawaiian bird along a gradient of elevation. Journal of Biogeography 29(5-6): 789-808.
- Barnes, J. E. 2008. Personal communication from J. Barnes, Director, NOAA Mauna Loa Observatory regarding collection of air quality information Colleen Bergmanis SRGII.
- Barrere, Dorothy B., Mary Kawena Pukui, & Marion Kelly. 1980. *Hula: Historical Perspectives*. Pacific Anthropological Records No. 30, Department of Anthropology, Bernice Pauahi Bishop Museum, Honolulu.
- Bayman, J. M., Moniz-Nakamura, Jadelyn J., Rieth, Timothy M., and Paraso, C. Kanani. 2004. "Stone adze production and resource extraction at Pohakuloa, Hawaii Island." Hawaiian Archaeology 9: 83-104.
- Bayman, J. M. and J. J. M. Nakamura. 2001. "Craft specialization and adze production on Hawaii Island." Journal of Field Archaeology 28(3/4): 239-252.
- Birchard, T. 2008. Personal communication from T. Birchard, lead forecast/meteorologist of the National Weather Service Forecast Office Honolulu based at UH Manoa regarding climate regime at Mauna Kea. C. B. SRGII.
- Brown, J. M. 2008. Personal communication from Jackie Brown, Grinnell College, to Jennifer Garrison, SRGII, regarding Tephritid fly species on Mauna Kea.
- Bryan, L. W. 1939. "Lake Waiiau of Hawaii." Paradise of the Pacific 51(2): 10-11.

-
- Buck, Sir Peter. 1957. *Arts and Crafts of Hawaii*. Bernice P. Bishop Museum Special Publication 45. Honolulu.
- Businger, S., R. McLaren, et al. 2002. "Starcasting." Bulletin of the American Meteorological Society **83**(6): 858-871.
- Byrne, D. (2008). Personal communication from D. Byrne, Manager.
- Char, W. P. 1985. Botanical survey for the proposed temporary construction camp housing at Hale Pohaku, Mauna Kea, Island of Hawaii. Appendix A in: MCM Planning and University of Hawaii. 1985. Final supplemental environmental impact statement for construction camp housing, amendment to the Mauna Kea Science Reserve Complex Development Plan. Hale Pohaku, Hamakua, Mauna Kea, Hawaii. Prepared for MCM Planning Honolulu, HI.
- Char, W. P. 1999a. Botanical Resources, Hale Pohaku Mid Elevation Facilities. Appendix G of Group 70. 2000. Mauna Kea Science Reserve Master Plan. Honolulu, HI.
- Char, W. P. 1999b. Botanical Resources, Mauna Kea Summit. Appendix G of Group 70. 2000. Mauna Kea Science Reserve Master Plan. Honolulu, HI.
- Conant, S. 1980. Recent records of the 'ua'u (dark-rumped petrel) and the 'a'o (Newell's shearwater) in Hawaii. 'Elepaio 41(2): 11-13.
- Conant, S., M. Hadfield, P. Aldrich, D. Barshis, N. Bustos, T. Daly-Engel, J. Eble, H. Eijzenga, J. Eijzenga, K. Hall, E. Huppman, K. Page, D. Reding, A. Stompert, N. Sugii, A. Whitehead and N. Yeung. 2004. Mauna Kea Biological Resources Management Plan. Department of Zoology, University of Hawaii Honolulu, HI.
- Cooper, A. 2008. Personal communication from Andrew Cooper, to Colleen Bergmanis, SRGII, regarding nieve penitentes on Mauna Kea.
- da Silva, S. C. 2006. Climatological analysis of meteorological observations at the summit of Mauna Kea. Physics Department, University of Lisbon: 77 p.
- DBET (Department of Business Economic Development and Tourism). 2007. The State of Hawaii Data Book.
- de Silva, Kihei & de Silva, Mapuana. 2006. *E Ho`ka Nani I Mana*. Ka`iwakiloumoku-Hawaiian Cultural Center, University of Hawaii at Manoa.
<http://hccp.ksbe.edu/kaleinamanu/8-ehoikanani.php>, accessed 12/31/08.
- DePaolo, D. J. and E. M. Stolper. 1996. "Models of Hawaiian volcano growth and plume structure: Implications of results from the Hawaii Scientific Drilling Project." Journal of Geophysical Research **101**(B5): 11,643-11,654.
- Dillon, R. D. 1979. "Microbiology of an isolated alpine lake (Lake Waiau, Hawaii)." National Geographic Society, Research Reports: 97-100.
-

-
- Ehlmann, B., R. E. Arvidson, et al. 2005. "Hydrologic and isotopic modeling of alpine Lake Waiau, Mauna Kea, Hawaii." Pacific Science **59**(1): 1-15.
- Eiben, J. 2008. Personal communication from Jesse Eiben, University of Hawaii, to Jennifer Garrison, SRGII, regarding current wekiu bug study.
- Ellis, William. 1979. *Journal of William Ellis: Narrative of a Tour of Hawaii, or Oowhyee; with Remarks on the History, Traditions Manners, Customs, and Language of the Inhabitants of the Sandwich Islands.* Charles E. Tuttle Company, Inc. Rutland, Vermont.
- Englund, R. A., D. A. Polhemus, F. G. Howarth and S. L. Montgomery. 2002. Range, habitat, and ecology of the wekiu bug (*Nysius wekiuicola*), a rare insect species unique to Mauna kea, Hawai'i Island. Final report. Prepared for Office of Mauna Kea Management, University of Hawaii. Hawaii Biological Survey Report 2002-023. Bishop Museum Honolulu.
- Englund, R. A., A. Ramsdale, M. McShane, D. J. Preston, S. Miller and S. L. Montgomery. 2005. Results of 2004 Wekiu Bug (*Nysius wekiuicola*) Surveys on Mauna Kea, Hawai'i Island. Final Report. Prepared for Office of Mauna Kea Management. Hawaii Biological Survey Report 2005-003. Hawaii Biological Survey, Bishop Museum Honolulu, HI.
- Englund, R. A., A. E. Vorsino and H. M. Laederich. 2007. Results of the 2006 Wekiu Bug (*Nysius wekiuicola*) Surveys on Mauna Kea, Hawai'i Island. Final Report. Prepared for Office of Mauna Kea Management. Hawaii Biological Survey Report 2007-003. Hawaii Biological Survey, Bishop Museum Honolulu, HI.
- Englund, R. A., A. E. Vorsino, H. M. Laederich, A. Ramsdale and M. McShane. 2006. Results of 2005 Wekiu Bug (*Nysius wekiuicola*) Surveys on Mauna Kea, Hawai'i Island. Final Report. Prepared for Office of Mauna Kea Management. Hawaii Biological Survey Report 2006-010. Hawaii Biological Survey, Bishop Museum Honolulu, HI.
- Environmental Council, State of Hawai'i. 1997. *Guidelines for Assessing Cultural Impacts*, November 19, 1997.
- Gagné, W. C. and L. W. Cuddihy. 1990. Vegetation. Manual of the Flowering Plants of Hawai'i. W. L. Wagner, D. R. Herbst and S. H. Sohmer. Honolulu, Bishop Museum Press: 45-114.
- Giambelluca, T. W. and M. Sanderson. 1993. *The Water Balance and Climate Classification. Prevailing Trade Winds, Weather and Climate in Hawai'i*. M. Sanderson. Honolulu, University of Hawaii Press.
- Giffin, J. G. (1982). *Ecology of the mouflon sheep on Mauna Kea : final report*, State of Hawai'i, Dept. of Land and Natural Resources, Division of Forestry and Wildlife: 65 p.
- Good, L. (2003) "Mauna Kea's Visitor Information Station." *Na Kilo Hoku: The Ones who Look to the Stars* **Volume**, DOI:

-
- Gregory, Herbert E. & Chester K. Wentworth. 1937. General Features and Glacial Geology of Mauna Kea, Hawaii. *Bulletin of the Geological Society of America* 48:1719-42.
- Group 70. 1980. Hale Pōhaku, Hamakua, Mauna Kea, Hawai'i, mid-elevation facilities master plan :complex development report. Honolulu, HI, Dept. of Land and Natural Resources, State of Hawai'i.
- Group 70. 1983a. Mauna Kea Science Reserve complex development plan, Mauna Kea, Hamakua, Hawai'i. Honolulu, HI, Prepared for Research Corporation of the University of Hawai'i.
- Group 70. 1983b. Mauna Kea Science Reserve complex development plan: final environmental impact statement, Mauna Kea, Hamakua, Hawai'i. Honolulu, HI, Prepared for Research Corporation of the University of Hawai'i.
- Group 70. 1982. Mauna Kea Science Reserve complex development plan: draft environmental impact statement, Mauna Kea, Hamakua, Hawaii. Honolulu, HI, Prepared for Research Corporation of the University of Hawaii. Vol. I, Vol. II.
- Group 70 International. 1999. Mauna Kea Science Reserve Master Plan : final environmental impact statement. Master Plan. Honolulu, HI, Prepared for University of Hawaii. Vol.I, Vol.II.
- Group 70 International. 2000. Mauna Kea Science Reserve Master Plan, March 2000. Master Plan. Honolulu, HI, University of Hawaii. **Vol.I, Vol.II**: 2 vols.
- Group 70 International, Inc. 2000. Final Environmental Impact Statement for the Mauna Kea Science Reserve Master Plan. Prepared for The University of Hawai'i .
- Grumbine, R. E. 1994. "What is ecosystem management?" *Conservation Biology* 8(1): 27-38.
- Hartt, C. E. and M. C. Neal. 1940. The plant ecology of Mauna Kea, Hawaii. Ecology 21(2): 237-266.
- Hawaii Audubon Society. 1997. *Hawaii's Birds*. Honolulu, HI, Hawaii Audubon Society.
- Helber Hastert & Fee, Inc. 2006. Final Environmental Assessment University of Hawai'i 24-Inch Telescope Observatory Renovation. Prepared for The University of Hawai'i at Hilo and the National Science Foundation.
- Hemmes, D. E. and D. E. Desjardin. 2002. *Mushrooms of Hawai'i*. Berkeley, CA, Ten Speed Press.
- Hess, S. C., P. C. Banko, G. J. Brenner and J. D. Jacobi. 1996. Tree densities in a subalpine woodland on Mauna Kea, Hawaii. Proceedings of the Western Association of Fish and Wildlife Agencies: Honolulu Hawaii, July 22 - 26, 1996.: 225-234.

-
- Hess, S. C., P. C. Banko, G. J. Brenner and J. D. Jacobi. 1999. Factors related to the recovery of subalpine woodland on Mauna Kea, Hawaii. Biotropica 31(2): 212-219.
- Hess, S. C., P. C. Banko, M. H. Reynolds, G. J. Brenner, L. P. Laniawe and J. D. Jacobi. 2001. Drepanidine movements in relation to food availability in subalpine woodland on Mauna Kea, Hawaii. Studies in Avian Biology 22: 154-163.
- Hibbard, Don. 1999. Letter of May 3, 1999 to Dr. Robert McLaren (IfA) Regarding Historic Preservation Review of the Proposed W.M. Keck Outrigger Telescopes Project.
- Howarth, F. G. 1987. Evolutionary ecology of aeolian and subterranean habitats in Hawaii. Trends in Ecology and Evolution 2: 220-223.
- Howarth, F. G., G. J. Brenner and D. J. Preston. 1999. An arthropod assessment within selected areas of the Mauna Kea Science Reserve. Final Report. Prepared for the University of Hawaii Institute of Astronomy. Appendix J in Group 70. 2000. Mauna Kea Science Reserve Master Plan. Bishop Museum and Pacific Analytics Honolulu.
- Howarth, F. G. and S. L. Montgomery. 1980. Notes on the ecology of the high altitude aeolian zone on Mauna Kea. Elepaio 41(3): 21-22.
- Howarth, F. G. and F. D. Stone. 1982. An assessment of the arthropod fauna and aeolian ecosystem near the summit of Mauna Kea, Hawaii. Submitted to Group 70. Bernice P. Bishop Museum Honolulu.
- Hu, D., C. Glidden, J. S. Lippert, L. Schnell, J. S. MacIvor and J. Meisier. 2001. Habitat use and limiting factors in a population of Hawaiian dark-rumped petrels on Mauna Loa, Hawaii. Studies in Avian Biology 22: 234-242.
- John M. Knox & Associates, Inc. 2007. Employment Survey Summary. Prepared for The University of Hawai'i at Manoa Institute for Astronomy.
- Juvik, J. O. and S. P. Juvik. 1984. Mauna Kea and the myth of multiple use endangered species and mountain management in Hawaii. Mountain Research and Development 4(3): 191-202.
- Juvik, S. P. and J. O. Juvik, Eds. 1998. Atlas of Hawaii. Honolulu, University of Hawai'i Press.
- Kamakau, Samuel M.
1961. *Ruling Chiefs of Hawaii*. Kamehameha Schools Press. Honolulu.

1964. *Ka Po` Kahiko (The People of Old)*. Bernice P. Bishop Museum Special Publication 51. Honolulu.

1991. *Tales and Traditions of the People of Old, Nā Mo`olelo a ka Po`e Kahiko*. Bishop Museum Press, Honolulu.
- Kanahele, Pualani K. & Edward .L.H. Kanahele. 1997. A Hawaiian Cultural Assessment of the Proposed Saddle Road Alignments. Project A-AD-6(1). Hilo, HI.

-
- Kilmartin, Jerome. 1974. Na Mea o Mauna Kea (Things About Mauna Kea). *Explorers Journal* 52 (1): 12-16.
- Kjargaard, M. S. 1988. Faunal survey for the proposed VLBA antenna facility, Mauna Kea, Hamakua, Hawaii. Appendix F in MCM Planning. 1988. Final supplemental environmental impact statement VLBA Antenna Facility, Mauna Kea, Hamakua, Hawaii, September, 1988. Amendment to the Mauna Kea Science Reserve Complex Development Plan. Prepared for The National Radio Astronomy Observatory, Socorro, New Mexico.
- Koehler, R. 2008. Personal communication from R. Koehler, Director, Mauna Kea Observatory Support Services to Colleen Bergmanis, SRGII.
- Langlas, Charles. 1999. Supplement to Archaeological, Historical and Traditional Cultural Property Assessment for the Hawai'i Defense Access Road A-AD-6(1) and Saddle Road (SR200) Project.
- Laws, E. A. and A. H. Woodcock. 1981. "Hypereutrophication of an Hawaiian alpine lake." *Pacific Science* 35(3): 257-261.
- Lippiatt, S. 2005. "The isolation and identification of diatoms from Lake Waiau sediments." *Journal of Young Investigators* 13(4): 6 p.
- Lockwood, J. 2000. Mauna Kea Science Reserve Geological Resources Management Plan. Appendix H of Group 70. 2000. Mauna Kea Science Reserve Master Plan. Honolulu, HI.
- Macdonald, G. A., A. T. Abbott, et al. 1983. *Volcanoes in the sea: the geology of Hawaii*. Honolulu, University of Hawaii Press.
- Maciolek, J. A. 1969. "Fresh water lakes in Hawaii." *Verhandlungen-Internationale Vereinigung fur theoretische und angewandte Limnologie (Proceedings-International Association of Theoretical and Applied Limnology)* 17: 386-391.
- Malo, David. 1951. *Hawaiian Antiquities*. Bernice P. Bishop Museum Special Publication 2. Bishop Museum Press, Honolulu.
- Maly, Kepa. 1999. "Mauna Kea Science Reserve and Hale Pohaku Complex Development Plan Update: Oral History and Consultation Study, and Archival Literature Research. Ahupua'a of Ka'ohe (Hamakua District) and Humu'ula (Hilo District), Island of Hawai'i. In Mauna Kea Science Reserve Master Plan (Appendix I), Group 70 International, Inc. Honolulu.
- Maly, Kepa, and Onaona Maly. 2005. Mauna Kea—Ka Piko Kaulana o Ka `Aina (Mauna Kea—The Famous Summit of the Land: A Collection of Native Traditions, Historical Accounts, and Oral History Interviews for: Mauna Kea, the Lands of Ka'ohe, Humu'ula and the `Aina Mauna on the Island of Hawai'i. Prepared for the Office of Mauna Kea Management. Kumu Pono Associates LLC. Hilo.

Mauna Kea Management Board. 2004. Minutes - Regular Meeting - January 27, 2004.

Kumu Pono Associates LLC. 2006. Appendix A: Mauna Kea—Ka Piko Kaulana o Ka `Aina (Mauna Kea—The Famous Summit of the Land: A Collection of Oral History Interviews Documenting Historical Accounts and Recollections of Mauna Kea and the Mountain Lands of Hāmākua, Hilo, and South Kohala, on the Island of Hawaiʻi. Prepared for the Office of Mauna Kea Management. Hilo.

Massey, J. E.

1978. Lake Waiau : a study of a tropical alpine lake, past and present. Honolulu, HI, University of Hawaii at Manoa: 130 p.

1979. "The diatoms of contemporary and ancient sediments from Lake Waiau, Hawaii, and their geochemical environment." Review of Palaeobotany and Palynology 27(1): 77-83.

McCoy, P. C.

1977. "The Mauna Kea Adze Quarry Project: a summary of the 1975 field investigations." Journal of the Polynesian Society 86(2): 223-244.

McCoy, P. C.

1984. Mauna Kea summit region survey: a summary of the 1984 fieldwork. Honolulu, HI, Dept. of Anthropology, Bishop Museum: 11 p.

McCoy, Patrick C.

1986. Archaeological Investigations in the Hopukani and Lilo Springs Area of the Mauna Kea Adze Quarry, Hawaiʻi. Ms. on file at the Department of Anthropology, Bishop Museum.

1990. Subsistence in a "Non-Subsistence" Environment: Factors of Production in a Hawaiian Alpine Desert Adze Quarry. In *Pacific Production Systems: Approaches to Economic Prehistory*, edited by D.E. Yen and J.M.J. Mummery, pp. 85-119. Occasional Papers in Prehistory, No. 18, Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.

1999b. Neither Here Nor There: A Rites of Passage Site on the Eastern Fringes of the Mauna Kea Adze Quarry, Hawaiʻi. *Hawaiian Archaeology* 7:11-34.

McCoy, P. C. and R. A. Gould. 1977. "Alpine archaeology in Hawaii." Archaeology 30(4): 234-243.

McEldowney, Holly. 1982. Ethnographic Background of the Mauna Kea Summit Region. Report 1 In *Cultural Resources Reconnaissance of the Mauna Kea Summit Region*. Bishop Museum Department of Anthropology ms 110192.

McLaren, Robert. 2009. Personal communication from Robert McLaren, University of Hawaii Institute for Astronomy to Stephanie Nagata, Office of Mauna Kea Management, January 26, 2009.

-
- McNarie, A. D. 2004. "Mercury on the mountain." *Hawaii Island Journal* **Volume**, DOI:
- Medeiros, M. J. 2008. Personal communication from Matthew Medeiros, U.C. Berkeley, to Jennifer Garrison, SRGII, regarding moth species diversity on Mauna Kea.
- Melvin, D. 1988. "Poliahu : snow goddess of Mauna Kea." *Spirit of Aloha* **13**(6): 51.
- Mitchell, C., C. Ogura, D. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard and A. McClung. 2005a. Hawaii's comprehensive wildlife conservation strategy. As submitted to the National Advisory Acceptance Team, Dept. of Land and Natural Resources Honolulu, HI. Retrieved from <http://www.state.hi.us/dlnr/dofaw/cwcs/>
- Moore, J. G. and D. A. Clague. 1992. "Volcano growth and evolution of the island of Hawaii." *Geological Society of America Bulletin* **104**(10): 1471-1484.
- Mueller-Dombois, D. and F. R. Fosberg. 1998. *Vegetation of the Tropical Pacific Islands*. New York, Springer-Verlag.
- Mueller-Dombois, D. and V. J. Krajina. 1968. Comparison of east-flank vegetations on Mauna Loa and Mauna Kea, Hawaii. *Proceedings of the Symposium on Recent Advances in Tropical Ecology*. Varanasi, India., Varanasi International Society for Tropical Ecology: p. 508-520.
- Nagata, S. 2007. Personal communication from Stephanie Nagata, OMKM, to Kristin Duin and Jennifer Garrison, SRGII, regarding MKSR.
- NASA. 2005. *Final Environmental Impact Statement for the Outrigger Telescopes Project, Mauna Kea Science Reserve, Island of Hawaii*. National Aeronautics and Space Administration (NASA), Universe Division, Science Mission Directorate, Washington, D.C.
- Neal, M. C. 1939. "Vegetation of Lake Waiau, Hawaii." *Paradise of the Pacific* **51**(10): 7, 32.
- Nullet, D., J. O. Juvik, et al. 1995. "A Hawaiian mountain climate cross-section." *Climate Research* **5**: 131-137.
- Oboyski, P. T. 2008. Personal communication from Peter Oboyski to Jennifer Garrison, SRGII, regarding arthropods at Hale Pohaku and in the Mauna Kea Science reserve.
- Orr, Maria. 2004. Cumulative Cultural Impact Study/Assessment, Desktop Study & Ethnographic Survey, NASA W.M. Keck Observatory Outrigger Telescopes, Mauna Kea, Kahohe & Humu'ula Ahupua'a, Moku of Hamakua & Hilo, Hawaii. Prepared for International Archaeological Institute, Inc. (IARII), National Aeronautics and Space Administration (NASA), Tetra Tech, Inc., and Science Applications International Corporation (SAIC).

Parker, Patricia L. & Thomas F. King. 1998. *National Register Bulletin 38: Guidelines for Evaluating and Documenting Traditional Cultural Properties*. U.S. Department of the Interior, National Park Service, National Register of Historic Places.

PHRI (Paul H. Rosendahl, Ph.D., Inc.) 1999. Cultural Impact Assessment Study – Native Hawaiian Cultural Practices, Features, and Beliefs Associated with the University of Hawai'i Mauna Kea Science Reserve Master Plan Project Area. Prepared for University of Hawai'i Mauna Kea Science Reserve Master Plan, Technical Report for Environmental Impact Study.

Polhemus, D. A. 1998. *Nysius aa* (Heteroptera: Lygaeidae), a new species of micropterous wekiu bug from the summit of Mauna Loa volcano, Hawaii. Proceedings of the Entomological Society of Washington 100(1): 25-31.

Polhemus, D. A. 2001. A preliminary survey of Wekiu Bug populations at Puu Hau Kea, in the Mauna Kea Ice Age Natural Area Reserve, Hawaii Island, Hawaii. Smithsonian Institution Washington, D.C.

Porter, S. C. 1972a. "Buried caldera of Mauna Kea Volcano, Hawaii." Science 175: 1458-1460.

Porter, S. C. 1972b. "Distribution, morphology, and size frequency of cinder cones on Mauna Kea Volcano, Hawaii." Geological Society of America Bulletin 83(12): 3607-3612.

Porter, S. C.

1972. "Distribution, morphology, and size frequency of cinder cones on Mauna Kea Volcano, Hawaii." Geological Society of America Bulletin 83(12): 3607-3612.

1979a. "Hawaiian glacial ages." Quaternary Research 12: 161-187.

1979b. "Quaternary stratigraphy and chronology of Mauna Kea, Hawaii: A 380,000-yr record of mid-Pacific volcanism and ice-cap glaciation." Geological Society of America Bulletin, Part II 90(7): 908-1093.

1997a. "Late Pleistocene eolian sediments related to pyroclastic eruptions of Mauna Kea volcano, Hawaii." Quaternary Research 47(3): 261-276.

1997b. "Volcanic loess and dune sand related to late Pleistocene eruptions of Mauna Kea Volcano, Hawaii [abs.]." Geological Society of America Abstracts with Programs v. 29(no. 5): p. 57.

2005. "Pleistocene snowlines and glaciation of the Hawaiian Islands." Quaternary International 138-139: 118-128.

Porter, S. C. and R. A. Englund. 2006. Possible geologic factors influencing the distribution of the Wekiu Bug on Mauna Kea, Hawaii. Hawaii Biological Survey Report 2006-031. Prepared for the Office of Mauna Kea Management by S.C. Porter and R.A. Englund, Hawaii Biological Survey, Bishop Museum Honolulu, HI.

-
- Porter, S., M. Stuiver, et al. 1977. "Chronology of Hawaiian glaciation." *Science* **195**: 61-63.
- Preston, E. D. 1895. Determination of latitude, gravity, and the magnetic elements at stations in the Hawaiian Islands, including a result for the mean density of the earth, 19-891, 1892. In *Report of the Superintendent of the United States Coast and Geodetic Survey for the Fiscal Year Ending June 30, 1893, part II*. Washington, D.C.: Government Printing Office.
- Pukui, Mary Kawena, and Samuel Elbert. 1971. *Hawaiian Dictionary*. University Press of Hawaii. Honolulu.
- Pukui, Mary Kawena, E.W. Haertig, & Catherine A. Lee. 1972. *Nānā I Ke Kumu (Look to the Source)*. Volume 1. Hui Hānai, Honolulu, HI.
- Raine, C. T. 1939. "Meteorological reports of the Mauna Kea Expedition, 1935 (II); the meteorological observations at Lake Waiau, August 8-19, 1935." *Bulletin of the American Meteorological Society* 20: 97-103.
- Richardson, M. 2002. Life in Mauna Kea's alpine desert. *Endangered Species Bulletin* 27(2): 22-23.
- Robichaux, R. H., S. Bergfeld, M. Bruegmann, J. Canfield, P. Moriyasu, T. Rubenstein and T. W. Tunison, Frederick. 2000. Reintroducing Hawaii's silverswords. *Endangered Species Bulletin* 25(3): 22-23.
- Sato, H. H., W. Ikeda, et al. 1973. Soil Survey of the Island of Hawaii, State of Hawaii. United States Department of Agriculture - Soil Conservation Service.
- Scott, J. M., S. Mountainspring, F. L. Ramsey and C. B. Kepler. 1986. *Forest bird communities of the Hawaiian Islands : their dynamics, ecology, and conservation*. Los Angeles, CA, Cooper Ornithological Society.
- Scowcroft, P. G. and J. G. Giffin. 1983. Feral herbivores suppress mamane and other browse species on Mauna Kea, Hawaii. *Journal of Range Management* 36(5): 638-645.
- Sharp, W. D. and P. R. Renne. 2005. "The 40 Ar/39 Ar dating of core recovered by the Hawaii Scientific Drilling Project (phase 2), Hilo, Hawaii." *G³ (Geochemistry, Geophysics, Geosystems)* v. 6(no. Q04G17): doi:10.1029/2004GC000846.
- Sherrod, D. R., J. M. Sinton, et al. 2007. Geologic map of the State of Hawai'i, U.S. Geological Survey: 83 p.
- Smith, C. W., W. J. Hoe and P. J. O'Conner. 1982. Botanical Survey of the Mauna Kea summit above 13,000 feet. Prepared for Group 70. October 1982.
- Thrum, Thomas G. 1921. Notes. In Kenneth P. Emory, *An archaeological Survey of Haleakala*. Bernice P. Bishop Museum Occasional Papers 7(11):237-259. Honolulu.
- Tomlinson, A. 2007. Personal communication from Andrew Tomlinson, PCSI, to Jennifer Garrison, SRGII, regarding location of Mauna Kea silversword in the MKSR.

-
- Ugolini, F. C. 1974. "Hydrothermal origin of the clays from the upper slopes of Mauna Kea, Hawaii." Clay and Clay Minerals **22**: 189-194.
- UHH (University of Hawaii at Hilo) 2008. Environmental Impact Statement Preparation Notice/Environmental Assessment Thirty Meter Telescope Project, September 23, 2008.
- USFWS. 1994. Recovery plan for the Mauna Kea Silversword (*Argyroxiphium sandwicense* ssp. *sandwicense*). from http://ecos.fws.gov/docs/recovery_plans/1993/930930a.pdf.
- U.S. Geological Survey. 2002. "Mauna Kea: Hawaii's Tallest Volcano." from <http://hvo.wr.usgs.gov/volcanoes/maunakea/>.
- University of Hawaii Institute for Astronomy. 2002. Final environmental assessment for the W. M. Keck Observatory Outrigger Telescopes Project. March 2002. Outrigger. Hilo, HI.
- Valeri, Valerio. 1985. *Kingship and Sacrifice: Ritual and Society in Ancient Hawaii*. The University of Chicago Press, London.
- Wagner, W. L., D. R. Herbst and S. H. Sohmer. 1990. *Manual of the Flowering Plants of Hawaii'i*. Honolulu, Bishop Museum Press.
- Wainscoat, R. J. 2007. Protection of Hawaii's Observatories from Light Pollution. Starlight: A Common Heritage. C. Marín and J. Jafari, Starlight Initiative: 379-384.
- Walker, G. P. L. 1990. "Geology and volcanology of the Hawaiian Islands." Pacific Science v. **44**(no. 4): p. 315-347.
- Walker, M. F. 1983. "A comparison of observing conditions on the summit cones and shield of Mauna Kea." Publications of the Astronomical Society of the Pacific **95**: 903-918.
- Wentworth, C. K. 1935. "Mauna Kea, the white mountain of Hawaii." Mid-Pacific Magazine **48**(4): 290-296.
- Wentworth, C. K. 1940. "Ablation of snow under the vertical sun in Hawaii." American Journal of Science **238**(2): 112-116.
- Wentworth, C. K. and W. E. Powers. 1941. "Multiple glaciation of Mauna Kea, Hawaii." Geological Society of America Bulletin **52**: 1193-1218.
- Westervelt, W.D. 1963. *Hawaiian Legends of Volcanoes*. Reprint. Charles E. Tuttle, Rutland, VT.
- Williams, A. C. 1994. Effects of non-native grasses on a dry subalpine forest native to Hawaii and a discussion of effects of canopy on understory productivity, University of California at Berkeley: 46 pp.

-
- Wolfe, E. W. and J. Morris. 1996a. Geologic map of the Island of Hawaii. U.S. Geological Survey Miscellaneous Investigations Series I-2524-A.
- Wolfe, E. W. and J. Morris, compilers. 1996b. Sample data for the geologic map of the island of Hawaii. U.S. Geological Survey Miscellaneous Investigations Series Map I-2524-B: 3.
- Wolfe, E. W., W. S. Wise, et al. 1997. "The geology and petrology of Mauna Kea volcano, Hawaii : a study of postshield volcanism." U.S. Geological Survey Professional Paper 1557: 129 p., 4 pls. (maps) in slipcase.
- Wood, C. A. 1980. "Morphometric evolution of cinder cones." Journal of Volcanology and Geothermal Research **7**: 387-413.
- Woodcock, A. H. 1974. "Permafrost and climatology of a Hawaii volcano crater." Artic and Alpine Research **6**(1): 49-62.
- Woodcock, A. H. 1980. "Hawaiian alpine lake level, rainfall trends, and spring flow." Pacific Science **34**(2): 195-209.
- Woodcock, A. H., A. S. Furumoto, et al. 1970. "Fossil ice in Hawaii?" Nature **226**(5248): 873.
- Woodcock, A. H., R. Meyer, et al. 1966. "Deep layer of sediments in alpine lake in the tropical mid-Pacific." Science **154**: 647-648.
- Ziegler, A. C. 2002. Hawaiian Natural History, Ecology and Evolution. Honolulu HI, University of Hawaii Press.