



MAUNA KEA SCIENCE RESERVE MASTER PLAN

Prepared for:
The University of Hawai'i

Prepared by:
Group 70 International, Inc.

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MASTER PLAN ADOPTION

On June 16, 2000, the University of Hawai‘i Board of Regents adopted the following document, the Mauna Kea Science Reserve Master Plan, as the policy framework for the responsible stewardship and use of University-managed lands on Mauna Kea through the year 2020. At the same time, the Regents called for the immediate establishment of the Office of Mauna Kea Management, the Mauna Kea Management Board, and the Kahu Kūpuna Council, as the first steps in the implementation process.

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Mauna Kea Science Reserve is an 11,288 acre area of land leased by the University of Hawai'i from the State of Hawai'i for use as a scientific complex. Facility development in the Science Reserve has focussed predominantly on the summit area above 13,200 feet. Support facilities have been developed at Hale Pōhaku (elevation 9,200 feet) outside the Science Reserve. The Reserve was established in 1968 when the Board of Land and Natural Resources approved a 65 year lease (Lease No. S-4191). Two parcels in the summit region excluded from the Science Reserve belong to the Mauna Kea Ice Age Natural Area Reserve (NAR).

The University of Hawai'i adopted the Mauna Kea Science Reserve Complex Development Plan (CDP) in 1983 which has guided development up to the present time. The CDP projected development up to the year 2000 and has been largely implemented. The 1983 Plan and the State of Hawai'i's efforts to develop astronomy as an academic discipline and an industry have been largely successful. Today, Mauna Kea is known as the premier location for astronomy in the Northern hemisphere and has a significant positive economic impact on the State of Hawai'i and the Big Island. This report is an update of the 1983 Plan and extends the planning horizon to the year 2020.

The Plan also addresses issues and concerns that have arisen in 30 years of development on the mountain. It specifically addresses comments and recommendations included in the 1998 Legislative Auditor's report on the management of Mauna Kea. The Plan integrates future uses (education, research, culture and recreation) with a deeper awareness of the natural and cultural resources and significance of Mauna Kea. In particular, the Plan lays the groundwork for implementation of educational outreach to the native Hawaiian community at primary, secondary, and post-secondary levels. New ethnographic, archaeological and biological studies of the mountain have expanded knowledge and increased sensitivity to the special qualities that make Mauna Kea a unique place on the planet.

The Master Plan report is structured in three parts. The first section lays out the direction and methodology of the Plan. The second section identifies the major components of the Plan. This section presents existing conditions and the historical background of these components. It also includes a chapter on issues and opportunities. The third section integrates these components into physical and management plans which make up the Master Plan. The physical and management plans represent a major change in the allocation of use areas and management structure.

New Management Organization: To implement this Plan a new management structure with a single point of contact located on the Island of Hawai'i is recommended. This organization would be an operational unit within the administrative purview of the Office of the Chancellor at UH Hilo. The organization would have a director, administrative staff, rangers and maintenance personnel. Additionally, it would serve as the nerve

center for volunteers and organizations affiliated with Mauna Kea. This single point of contact, given comprehensive management authority located in Hilo and on the mountain, would integrate management responsibilities to protect the sustainability of Mauna Kea's resources. It would coordinate interagency issues and be a conduit to the community. The continuous presence of rangers on the mountain at all times is expected to vastly improve stewardship of Mauna Kea. Being an operational unit of UH Hilo emphasizes the permanence of the organization and the University's commitment to its operations.

Community Involvement: The Plan recommends that the University appoint a Mauna Kea Management Board to provide the community with a direct voice into the management of the mountain. Additionally, a Kahu Kupūna Council is recommended to provide advice and direction on native Hawaiian cultural issues. Establishment of a professional Design Review Committee is also recommended. This Committee would review all project proposals to ensure that project plans conform to the design guidelines and intents of the Master Plan. Additionally, a docent program and other volunteer programs coordinated by the new management organization would provide nearly constant, intimate community involvement in the care of the mountain. Community input during the Master Plan process is addressed in Section XII.

Management Policy Guidelines: The Plan recommends management policy guidelines that may be further developed and adopted by the new management organization. Hours of operation and the possible development of a shuttle service are proposed for safety and resource protection. Recommendations are also made concerning the support facilities at Hale Pōhaku and the summit and concerning safety and security procedures. Public access would remain open but may be managed through registration as needed for safety or resource protection purposes. All existing uses such as snow playing, skiing and hunting will be permitted. Hunting usually occurs in the lower elevations. Parking areas would be increased incrementally at Hale Pōhaku, and near the summit "Poi Bowl" area as demand increases. There would be no restrictions on religious worship.

Physical Planning Guide: The Physical Planning Guide consists of four major components: natural resources, culture, education and research, and recreation. The existing 11,288-acre Science Reserve would be divided into two areas under the new Plan. The great majority of the Science Reserve (95%) will become a 10,760-acre Natural/Cultural Preservation Area, with no development activity. The remaining 525 acres (5%) are designated as an Astronomy Precinct, thereby greatly reducing the area previously available for astronomy development. The 525-acre area would be subject to architectural, environmental, and cultural controls. All currently undeveloped summit *pu'u* (hills or cinder cones) would remain undeveloped. Support facilities at Hale Pōhaku would be expanded incrementally as needed, and existing construction cabins will become available for public use. Management and expansion of the facilities at Hale Pōhaku would accommodate other educational and research programs as well as cultural and recreational uses that are compatible with ongoing operations. A common database containing information about all the major components is recommended to facilitate management efforts and integrate policies.

The Physical Planning Guide directs future development on the mountain in three ways. First, the Plan consists of plans, maps, geographic information system (GIS), and criteria, which promote the sustainable use, enhancement and development of the Mauna Kea Science Reserve. Second, design guidelines and project review procedures guide physical development through assessments of site location, size, mass, color and other physical attributes. Third, it identifies an Astronomy Precinct which contains astronomy development within and near existing developments and creates a natural/cultural preservation area for the remainder of the Science Reserve. The following highlights some of the important concepts associated with each component area:

Natural Resources: Natural resources are protected in the following way:

- Identification and GIS mapping of resources.
- The bulk of the Science Reserve (10,760 acres) is designated as a natural and cultural preservation area.
- Future facilities will be designed and sited to avoid and minimize impacts to sensitive habitat and rare or fragile geological features. Additionally, development approvals would contain conditions for the protection of natural resources.
- Registration procedures and signage plans would be geared to educate visitors about the value and fragility of these resources.
- Volunteer groups would be encouraged to adopt the mountain and support activities that sustain the mountain.

Archaeology and Culture: The cultural resources component includes the following:

- GIS mapping of known features.
- Designation of 10,760 acres as a Natural and Cultural Preservation Area. This designation highlights the cultural values of Mauna Kea.
- The importance of geo-physical forms such as Pu‘u Poli‘ahu, Pu‘u Lilīnoe, other summit *pu‘u* and Wai‘au is recognized and protected in the Plan. All undeveloped *pu‘u* are preserved.
- A view corridor to the west is preserved based on a common cultural practice with a potential for future interpretation.
- Modern cultural practitioners would have unrestricted access.
- The formation of a Kahu Kupūna Council to provide advice and facilitation in cultural matters is recommended.
- Photographic monitoring of historic sites is suggested.
- Registration procedures, signage and docent programs are recommended to educate the public on the value of cultural resources and the appropriate protocol for movement in sensitive areas.
- Special development protocols are recommended to avoid inadvertent impacts on cultural properties.
- Management practices would be coordinated with the State Historic Preservation Office.

Education and Research: The education and research component includes the following proposed actions and developments:

- Recycling of up to five of the existing observatory sites with renovations or newer Optical/Infrared facilities. Five potential recycle sites are identified.
- Expansion of the Keck facility to include 4 to 6 outrigger telescopes within the existing Keck site and no higher than 1/3 the height of the existing Keck telescopes.
- Expansion of the Submillimeter Array to include up to 24 new pads and 12 new antennas in addition to the 12 currently permitted antennas.
- One additional site for a new conventional Optical/IR instrument on the north plateau.
- Site for a Next Generation Large Telescope with a mirror 25 to 50 meters in diameter.
- Expanded educational outreach, with particular emphasis on native Hawaiians.
- A UH Hilo instructional telescope and site to replace the existing cinderblock building located between the UKIRT and UH 24-inch telescopes. The telescope is designated for use in teaching and training students. Besides basic undergraduate education, this facility would facilitate training for jobs in astronomy.
- The total economic impact of the mountain's existing observatories in the State is estimated at \$142 million annually. This includes employment and expenditures directly related to telescope operations as well as the indirect impact of purchases made by astronomy-related firms and employees. Construction expenditures in the County of Hawai'i have totaled approximately \$207 million to date.
- Other academic disciplines and programs are specifically encouraged to view the mountain as an outdoor classroom and laboratory. These efforts would be supported at Hale Pōhaku and the summit area.
- Joint use of existing facilities/new support facilities at Hale Pōhaku.
- Docent programs in broad areas of natural, cultural and educational areas within the management plan.
- Special educational and cultural events at Hale Pōhaku.

Recreation: Recreational opportunities are protected and supported as follows:

- A public recreational shelter and comfort station is included for visitors, spectators and recreationalists in the Astronomy Precinct summit snow area.
- Recreational activities that are currently allowed will continue to be permitted.

This document, the UH Mauna Kea Science Reserve Master Plan, provides the policy framework for the responsible stewardship and use of University-managed lands on Mauna Kea through the year 2020. It proposes several significant land use and management structural changes based on a new paradigm of the University's leased lands as a natural and Hawaiian cultural reserve in addition to being a Science Reserve. This framework represents a vision which will require conscientious implementation and development over the years to realize, yet one which promises the achievement of stated goals and objectives of the Master Plan. As these goals and objectives are realized, it is hoped that Mauna Kea will increase in its meaning and value to many individuals and groups in the community who see it as a unique treasure worthy of our respect and care.

MAUNA KEA SCIENCE RESERVE MASTER PLAN

I. INTRODUCTION

INTRODUCTION

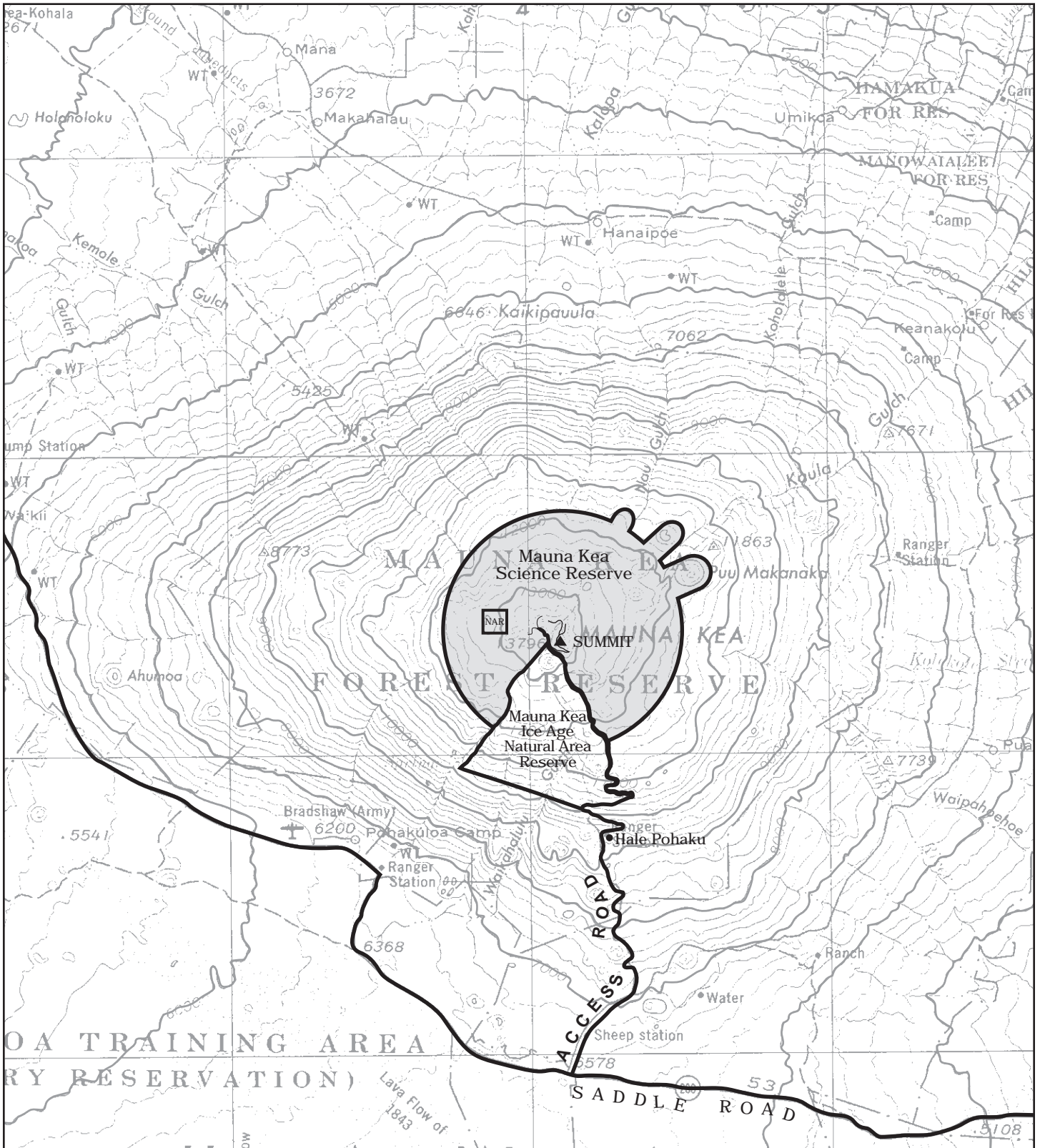
The ancient saying “*Mauna Kea kuahiwi ku ha‘o i ka mālie*” (Mauna Kea is the astonishing mountain that stands in the calm) (Pukui 1983: No. 2147), expresses the universal feeling experienced by all who come in contact with this special place. Standing tall over the Island of Hawai‘i, Mauna Kea is home to vast physical, natural and cultural resources (Figure I-1). From early adze makers to modern day astronomers, Mauna Kea has long been a special place for work, worship, and reflection. For native Hawaiians, both ancient and modern, the feelings for Mauna Kea go beyond wonder and astonishment, to the recognition of the mountain as a sacred domain. These profound feelings of reverence are expressed in the saying: “*O Mauna Kea ko kākou kuahiwi la‘a*” (Mauna Kea, our sacred mountain). As with other ethnic cultures throughout the world, early Polynesians believed their highest points of land were the most sacred; and Mauna Kea having the highest mountain top in all of Pacific Polynesia, was considered the most sacred place of all. Standing tall over the island of Hawai‘i, Mauna Kea was host to early Hawai‘ian traditions which included religious practices, study of the heavens, and tool making in the Keanakāko‘i adze quarry.

For many years hikers, hunters, scientists, worshippers, and skiers have come to the highest mountain in the Pacific Basin. In the past three decades the Mauna Kea Science Reserve has evolved into the world’s premier astronomy complex. Mauna Kea’s observatories are known worldwide for their advanced technologies, excellent viewing environment, and the discoveries that have been made with these facilities. The development of this complex has not come without its costs. The roadway that was installed for the testing and construction of the first telescopes has opened the mountain to all. Physical development, foot and vehicular traffic, and the byproducts of man’s use of the mountain have all left temporary and permanent impacts on the mountain. More positively, the access has provided a wealth of information and enjoyment for those who have taken interest in this great mountain.

The Science Reserve is a 11,288 acre area of land that is leased by the University of Hawai‘i from the State of Hawai‘i for use as a scientific complex (Figure I-2). The astronomy complex is centered near the middle of the summit plateau while the remainder of the Science Reserve serves as a buffer area. The Science Reserve is a circular area (2.5 miles in radius) centered on the Mauna Kea summit -- approximately those lands above the 12,000 foot elevation -- except for those areas that are part of the Mauna Kea Ice Age Natural Area Reserve.

Tomorrow, when we are gone, man will continue to look to his ancestors for wisdom and guidance, seek knowledge and joy in his physical world, and look to the stars and elsewhere to answer universal questions. Given the changes that Mauna Kea has experienced over time, we must ask ourselves what the mountain will be like in the future. Will this cultural treasure be well cared for and preserved? Will it be more accessible to hikers, cultural practitioners, scientists, students, and skiers? Will its natural





Mauna Kea Science Reserve

Mauna Kea Science Reserve
Master Plan



Figure 1-2
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resources be in better condition than they are today? Will native Hawaiians again play leading roles in discoveries and way finding for humanity? The answers will rest in the hands of those who accept the responsibility of stewardship entrusted to them.

The Mauna Kea Science Reserve Master Plan is an update and extension of the 1983 Mauna Kea Science Reserve Complex Development Plan. The 1983 Plan provided a physical plan for astronomy development to the year 2000 and presented a management plan and implementation strategy for managing and monitoring the various uses of the mountain. The purpose of this Plan update is to develop physical and management plans to guide the use of and facility development within the Mauna Kea Science Reserve, Summit Access Road, and Hale Pōhaku, for the next twenty years.

The 1983 Plan has largely been implemented in terms of the astronomy facilities that have been built or are under construction and the improvements that have been made to the infrastructure and mid-elevation facilities. This planning effort extends the physical planning for the mountain another 20 years and more fully integrates non-astronomy resources and uses. The management plan offers an organizational solution and policy guidance to address some of the use conflicts, maintenance, and access issues that exist today. The Master Plan assumes that the Mauna Kea Science Reserve will continue, and even grow, in importance to scientists, educators, naturalists, and recreational users in the years to come.

The Master Plan report is structured in three parts. The first section includes the introduction, goals and objectives, and methodology, which establish the direction and process for the Plan. The second section details the components that make up the physical environment and human use of Mauna Kea. The relationships among these components – the natural environment, culture, education and research, and recreation – are analyzed and integrated into future plans in the third section of the Master Plan. The physical and management plans which make up the Master Plan propose facilities, supporting infrastructure, preservation areas, and a management structure and policies to guide the future of uses within the Science Reserve.

This approach to the Master Plan is based on the principles of integrated cultural and natural resources management planning. This Plan appreciates and respects the interrelationships of all facets of the natural systems and cultural context of the site and provides a framework for sustainable development on the mountain. The Plan values preservation and interpretation of indigenous natural and cultural resources and the uniqueness of these resources on Mauna Kea. The proposed Plan, in its simplest sense, attempts to balance economic and scientific prosperity, social equity, cultural values, and environmental integrity.

MAUNA KEA SCIENCE RESERVE MASTER PLAN

II. GOALS AND OBJECTIVES

GOALS AND OBJECTIVES

The following goals and objectives were established to guide the preparation of the Master Plan.

Update the 1983 Mauna Kea Science Reserve Complex Development Plan by:

- 1) Developing a vision for the sustainable use and enhancement of the Mauna Kea Science Reserve as a Hawaiian place with significant and unique cultural, natural, educational/ research and recreational values, meanings and potentials, both locally and globally.
- 2) Integrate and balance cultural, natural, education/research and recreational values and uses in a physical and management plan which will remedy existing problems and provide a framework and structure for the responsible and sustainable stewardship of the Mauna Kea Science Reserve.

These goals have been carried throughout the master planning process from the integration of data to the formulation of physical plans and a proposed management structure. The goals of sustainability and integration should continue to guide the future decision making for Mauna Kea through and beyond the implementation of this plan.

A. Cultural Objectives

- 1) Promote a greater knowledge base and understanding of cultural resources, Hawaiian cultural practices, and significance of archaeological sites, place names, and geophysical elements (such as cinder cones, glacial deposits, etc.), through the planning process.
- 2) Preserve and manage cultural resources in a sustainable manner so that future generations may share in the understanding and knowledge of the mountain's archaeological and cultural sites.
- 3) Protect the opportunities for individuals and groups to engage in cultural practices.
- 4) Define areas, criteria and support facilities for cultural resources and practices, as applicable, to allow for sustainable, integrated planning and management.
- 5) Preserve the cultural landscape to enhance meaning, relationships, and resources for modern appreciation, research, and practice.

The cultural objectives recognize that Mauna Kea, the highest point in Pacific Polynesia, is a revered resource and the site of Hawaiian cultural practice today. This plan

encourages preservation of cultural resources and at the same time supports use and further understanding of the mountain's resources by practitioners and others.

B. Natural Resources Objectives

- 1) Promote a greater knowledge base focused on the most critical natural resources to include flora, fauna, and natural landforms, through the planning process.
- 2) Protect and preserve, through planning and management, unique geological features and biological communities, recognizing the symbiotic relationship between the two in the Science Reserve.
- 3) Use natural resource areas for recreation in a manner that both protects the resources and promotes the safety of individuals.
- 4) Allow for current and future use of natural resources for educational programs and Hawaiian cultural practices for the community, schools and universities, and visitors.
- 5) Protect the mountain's natural landscape to preserve its cultural and scenic values.
- 6) Define specific areas and criteria for natural resource use as applicable, to allow for sustainable, integrated planning and management.

As in the case of cultural resources, the Master Plan encourages greater understanding, appropriate use, and preservation of the mountain's natural resources. The Master Plan objectives call for the integration of natural resources with cultural resources and use, education and research, and recreation components.

C. Education/Research Objectives

- 1) Expand knowledge of the Science Reserve as an educational resource for the benefit of the community, including native Hawaiians, students, researchers, and visitors, through the planning process.
- 2) Protect natural and cultural resources and insure managed access to the Science Reserve for education and research use.
- 3) Protect and enhance astronomy research at Mauna Kea as the premier observatory site in the Northern Hemisphere.
- 4) Define areas, criteria and support facilities for education and research as applicable, to allow for sustainable, integrated planning and management.

The education and research objectives recognize the importance of astronomy activity at Mauna Kea and encourage appropriate use of the mountain for further education and research use in other fields to include science and cultural fields.

D. Recreational Objectives

- 1) Expand understanding of recreational uses and potentials of the Science Reserve.
- 2) Retain and enhance recreational opportunities within the Science Reserve, while protecting natural resources, cultural resources, and cultural practices.
- 3) Define areas, criteria and support facilities for recreational uses, sightseeing and commercial tours, as applicable, to allow for sustainable, integrated planning and management.

The above objectives encourage mixed use of Mauna Kea in an organized setting and with the primary importance given to the preservation of the resources of the mountain. Recreational activities are guided in a direction that promotes safety and practices that respect the mountain's natural and cultural values.

E. Physical Plan Objectives

- 1) Create physical plans, maps, and criteria which promote the sustainable use, enhancement and development of resources of the Science Reserve in order to:
 - Protect historic/cultural resources and practices: e.g. archaeology sites, Hawaiian cultural practices
 - Protect natural resources: e.g. Wēkiu habitat, alpine ecosystem
 - Protect and enhance education and research: e.g. astronomy, ecology, geology
 - Protect and enhance recreational opportunities: e.g. hiking, skiing
- 2) Analyze and depict physical implications of uses over time; address and mitigate visual and environmental impacts.
- 3) Guide future physical development, not only locationally, but with respect to character, size, mass, color and other physical attributes.
- 4) Define infrastructure and elements to support goals regarding natural resources, culture, education/research, and recreation.

These objectives are further detailed in the Physical Planning Guide (Section IX).

F. Management Plan Objectives

- 1) Create a funded structure for sustainable, focused management of resources and operations of the Mauna Kea Science Reserve in order to:
 - Protect historic/cultural resources: e.g. archaeology sites, Hawaiian cultural practices
 - Protect natural resources: e.g. Wēkiu habitat, alpine ecosystem
 - Protect and enhance education and research: e.g. astronomy, ecology, geology, Hawaiian culture and archaeology
 - Protect and enhance recreational opportunities: e.g. hiking, snow play, skiing
 - Promote public safety

- 2) Create a funded structure which meets the following objectives:
 - Promotes community input.
 - Establishes local management.
 - Establishes a focal point for management responsibility.
 - Establishes clear lines of decision making and accountability.
 - Is economically and structurally feasible.
 - Provides a base for future expansion of the scope of activities in the Science Reserve.

These objectives are further detailed in the physical and management plan sections (Sections IX and X).

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

III. METHODOLOGY

METHODOLOGY

During the preparation of the 1983 plan, studies were undertaken which were the first of their kind on Mauna Kea and which provided valuable scientific, archaeological, and ethnographic information. Follow-up work and additional studies have been accomplished in the preparation of this Master Plan as follows:

Dr. Francis Howarth of the Bishop Museum and colleague Greg Brenner have conducted field work and analysis updating arthropod studies done in the 1980s. During the earlier work, Howarth and his team identified numerous arthropods including the Wēkiu bug, which exists only on Mauna Kea and which had not been discovered previously. Recently, Howarth and Brenner tested the bug's population distribution, assessed seasonal trends, and expanded on their understanding of the bug. Their surveys also included other endemic and introduced species.

Archaeologist Patrick McCoy has worked on Mauna Kea for over two decades studying sites in the Mauna Kea Science Reserve and in the Mauna Kea Ice Age Natural Area Reserve. A total of 93 archaeological sites have been identified in surveys encompassing some 3000 acres of land in the Science Reserve (McCoy, 1999). McCoy and Holly McEldowney, both with the State Historic Preservation Division, have prepared an historic preservation management plan for Mauna Kea. The plan identifies and assesses the archaeological sites that have been found in the Science Reserve and suggest guidelines for the future management of the sites and the broader summit plateau.

Cultural specialist Kepā Maly has conducted oral history interviews and archival research to “document some of the traditions and practices associated with Mauna Kea, and to identify some of the significant features of the landscape, including natural and man-made cultural resources on Mauna Kea so that they can be protected, preserved, and appropriately managed in the future” (Maly, 1999).

In addition to Maly's work for this Plan, he conducted earlier archival research of the Humu'ula and Ka'ohē *ahupua'a* for the Native Lands Institute (Maly, 1998). Other cultural specialists have also conducted ethnographic research that is valuable to this effort. Edward and Pualani Kanahēle (1997), and Charles Langlas (1997) conducted studies in association with the Saddle Road Improvement project. Their work provides important information and adds to the greater understanding of Mauna Kea as a cultural place.

The ongoing studies of the natural and cultural resources of Mauna Kea provide sound information that can be used for physical planning and management policy decision-making. In preparing this plan, recent and historical data were compiled in a Geographic Information System (GIS). Information on slope, Wēkiu bug habitat, flora, archaeological sites, cultural landscape features, roads, and astronomy facilities were layered together and analyzed in relationship to one another. These components are

described in Sections IV through VII and analyzed in Section IX. By looking at the information in an integrated way, areas that must be protected and areas that can be used for educational and recreational uses and facilities, including new astronomy facilities, are identified. The physical and management plans included in this Master Plan recommend the continued integration of knowledge, resources, uses and management practices.

In addition to expert research, this planning process incorporates broad community input. In the Spring of 1998, University of Hawai'i president Kenneth Mortimer invited twenty-four individuals to serve on the Mauna Kea Advisory Committee to "help the University of Hawai'i as it plans for future facilities development on the mountain and strives to improve its management of the Science Reserve and the Visitors' Station at Hale Pōhaku." (Mortimer, May 8, 1998) Committee members represented various organizations including the University of Hawai'i at Hilo, the UH Institute for Astronomy, environmental groups, the business community, native Hawaiian organizations, state agencies, county government, and the broader Hawai'i community. In his invitation to the individual committee members the President stated that "The purpose of the Mauna Kea Advisory Committee in its broadest terms is to provide needed input to the University of Hawai'i and the people of the State of Hawai'i regarding the conditions under which future development should occur on Mauna Kea" (Mortimer, May 8, 1998).

This Committee met regularly from June, 1998 to August, 1999 to discuss existing conditions, management issues, and the future uses and management of Mauna Kea. The Committee invited various experts to their meetings and conducted an initial round of public meetings to gather the opinions and suggestions of the broader Hawai'i Island community. Public meetings were held in the communities of Waimea, Kona, and Hilo on August 31, September 1, and September 3, 1998, respectively. Approximately 50 individuals attended the Waimea meeting, 15 attended the Kona meeting, and 100 attended the meeting in Hilo (all numbers are estimates). A variety of views were expressed during these meetings. Some individuals expressed the need for better management of the mountain's resources. Some felt that no more astronomy facilities should be developed on the Mauna Kea summit plateau. Others expressed an appreciation for the scientific and economic benefits provided by the astronomy industry and a desire for astronomy to continue and expand.

During Advisory Committee meetings, several members presented specific proposals, representing their views or the views of organizations they represent. Committee members reviewed and discussed proposals before providing recommendations.

The Committee conducted a second series of public meetings during which specific physical and management proposals were presented to the community. As in the first series of public meetings, these were held in Waimea, Kona, and Hilo on May 24, 25, and 27, 1999, respectively. During these meetings a slide presentation was given by Group 70 International, Inc. The presentation reviewed the natural, cultural, recreational and educational resources of the mountain and introduced the master plan, with proposed

facilities and management structure. Community members were asked to share their reactions and proposals for the mountain. Based on their own deliberations and the feedback received from the community, the Mauna Kea Advisory Committee formulated and forwarded their recommendations to the University President. In addition to the information shared in Committee meetings and public meetings, Group 70 also met with other community members, groups, and experts to discuss possible recommendations for the physical and management plans. Among those contacted were representatives of the astronomy community nationwide, the National Park Service, the Department of Land and Natural Resources, the UH Administration, the Department of Hawaiian Home Lands, and representatives of various Hawai'i Island organizations such as the ILWU, Chambers of Commerce, and local school administrations. This report, while a product of Group 70 International which is responsible for any errors, therefore incorporates the recommendations of the Mauna Kea Advisory Committee, and the input of many other stakeholders.

An Environmental Impact Statement (EIS) has been prepared for this Master Plan in accordance with Hawai'i Revised Statutes, Chapter 343. During the public review process, the comments received from the public and from governmental agencies were assessed and responses incorporated into the revised Master Plan report. The Final EIS was accepted by the Governor on February 2, 2000. The University of Hawai'i Board of Regents adopted the Mauna Kea Science Reserve Master Plan in June 2000.

PLANNING COMPONENTS BACKGROUND SECTIONS

Natural Environment Culture Education and Research Recreation Issues and Opportunities

In Hawai‘i and elsewhere, those who know of Mauna Kea have a personal sense of the mountain and its resources. While each has their own experience and perception, there is a wealth of historical and scientific knowledge available for sharing and for use in planning for the future of the mountain.

The following sections explore the use and resource components that combine to create the unique history, landscape and activities of Mauna Kea. The natural environment – the *pu‘u*, glacial remains, atmospheric qualities, and views - and cultural resources – landscape and archaeological sites - of Mauna Kea shape much of today’s use of the mountain. Because of the unique natural and cultural qualities of the mountain, its slopes and summit plateau are used by a variety of individuals and organizations for cultural practice, education, research, and recreation.

Natural environment, culture, education and research, and recreation components are presented in the following sections. Previous studies are reviewed and on-going research is discussed. Current uses are explored as are the potentials for new uses in the future. The use and management of these components, and their relationships with each other create both issues that must be addressed and opportunities that may be explored. These issues and opportunities are also discussed.

Taken as a whole, these sections provide the basis for the development of the physical and management plans that follow. Many of the Master Plan’s recommendations are based on the research and issues explored here.

MAUNA KEA SCIENCE RESERVE MASTER PLAN

IV. NATURAL ENVIRONMENT

NATURAL ENVIRONMENT

Geologic History

The Hawaiian Archipelago, extending 2,200 miles across the Pacific Ocean, was built almost entirely by volcanic activity. The oldest of the volcanoes are in the northwest and the youngest extend to the southeast. Each island is the top of an enormous volcano that grew from the seafloor to above sealevel, modified by stream and wave erosion and by minor amounts of organic reef growth.

Mauna Kea formed as a shield volcano that was later modified by neatly formed cinder cones and associated blocky lava flows. It is a dormant postshield stage volcano that last erupted about 4,500 years ago; and hence cannot yet be labeled as extinct. The oldest exposed lava flows on Mauna Kea are approximately 250,000 years old. The mountain's latest volcanic activity was characterized by explosive eruptions that produced widespread ash deposits. (Clague in Atlas of Hawaii , 1998).

The dome of Mauna Kea measures 30 miles across and is studded with cinder cones in a pattern indicating that the volcano was built over rifts extending eastward, southward, and westward. The volcanic rocks of Mauna Kea are divided into two series. The older Hamakua series is made up chiefly of primitive olivine basalts and forms the bulk of the mountain. The overlying Laupahoehoe volcanic series predominantly consists of andesine andesites ("hawaiites") and forms a thin veneer over the upper part of the mountain. The Laupahoehoe series is the thickest at the Mauna Kea summit where it has filled in the summit caldera. This volcanic series is characterized by both short and long *a'a* flows and bulky cinder cones. (Stearns, 1966).

During the last glaciation of the Pleistocene epoch, an ice cap covered approximately 27 square miles of the summit area of Mauna Kea (Porter, 1979). The tops of several of the mountain's cinder cones stood above the ice cap, which had an average thickness of 200 feet and a maximum thickness of 350 feet in places. Within the limits of this glacier, which reached down to the 11,000 and even the 10,500-foot elevation, many areas were scraped bare of ash and cinder. (Macdonald and Abbott, 1970).

The scouring action of the glacier is documented today by the common occurrence of glacially polished rock outcrops in the summit area and by glacial till deposits and classic terminal moraines such as those of Pohakuloa Gulch. In other parts of the summit plateau, oversteepened sides of *pu'u* and large areas of glacial till indicate the extent of the glacier. Areas of buried ground ice in the craters of two of the summit cinder cones show that permafrost exists near the summit where the mean annual temperature is below freezing . Cycles of freezing and thawing continue today, creating ever-changing patterns of rock fragments. These fragments of various coarseness are constantly moving, sorted into stripes and polygons . Mauna Kea, seemingly quiet and still, is never at rest.

During this period, volcanic eruptions continued to take place beneath the ice cap, forming several subglacial lava flows. Margins of these lava flows cooled quickly against ice meltwater, creating uniquely hard, dense rock in many places. Thousands of years later, this fine-grained, dense rock was sought after by Hawaiians who used it to craft adzes.

The landscape that exists today was formed by volcanic and glacial activity and is a unique environment for insects, spiders, lichens, ferns, and mosses. Rocky outcrops, loose cinder, and smooth lava flows make up habitats that combine with the snowfall and wind patterns of the summit area to support various forms of plant and animal life.

Among the many natural features found on Mauna Kea, the small alpine lake, Wai‘au, is unique and revered. Wai‘au is a nearly circular pond, 300 feet in diameter, situated on the summit platform of Mauna Kea at an altitude of approximately 13,020 feet. It is the highest lake within the boundaries of the Pacific Ocean basin and one of the highest lakes in the United States. The southern rim of the depression containing the lake is the rim of a subglacially-formed cinder cone, Pu‘u Wai‘au. The water of the lake, a maximum of 10 feet deep, is derived entirely from precipitation and runoff from the edges of the basin. (Stearns and Macdonald, 1946)

Mauna Kea’s Flora and Fauna

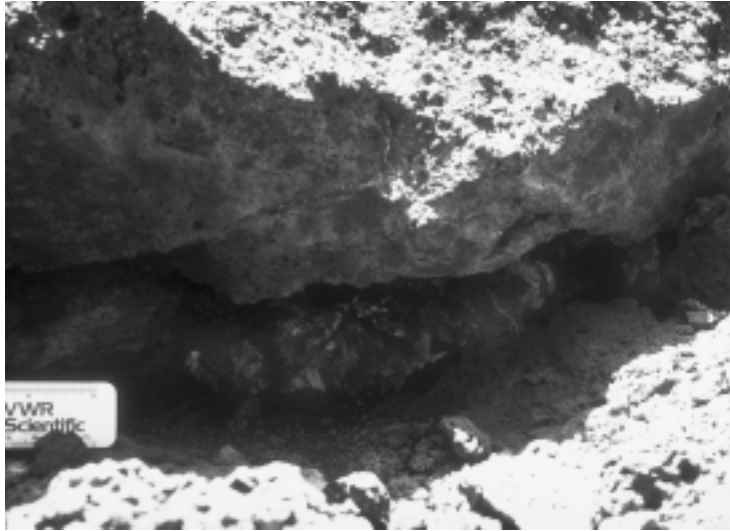
Over time, seeds and insects came to the islands carried by the wind from far away places. Some survived and some perished but eventually a diversity of plant and animal life evolved.

Hawai‘i’s plants evolved in the absence of indigenous browsing mammals and therefore bear no thorns or toxins (National Geographic, February 1999). Flightless birds adapted to an environment free of predators and were easy prey when man eventually came.

By the time the first humans arrived, the islands were lush with plants, birds, and insects. Cycles of intermittent volcanic activity have played a role in shaping how and where the species survive. The slopes of Mauna Kea host a wide range of ecosystems extending from the alpine summit region to the fertile lowlands.

Most of the Mauna Kea Science Reserve falls within the alpine ecosystem. While not obvious at first glance, the Mauna Kea summit region contains a variety of flora and fauna. Above 11,500 feet, small plants, mostly lichens, mosses, and ferns, grow in protected cracks and crevices (Figure IV-1 and Section IX).

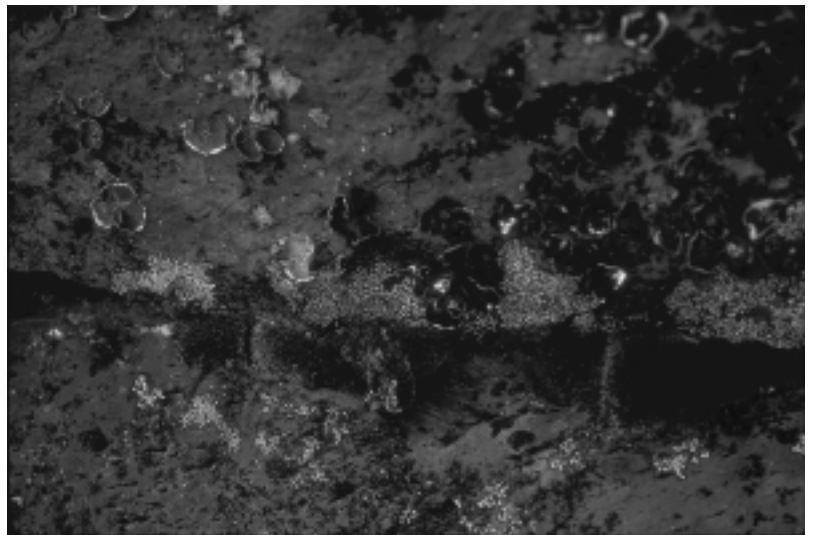
In 1982, Dr. Clifford Smith studied approximately 25 different lichen communities on Mauna Kea. Approximately half of the species are endemic to Hawai‘i, with two occurring only on Mauna Kea. High concentrations of lichens occur in areas with andesite rock outcroppings, generally on the north and west-facing sides where the lichens are able to intercept moisture from the tradewinds yet are not exposed to the full



Ferns in Crevice (Photo: Dr. Frank Howarth)



Mauna Kea Silversword (Photo: Institute for Astronomy)



Lichens & Moss (Photo: Dr. Frank Howarth)

Summit Flora Examples

sun. Fissures and small caves generally support lichen communities. In contrast, areas with cinder substrate do not provide good habitat for lichens. Winona Char (1999) indicates that lichen are found throughout the summit region.

Suitable moss habitat are widely distributed over the summit area. In his 1982 study, Dr. William Hoe collected approximately 12 species of mosses in the summit area. Less than a quarter of these species are endemic to Hawai'i. Mosses are most abundant on north-northeast facing sides of rock mounds, as well as south-southwest facing sides of these mounds. Some species are restricted to habitats that are at least partially protected by rock overhangs, while others are confined to deeply-shaded pockets and crevices where liquid water is available.

Also in 1982 Dr. Peter O'Conner studied vascular plants in the summit area of Mauna Kea and collected six different species. The *Cystopteris douglasii* is an endemic species found only in a few high altitude locations in the state. Vascular plants are found in areas of stable substrate. Most ferns are found within or at the base of andesitic rock outcrops where protection from sun and wind permits the accumulation of small amounts of soil and moisture. The Mauna Kea Silversword, a sub-species unique to this mountain, was once found in the summit area. It is suspected that feral ungulates destroyed much of this and other vegetation types.

The harsh climate of the Mauna Kea summit proves to be a difficult environment for the survival of many species. The summit region is an aeolian ecosystem where strong winds distribute dust, cinder, and food sources such as insects. The major component of the fauna on the Mauna Kea summit are arthropods such as spiders, moths, mites, springtails, centipedes, booklice, barklice, and true bugs. Feral pigs will occasionally travel to the higher elevations.

The one true bug found on the summit is the Wēkiu bug (*Nysius wēkiuicola*). The bug has been found only in the summit area of Mauna Kea above about 12,800 foot elevation, however, recent fieldwork has identified suitable habitat down to approximately 11,800 feet (Howarth, 1999) (Figure IV-2 and Section IX). A relative of this bug is found on Mauna Loa.

The Wēkiu is found under large boulders and in among loose cinders. Researchers speculate that undisturbed cinder cones allow the bug to migrate vertically within the substrate to escape cold and drought and to seek moisture. Larger pore spaces in the cinder allow movement and provide resting and hiding spaces. The Wēkiu is a long-legged, black carnivore which does not fly. The Wēkiu survives on the water and insects carried by the wind and deposited to the substrate in melting snow.

The Wēkiu has been the subject of extensive study by the team of Francis Howarth, Gregory Brenner, and David Preston. From August 1997, to September, 1998 a total of 179 person days have been spent on the mountain in sampling and reconnaissance work. The summit's areas with the most suitable habitat for the Wēkiu are shown in Figure IX-9 and discussed more in that section. In addition to broad areas of suitable substrate, the



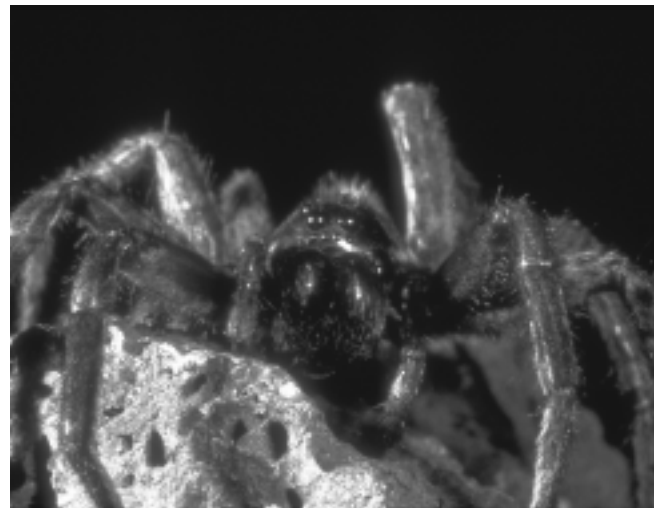
Average Size of Wēkiu Bug



Wēkiu Bug (Photo: William P. Mull)



Agrotis, moth (Photo: Stephen L. Montgomery)



Lycosa, wolf spider (Photo: William P. Mull)

Summit Fauna Examples

Mauna Kea Science Reserve Master Plan

climatic conditions above approximately 13,000 feet make habitation possible in small isolated areas where the surface geology has specific characteristics (Howarth, 1999). While there is suitable geologic conditions below 13,000 feet, climatic differences appear to be the reason for the low populations at these elevations.

Recent field studies and analysis indicate a decline in the Wēkiu population on Mauna Kea. The reasons for the decline in population are unclear at this time and may include climatic factors, man-made disturbances, alien predators or seasonal trends. A puzzling question for researchers is the lack of bugs on the undeveloped Pu‘u Mahoe in contrast to the presence of Wēkiu on the more developed Pu‘u Hau Oki, home of the Subaru Telescope (Howarth, 1999). The research and analysis of the Wēkiu bug, including management recommendations, are thoroughly discussed in the Environmental Impact Statement prepared for this Master Plan.

Other species, the Lycosid wolf spiders and noctuid moths have been found to be widespread at low to moderate population densities within the Science Reserve. Both species are good at dispersing and appear to take advantage of temporarily available resources to survive.

Further down the mountain, from approximately 11,000 foot elevation to the treeline, is alpine shrub land. *Pūkiawe* and *‘ōhelo* grow in this band on the mountain below the Science Reserve. Below the Science Reserve and in the area related to the mid-elevation facilities at Hale Pōhaku the mountain’s vegetation shifts to a sparsely wooded environment. The band from approximately 7,000 feet to 9,500 feet elevation is an open woodland of *māmane* (*Sophora chrysophylla*) and *naio* (*Myoporum sandwicense*). Both the *māmane* and *naio* are endemic species. Two species of mint and several native shrubs and vines occur in the area. Grasses and weeds also grow under the *māmane* tree, and sparse ground cover is found in this forest region. On the southwest side of the mountain and extending up the mountain, the *māmane* is mixed with *naio*. On the north side of the mountain, it is mixed with *koa* at lower elevations (Langlas, 1999). Mid-elevation flora and fauna are shown in Figure IV-3.

Nēnē, *‘ua‘u*, and *palila* were found in the *māmane* forest. These birds were prized for their meat and feathers. By 1990, the *‘ua‘u*, a pelagic seabird that breeds on many of the Hawaiian Islands between the months of May and October, were practically gone from the Saddle area between Mauna Kea and Mauna Loa, having been destroyed by mongoose. The *palila* (*Loxioides bailleui*) is a small bird of the Hawaiian honey-creeper subfamily that has been listed as an endangered species since 1966. Today the *‘ua‘u* as well as the *palila* is designated as an endangered species.

The seed of the *māmane* is the major food source of a number of bird species. The *palila*, a bird found nowhere else in the world, feeds on the green *māmane* seeds and the fruit of the *naio*. The *māmane* trees also provide shelter and nesting sites for the bird. The clumps of *māmane* are also important because they act as fog interceptors to provide themselves, and other species associated with them, with the small amounts of moisture



Naio (Photo: Winona Char)



Māmane (Photo: Winona Char)



Māmane Forest (Photo: Winona Char)



Palila and Māmane (Photo: Audibon Society "Birds of Hawaii")

Mid-Elevation Flora and Fauna Examples

Mauna Kea Science Reserve Master Plan

they need for survival. Pualani Kanahahele and Edward Kanahahele (1997) discuss the importance of the *māmāne* forest as a food source for the *palila*. The Kanahahele's explain that in the Hawaiian hierarchy system, the important entity is the source of food and not the animal that depends on this food. Noting this, the Kanahahele's explain that it is most important to preserve the *māmāne* forest as a cultural resource.

Introduced Mammals and the Destruction of Vegetation

In the late 1700s and early 1800s cattle were introduced and soon ran wild in the saddle between Mauna Loa and Mauna Kea. In addition to wild cattle, sheep and goats thrived on the mountain. As early as the 1820s, feral ungulates began destroying the summit area's silversword population and any other plants not protected in rocky crevices. In the 1820s and 1830s, Western, and later Hawaiian, hunters stalked wild cattle roaming the mid-elevation area slopes which were covered in *pili* grass and *māmāne* trees. However, this activity was not enough to keep the population in check. Feral sheep and goats destroyed large portions of the *māmāne* ecosystem by eating the leaves, stems, seedlings, and sprouts of the plants. The ungulate grazing has caused a gradual shift in the balance of trees from *māmāne* to *naio*. By 1850, the cattle had visibly destroyed portions of the upper 'ōhi'a-koa forest by eating the underbrush and stripping the trees. (Cordy, 1994) In a relatively short period of time, the landscape and use of the upper slopes of Mauna Kea changed dramatically.

By the late 1920's much of the vegetation had been destroyed and a government-sponsored eradication program began. Through hunting, fencing, and stock drives, feral cattle were eliminated from Mauna Kea and the feral sheep population, estimated at 40,000 in the mid 1930s was reduced to nearly 200 by 1950 (Giffin in Juvik and Juvik, 1984). With the decrease in wild animals, the forests of Mauna Kea began to regenerate themselves. Juvik and Juvik report that forest management policies shifted once again in the period following World War II. The number of game hunters increased and they were able to convince the government that sport hunting should be supported. In areas favored by hunters, the forest continued to regenerate. However, in less accessible areas the game returned and further damaged the fragile forest.

By destroying vegetation the rampant ungulates destroyed critical habitat for the *palila*. Efforts to protect the endangered *palila* bird resulted in a 1979 Federal court order mandating the removal of feral sheep and goats from the critical habitat area. A 1987 federal court order dictated the complete and permanent removal of all mouflon and hybrid sheep from the mountain. Though not popular with hunters, sheep and goat eradication programs have kept the numbers of feral ungulates in check and have assisted the revegetation of certain areas of the mountain. Over 30,000 acres of the *māmāne-naio* forest have been designated as the critical habitat of the *palila*. *Māmāne* revegetation programs have been undertaken to replenish the *palila* habitat. Revegetation efforts near the Hale Pōhaku facilities have favorable chances of success as the human activity tends to keep destructive animals out of the area.

MAUNA KEA SCIENCE RESERVE MASTER PLAN

V. CULTURE

CULTURE

The First Arrivals: Native Hawaiian Uses

In Hawaiian culture, natural and cultural resources are one and the same. Native traditions describe the formation of the Hawaiian Islands and the presence of life on and around them. All forms of the natural environment, from the skies and mountain peaks, to the valleys and plains, and to the shoreline and ocean depth are the embodiments of Hawaiian gods and deities. One Hawaiian genealogical account records that Wākea (the expanse of the sky) and Papa-hāna-moku (Papa – Earth mother who gave birth to the islands) and various gods and creative forces of nature gave birth to the islands. Hawai‘i, the largest of the islands, was the first-born of these island children. The account continues that the same god-beings were also the parents of the first man (Hāloa), and from this ancestor, all Hawaiian people are descended. In some genealogical chants, Mauna Kea is referred to as “Ka Mauna a Kea” (Wākea’s Mountain), and it is likened to the first-born of the Island of Hawai‘i. (Maly, 1999)

“Cultural attachment is demonstrated in the intimate relationship (developed over generations of experiences) that a people of a particular culture share with their landscape – for example, the geographic features, natural phenomena and resources, and traditional sites, etc., that make up their surroundings. This attachment to environment bears direct relationship to the beliefs, practices, cultural evolution, and identity of a people. In Hawai‘i, cultural attachment is manifest in the very core of Hawaiian spirituality and attachment to landscape. The creative forces of nature which gave birth to the islands (e.g., Hawai‘i), mountains (e.g. Mauna Kea) and all forms of nature, also gave birth to *nā kānaka* (the people), thus in Hawaiian tradition, island and humankind share the same genealogy.” (Maly, 1999, p. 27)

According to Kanahale and Kanahale (1997), the first Hawaiians landed on the island’s shores between 25 BCE and 125 CE. Many more Polynesians voyaged to Hawai‘i and settled over the next thousand years. During this settlement period, the early Hawaiians developed stable water and food sources and adapted to their new environment. (Kanahale and Kanahale, 1997) Hawaiians first settled near the shore where there was ready access to the ocean’s plentiful resources. The forests provided plants and animals for food, tools, and shelter. Flightless birds, knowing no predators before, became easy prey for Hawaiian hunters. The mountain tops, the highest points of the land, were considered sacred. Mauna Kea is among the most sacred of these high points.

As early as AD 1100, adze makers came in reverence to the Mauna Kea adze quarry, Keanakāko‘i (most of which is located in the Mauna Kea Ice Age Natural Area Reserve), to craft tools from the unique dense basalt found here. As part of the ritual associated with quarrying, craftsman erected shrines to their gods. Adze makers came to the mountain for short periods of time to work on the basalt that formed from molten lava which erupted under the glacial ice cap. They chipped out chunks of basalt and then

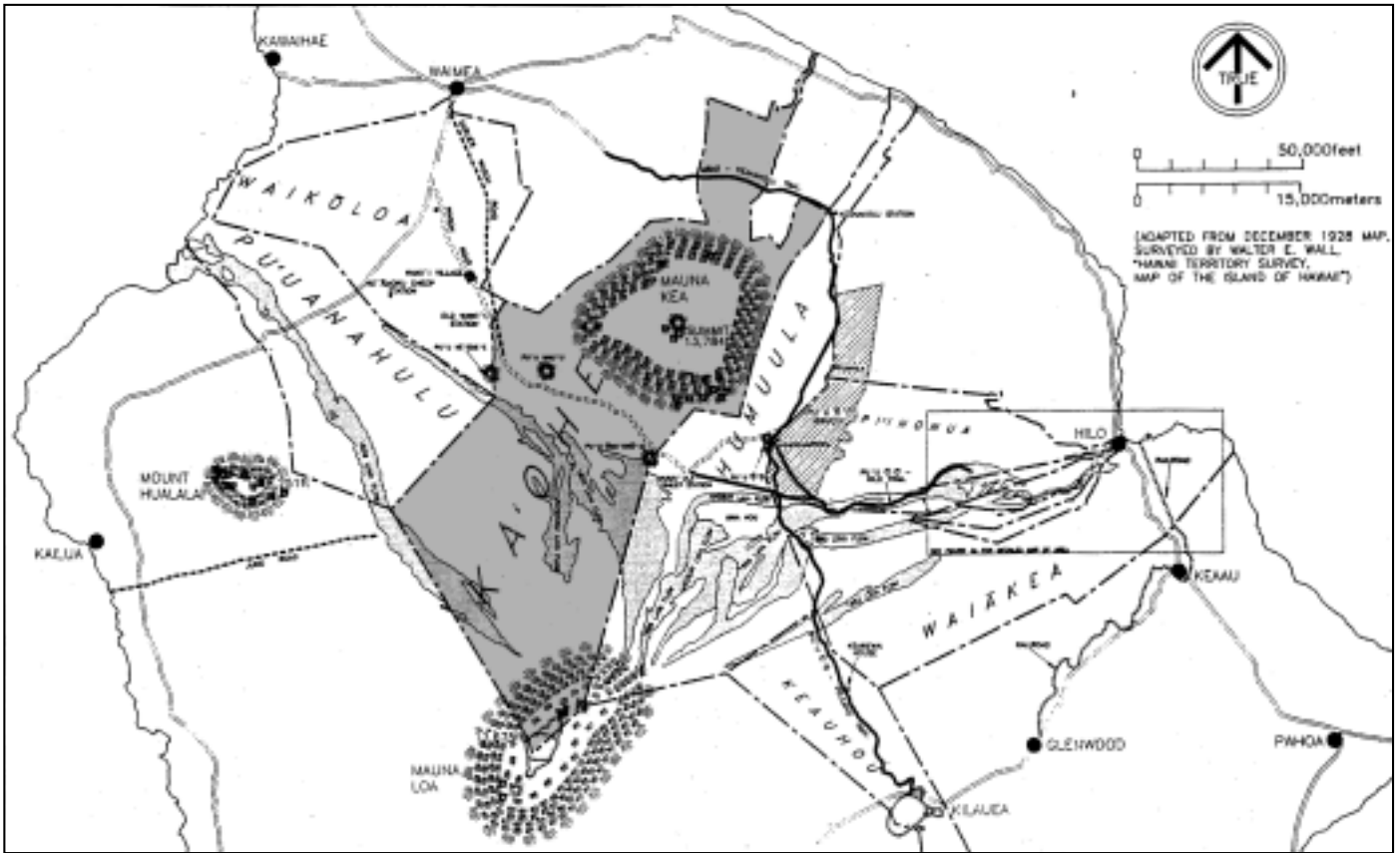
worked the stone to form refined tools in shelters and workshops they had built. Different areas were designated for chipping, rough-finishing, and fine-finishing. *Māmane* wood was preferred for adze handles. In addition to the quarrying of adze basalt, craftsmen also collected volcanic glass and dunnite/gabbro for cutting tools and octopus fishing gear sinkers (McCoy, various and Maly, 1999). Further down the mountain, near a spring, the adze makers erected shelters from which they would gather water, wood, and food to sustain them as they worked in the quarry. (PHRI, 1997) Remnants of shelters, shrines, adze manufacturing, food and offerings remain today to tell of these early craftsmen. The adze makers are thought to have come from neighboring areas and the adzes they crafted were widely used. Keanakākoʻi was an active place for hundreds of years, with intensive use after AD 1400 and eventual decline prior to Western contact.

Following the long period of initial settlement, an era of high culture ensued. The Hawaiian society advanced in all areas from the 1200s until the late 1700s. During this time political powers exerted their might and the structure of communities was refined. (Kanahele and Kanahele, 1997)

In the beginning of the 1600s, during the time of Umi, the Hawaiian Islands were divided into political regions. The larger islands (*mokupuni*) were divided into districts (*moku*). The *moku* were divided into *ahupuaʻa* and large *ahupuaʻa* were divided into *ʻili*. *Ahupuaʻa* were often entire valleys spanning from the top of the mountain ridge to the ocean. The *konoiki* managed the day-to-day operations of the *ahupuaʻa* with the aid of *luna* who were experts in various fields such as planting and fishing. Each *ahupuaʻa* contained nearly all of the resources Hawaiians required for survival from fresh water, plants, and a variety of animals, and was managed so that these resources could be sustained over time. (The Ahupuaʻa, 1994)

The *ahupuaʻa* of Kaʻohe spans the summit of Mauna Kea and includes the Mauna Kea Science Reserve (Figure V-1). The lower slopes of Mauna Kea reach into the *ahupuaʻa* of Humuʻula and Kaʻohe. Hawaiians hunted and gathered in Mauna Kea's *māmane* forests which were rich with vegetation and native birds including the *ʻuaʻu* (dark-rumped petrel), *nēnē*, and *palila*. So prized were the plump young *ʻuaʻu* that they could be eaten only by the *aliʻi*. Hawaiians came to the *koa* and *ʻōhiʻa* forest on the mountain's lower slopes to gather wood for canoe-making and to collect bird feathers. Above the *koa* forests was the open *māmane* forest where they may have hunted *ʻuaʻu* and *nēnē*.

All aspects of Hawaiian life were steeped in ritual. For the Hawaiian people, spiritual beliefs, cultural practices and all facets of daily life were intricately bound to the natural landscape of the islands. The lake, Waiʻau, was believed to contain pure water associated with the god Kāne and was used in healing and worship practices. Archaeologist Pat McCoy suggests that shrines located at the edge of the summit plateau may mark the transition to a spiritual zone associated with the summit of Mauna Kea (McCoy and McEldowney, 1982). The shrines may be associated with the snow line and thus



Source : PHRI, 1997, Archaeological Inventory Survey and Historic Traditional Cultural Assessment for the Hawai'i Defense Access Road A-AD-6(1) and Saddle Road (SR 200) project

represent shrines to Poli‘ahu and/or other deities. Hawaiians also buried the bones of their dead on the slopes of Mauna Kea.

Archaeology and Ethnographic Research

What we know today of Mauna Kea’s ancient use and meaning we have learned from the physical clues left behind on the mountain. Ethnographic research explores more recent human activity and the traditions that have been handed down within families over time.

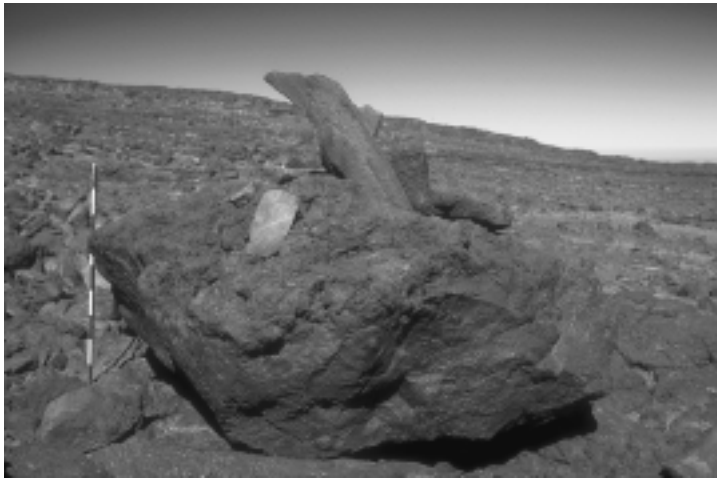
For the past two decades archaeologists have conducted extensive field work on the slopes of Mauna Kea, with access made much easier with the construction of a road to summit area. Approximately 3,000 acres, or 27 percent, of the Science Reserve has been surveyed to date (McCoy, 1999). Much of this archaeological work has been undertaken by Dr. Patrick McCoy, currently with the State Historic Preservation Division. McCoy and colleague Dr. Holly McEldowney have prepared an Historic Preservation Management Plan for Mauna Kea. As part of this plan, McCoy has inventoried and summarized the archaeological sites that provide a wealth of knowledge of past use of the mountain (McCoy, 1999) (Figures V-2 and V-3).

In addition to the archaeological field work, several individuals have recently conducted ethnographic studies concerning Mauna Kea. Their research is summarized here.

Dr. Charles Langlas of the University of Hawai‘i-Hilo worked with Paul H. Rosendahl, Ph.D., Inc. to prepare an Archaeological Inventory Survey and Historic and Traditional Cultural Assessment for the Hawai‘i Defense Access Road A-AD-6(1) and Saddle Road (SR 200) Project (1997). Pualani and Edward Kanahale prepared a Social Impact Assessment of Indigenous Hawaiian Cultural Values for this same project (1997).

In association with the preparation of this Master Plan, cultural specialist Kepā Maly conducted an oral history interview and archival research effort in the later part of 1998 to compile the thoughts and memories that those living today have of Mauna Kea (Maly, 1999). Maly interviewed 22 individuals and structured his research into broad groupings that are helpful in organizing the often generalized feelings that individuals have toward Mauna Kea.

McCoy summarizes the most recent archaeological work within the Mauna Kea Science Reserve. Based on field work undertaken between 1975 and 1997, a total of 93 archaeological sites have been identified in surveys covering approximately 3,000 acres within the larger Science Reserve, including the immediate summit ridge areas. These sites tell us much about the history of man’s association with Mauna Kea. Of the 93 sites, 76 are shrines, four are adze manufacturing workshops, and three are markers. One burial has been positively identified and four other possible burial sites exist. The function of five of the 93 sites is unknown. (McCoy 1999)

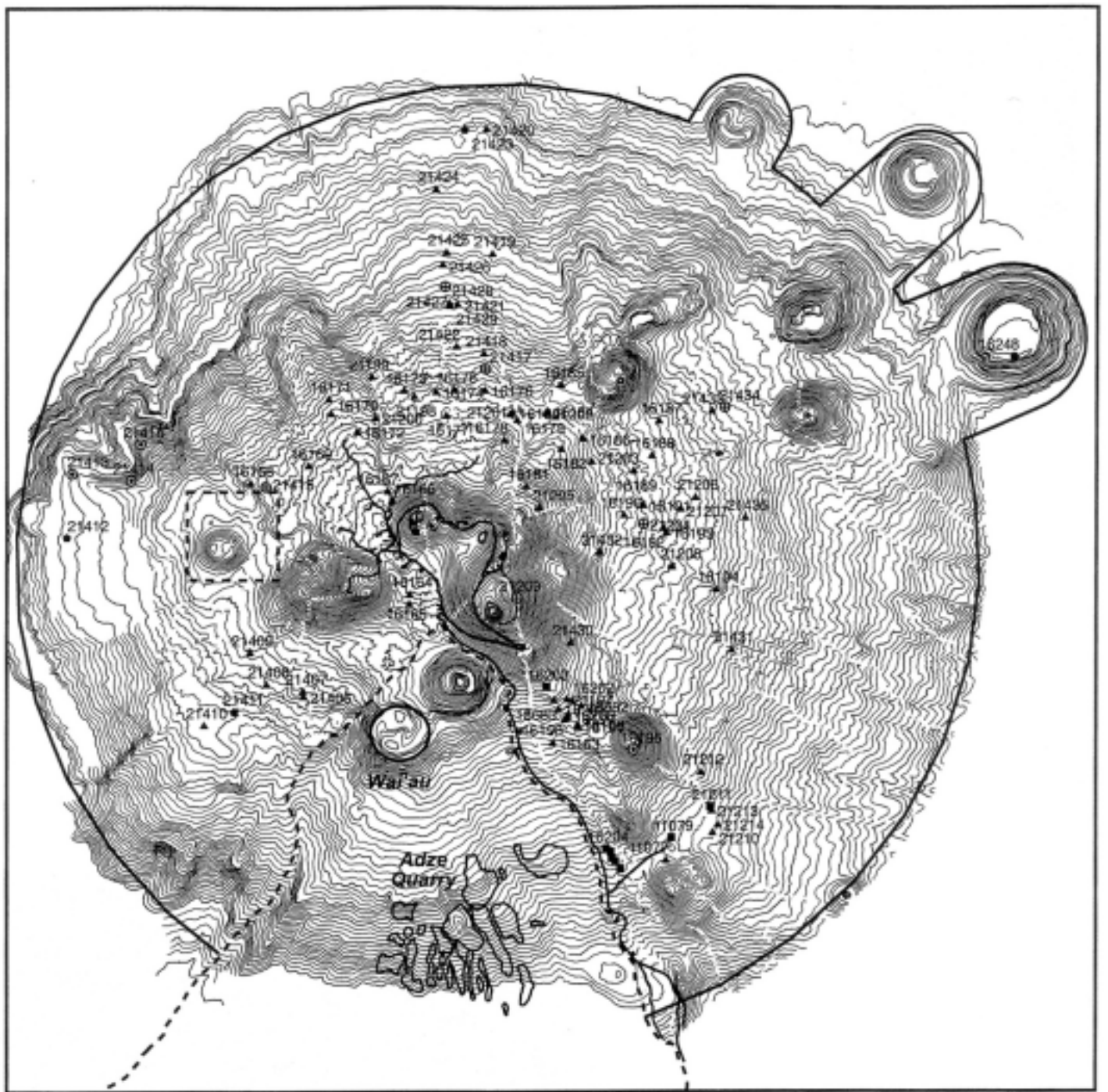


Archaeological Site Examples

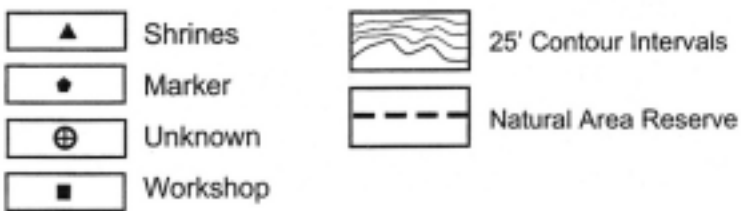
**Mauna Kea Science Reserve
Master Plan**

Photos: Pat McCoy

Figure V-2
Page V-5



Source: Hawaii Department of Land and Natural Resources
Historic Preservation Division, February 1999



Archaeology Sites Map - Science Reserve

Mauna Kea Science Reserve
Master Plan

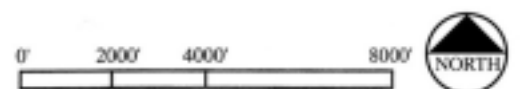


Figure V - 3
Page V - 6

Shrines

The term ‘shrine’ is used by McCoy to describe all of the religious structures that exist in the summit region of Mauna Kea. The most common of the archaeological features on Mauna Kea, shrines are characterized by the presence of one or more upright stones. The shrines at Mauna Kea range from single uprights to more sophisticated complexes with pavements and prepared courts.

The majority of shrines on Mauna Kea are located conspicuously on ridgetops or at breaks in the slope. It is not surprising that shrines were placed in prominent locations with commanding views of the landscape. Shrines have not been found on the tops of cinder cones.

McCoy suggests that each upright on a shrine may have stood for a separate god. The majority of uprights were made of angular slabs found in the glaciated area of Mauna Kea. These select stones were unmodified by their human gatherers and provided a place for the gods to inhabit when they were needed. Based on ethnographic information McCoy suggests that the pointed uprights might represent male gods and the flat-topped uprights, female gods.

Stone uprights were typically set in a crack in the bedrock and braced with a few stones. In other shrines, most notably those in the north and east slopes, uprights were set on the top of a boulder. In shrines dispersed throughout the summit area, stone uprights were set into low rubble heaps or piles of stones. In only a few cases, cairns were built to support the stone upright. Platforms were also built to support one or more uprights.

McCoy suggests that the shrines on Mauna Kea were erected for one of two, and possibly more, functions. Though they are not distinguished from each other by physical characteristics, the shrines can be classified as occupational or non-occupational in function. The eight occupational shrines are identified by the remains of specialized workshops and adze manufacturing byproducts.

The non-occupational shrines range in complexity from simple features with a small number of uprights to more complex structures with courts and larger numbers of uprights. Most of the shrines found on Mauna Kea have just 1 to 3 uprights, however, some have as many as 24 or 25 stone uprights. McCoy speculates that the simple shrines were built and used by small family groups and the larger, more complex structures were built and maintained by a priesthood. McCoy reasons that the larger number of uprights indicate a larger number of gods than most Hawaiians would probably have known. In addition, many of these more complex sites are isolated from the main areas of worship.

McCoy has interpreted the shrine complex in the summit region as evidence of an historically undocumented pattern of pilgrimage to worship the snow goddess, Poli‘ahu, and other mountain gods and goddesses.

Adze Quarrying and Manufacturing

The main adze quarry, Keanakāko‘i, is located within the Mauna Kea Ice Age Natural Area Reserve. The majority of the workshops and shrines associated with adze manufacturing are located near the main quarry. Four additional adze manufacturing workshops have been found in the Science Reserve across the Summit Access Road from the adze quarry. However, these workshops are of a different kind than those found in the adze quarry. Manufacturing byproducts such as flakes, cores, adze rejects, and hammerstones have been found at these workshops, however, no stone-tool quality raw material is found. Thus it is likely that adzes were flaked elsewhere and transported to these localities at a later stage of the manufacturing process. Each workshop has one or more shrines upon which adze byproducts were offered to the tutelary gods of adze making. McCoy has identified one of these workshops as the location of initiation rites for apprentice adze makers. (McCoy 1999)

Several of those interviewed by Maly have heard of or visited the adze quarry areas on Mauna Kea.

Coco Hind recalls, “I went up once [to Mauna Kea], a long time ago, we went up to Lake Waiau. I remember feeling kind of weak when we got up there, and it was the thin air. I wasn’t that old. We went up to Humu‘ula and then we took horses. We rode horses up to Wai‘au. I was with my father, my mother didn’t go. My mother was afraid of horses, she wouldn’t go near a horse.”... “... we went up and dad showed us this...there were other people with us too, my uncle Allan and his son, and others. He showed us this place where there were ‘*ōpihi* shells all over and it was where daddy said that they used to rough cut the adzes and then bring them down and finish them up, down below...” (Florence La‘i-ke-aloha-o- Kamālu “Coco” Vrendenburg-Hind, p. A-118 in Maly, 1999)

Trails and Access

In pre-contact times, it is suspected that travel to Mauna Kea was guided by individual knowledge of the landscape rather than by any distinct trails. It is possible that ridges were followed or that sources of water were known and visited along the way. Individuals going up the mountain likely visited the shrines erected by their family members to their gods. No evidence of pre-contact trails has been documented. (McEldowney, 1999)

Maly reports that by the later nineteenth and early twentieth centuries, trails were created and often traveled on horseback. The trails of Mauna Kea linked communities and cultural and natural resources together. To reach the summit, people left the near-shore and plains lands and traveled the mountain slopes to the summit. The trails ascend the slopes of Mauna Kea from nearly all of the major, and many of the smaller *ahupua‘a* which lie upon Mauna Kea’s slopes. Traditions pertaining to journeys on the mountain trails, and knowledge of Mauna Kea are still retained as important family history today. Mauna Kea’s trails, as told of in the oral and written histories, are depicted on the

annotated interview map (Figure V-4). Significantly, many of these trails converge at Wai‘au, in the Natural Area Reserve.

Interviewees told Maly of their elders travelling to Mauna Kea to worship in the summit region, gather water from Wai‘au for healing practices, procure stone for adze making, and take individuals’ ash remains to the summit area or to Wai‘au for their return to the Earth. Teddy Bell describes one of the mountain trails to Wai‘au.

“And then we also went from Waiki‘i” . . . “You go so far from Pu‘u Lā‘au . . . There used to be one pine tree forest. And from that reserve, there’s a clump of pine trees. That’s where they’ve got a lot of cones. From that pine trees, you look at Mauna Kea, the two sides, it’s almost like a *pali* but wide. And then you right up through that hollow there, and you come up to Lake Waiau. Almost to the end of the *pali* on Mauna Kea.” (Theodore “Teddy” Bell, Sr., p. A-128 in Maly, 1999) (This trail is indicated in Figure V-4 as K Waiki‘i-Waiiau trail.)

During the historic period, people have traveled the mountain for Territorial Forestry operations, ranching, hunting, and recreational activities. Lloyd Case describes game trails on the mountain.

“You know one of the most amazing things, and I don’t know if some of the old timers told you this. But a lot of these Hawaiian trails, a lot of them were used by the sheep, they became game trails after a while. The sheep would use some of these trails. Some of these trails we walked ‘em, on the Kemole side, Pu‘u Mali side. But a lot of them, they are still there, but you have to have a good trained eye to find ‘em.” (p. A-348 in Maly, 1999)

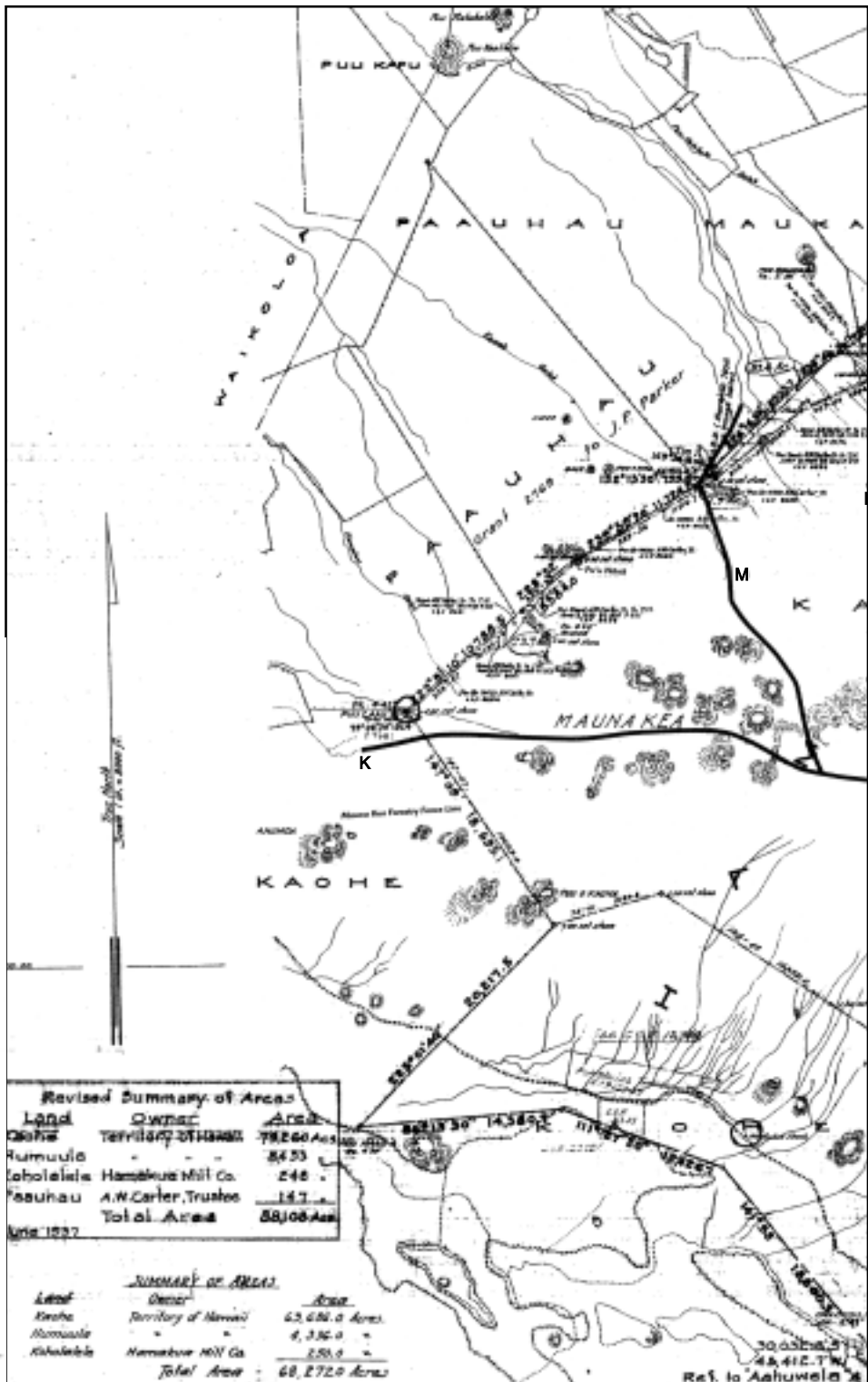
Burials

As was mentioned earlier, no shrines have been identified on top of cinder cones in the Mauna Kea Science Reserve. McCoy believes that these high and remote places were reserved for burying the dead. Although there are references to human burials on Mauna Kea in oral histories, only one burial site has been positively identified in the mountain summit area.

“To date the only positively identified human remains found in the Science Reserve are located at Site 16248 on the summit of Pu‘u Makaanaka (Fig. 1). Jerome Kilmartin, a surveyor with the United States Geological Survey, noted the presence of human remains on this prominent cinder cone in 1925.” (McCoy 1999)

Four other sites within the Science Reserve have been identified as possible burials by McCoy.

Figure 3. HTS Plat 613, March 1928 (State Survey Division)
 Annotated as Interview Map Showing
 Approximate Locations of Selected Sites
 Referenced During Oral History Interviews
 Kaua Pano Associates Report No. HMMR-21 (029/99)



Annotated Interview Map (Kepā Maly)

Mauna Kea Science Reserve
 Master Plan

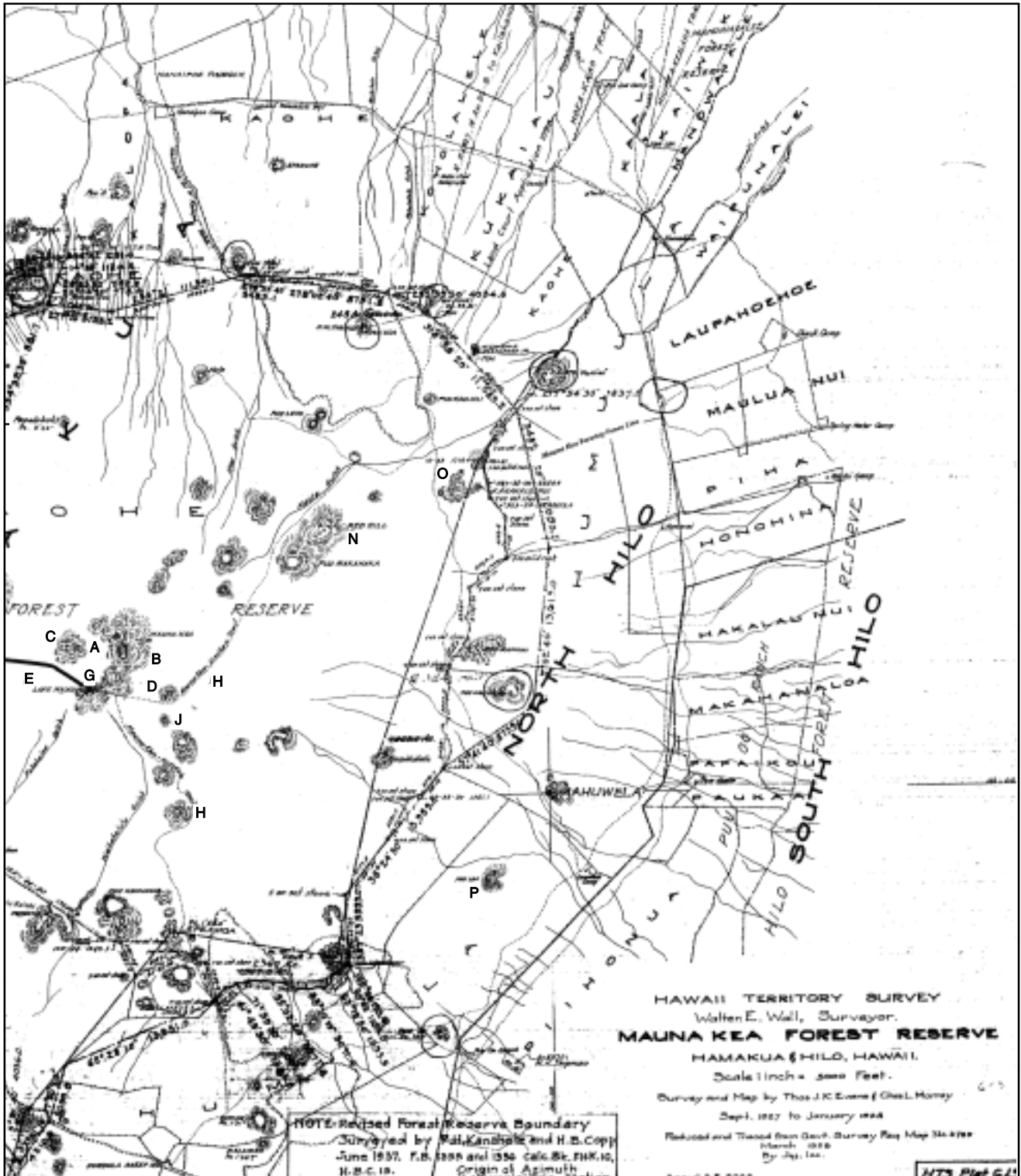


Figure V-4
 Page V-11

“There are four other sites in the surveyed areas of the Science Reserve that have been identified as possible burials (Sites 16195, 21413, 21414, and 21416). In each case there are compelling reasons to believe that the site is indeed a burial, but because human remains were not seen at the time the site was recorded it has been called a possible burial.”

Of these four possible burial sites one consists of two adjacent cairns located on the eastern rim of Pu‘u Līlīnoe. The other three are located on the southern and eastern rim of a large unnamed cinder cone on the northwestern edge of the Science Reserve. (McCoy 1999)

McCoy notes that archaeological sites have been found in all areas that have been surveyed to date but the distribution and density of the various types of sites follows certain patterns. The one burial and four possible burials have been found only on the tops of cinder cones and never with shrines.

While none of the individuals interviewed by Maly reported knowing of specific locations of burials in the immediate area of the Mauna Kea summit, many spoke of *ilina* (burial sites) in cinder cones, and other natural features in the region extending from about the 12,000 down to the 7,000 foot elevation. In modern times several family members or close friends of interviewees have had their cremated remains taken to the summit of Mauna Kea for release.

Summit Area

A significant pattern is the virtual absence of archaeological sites at the very top of the mountain. McCoy states that the “top of the mountain was clearly a sacred precinct that must, moreover, have been under a *kapu* and accessible to only the highest chiefs or priests.”

Most of the shrines in the Science Reserve are found on the northern and eastern slopes just above and below the 13,000 foot elevation. This pattern suggest that most of those who journeyed to the summit area came from the Hāmākua and Hilo sides of the mountain. Discussing the scarcity of sites on the western and southwestern slopes, McCoy makes the following observations:

“While the small number of shrines on this side of the mountain suggest the possibility of people coming from the Kona and South Kohala districts, the number would appear to have never been high. The implications are quite interesting. It suggests that while the mountain may have been viewed from a distance by people from everywhere on the island as a sacred mountain, in practice those who made the journey and worshipped there did not represent an even cross-section of the island populace. The implication is that access to the summit region was under the political control of the east Hawaii chiefdoms, a conclusion that is consistent with all of the other data.” (McCoy 1999)

All of those interviewed by Maly attributed spirituality and healing qualities to being on Mauna Kea; and several recorded that they still go to Mauna Kea for prayer and restoration. One described Mauna Kea as a sanctuary in ancient times. The area above the forest line was so sacred that once in the upper region, your enemies could not pursue you. (Maly 1999)

In addition to the sites identified within the Science Reserve, a wealth of physical evidence can be found in the Mauna Kea Ice Age Natural Area Reserve, outside of the Science Reserve. Within the Natural Area Reserve, the main adze quarry and numerous sites at Wai'au tell of the activity in this geologically and culturally unique area. Many of these sites have been inventoried but have yet to be fully analyzed and related to the other sites found on the mountain.

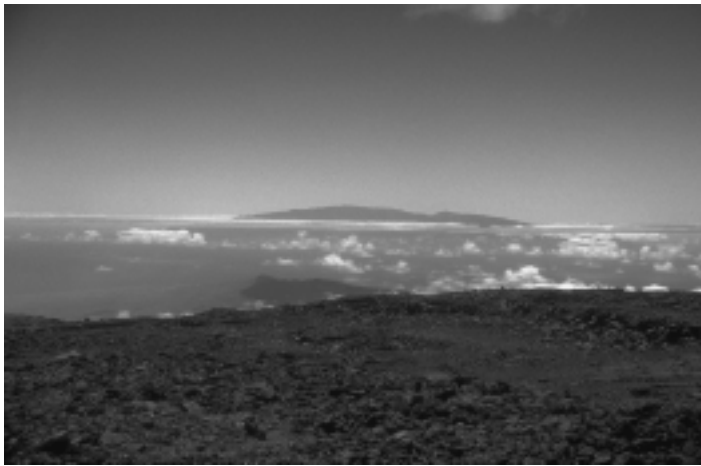
Cultural Landscape

The summit of Mauna Kea has been referred to as *wao akua* (region of the gods). The most common understanding of *wao akua* is that it was 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. Different people and family had different protocols when they traveled through these remote regions. (George Atta personal communication with Holly McEldowney and Pat McCoy, June 2, 1999)

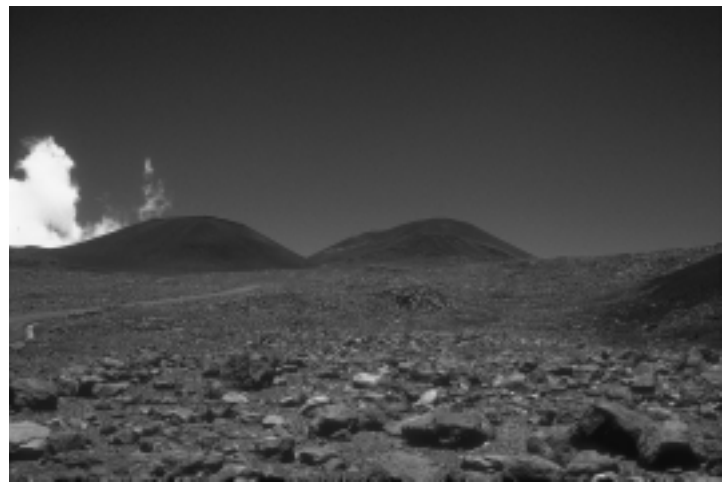
“Perhaps as a result of its prominence, isolation, and extreme environmental conditions, Mauna Kea’s place in the culture and history of the Hawaiian people is significant. This ‘cultural significance’ extends beyond a physical siting, sites or particular features which have been previously identified in archaeological site studies. Mauna Kea is a prominent feature on the cultural landscape of Hawai‘i which has been and continues to be, viewed from afar, and to which spiritual and cultural significance is attributed.” (Maly, 1999, p. 3)

The ancient saying “Mauna Kea kuahiwi ku ha’o i ka mālie” (Mauna Kea is the astonishing mountain that stands in the calm) (Pukui 1983: No. 2147), expresses the feeling that Mauna Kea is a source of awe and inspiration for the Hawaiian people. The mountain is a respected elder, a spiritual connection to one’s gods. Thus, the landscape can be interpreted as a significant facet of a Hawaiian’s identity. Mauna Kea is the focal point of numerous traditional and historical Hawaiian practices and narratives recorded by both native Hawaiians and foreign visitors. Views of the mountain landscape are presented in Figure V-5.

“A number of place names recorded for this mountain landscape are associated with Hawaiian gods. Other place names are descriptive of natural features and resources, or document events that occurred on the mountain.” (Maly, 1999) “Native families also



View from SMA Road, Haleakalā in background (Photo: Group 70)



Mauna Kea Summit Road, View to Summit Area (Photo: Group 70)



Summit Plateau Cinder Cones (Photo: Pat McCoy)

Landscape

retain names such as Maunakea, Poli‘ahu, Lili‘noe, and Wai‘au, which in some cases are directly tied to the mountain landscape.” (Maly, 1999)

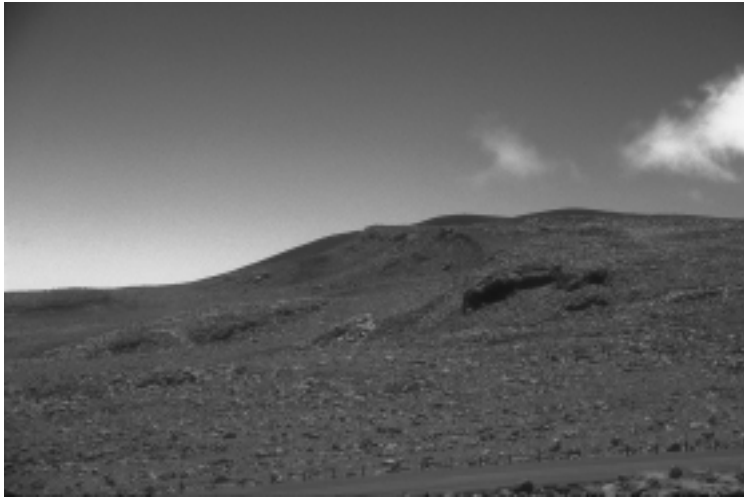
The Kanahelas (1997) tell of Mauna Kea as the *piko* or origin point for the island of Hawai‘i, and specifically the northern half of the island. Mauna Kea is, therefore, a place of great *mana*. Kanahela has also said that the three *pu‘u*, Poli‘ahu, Lili‘noe, and Wai‘au are named for three sister goddesses who are female forms of water. Poli‘ahu is embodied in the snow, Lili‘noe in mist, and Wai‘au in the lake. These *pu‘u* are where the goddesses manifest themselves. Of these three landforms two, Poli‘ahu and Lili‘noe, are located in the Science Reserve. Wai‘au is located in the Natural Area Reserve (Figure V-6).

Many of those interviewed by Kepā Maly expressed the significance Mauna Kea holds for them as Hawaiians and as individuals.

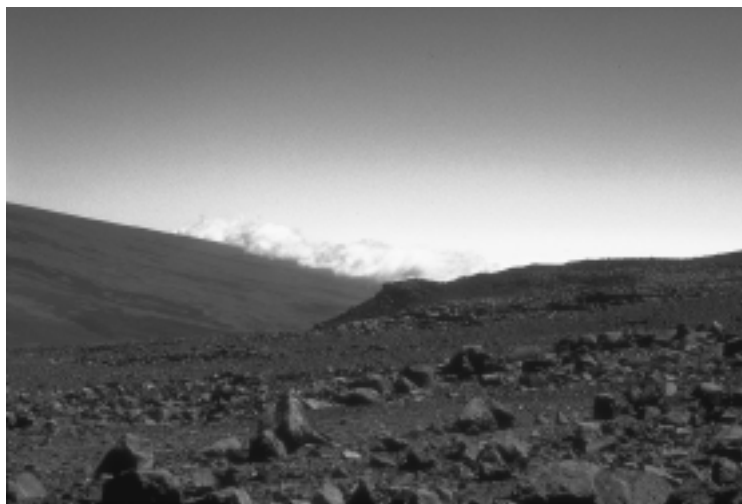
John Spielman and Pualani Kanahela describe Mauna Kea in the context of the entire Island of Hawai‘i and in Hawaiian ancestral history.

“And I think too, what is important to understand and for people to realize is that it is all connected. Although we are talking about Mauna Kea, Mauna Kea and Paniau are connected. When you go fishing from Paniau, you look up to Mauna Kea and you check out the weather. You look to the mountain and see what the weather patterns are doing. The Kohala mountains. So the fishermen use the mountains as visual aids to help them in their fishing. And perhaps, I don’t this as much, but from the mountain side down, but I would imagine that the farmers and the people that lived higher, would look down to the ocean to see if the weather was changing, the cloud patterns on the ocean. It’s all connected. It is not separate. But Mauna Kea, I think, is the focal point of this island. It is the *piko*, the breath . . .” (John K. Spielman, p. A-282 in Maly, 1999)

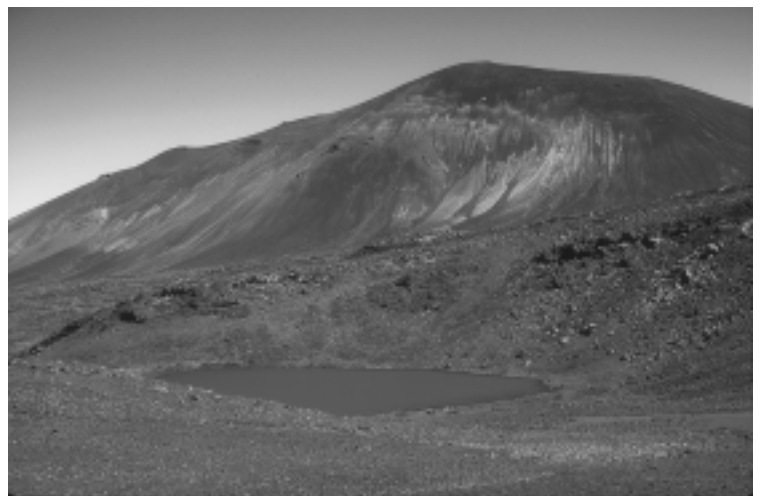
“Mauna Kea was always *kupuna* [an elder, ancestor] to us. Mauna Kea and Mauna Loa, the tips, they were always *kūpuna* [elders, ancestors]. and there was no wanting to go on top. You know, just to know that they were there was just satisfying to us. And so it was kind of a hallowed place that you know is there, and you don’t need to go there. You don’t need to bother it. But it is there, and it exists. And it was always reassuring because it was the foundation for our island.” (Pualani Kanaka‘ole Kanahela, p. A-366 in Maly, 1999)



Adze Quarry (Photo: Group 70)



Adze Quarry (Photo: Group 70)



Wai'au (Photo: Pat McCoy)

Natural Area Reserve (Adze Quarry, Wai'au)

Mauna Kea Science Reserve
Master Plan

Figure V-6
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Alexander Lancaster and Tita Spielman relay the significance of Mauna Kea to each of their families.

“Yes, my grandmother Alice. Her Hawaiian name is Kamahalo – she was named after her grandmother, my great, great, great grandmother. She said “ When you go up there, you going feel the spirit.” And you do feel the spirit.” (Alexander Kanani‘alika Lancaster, p. A-234 in Maly, 1999)

Regarding her family’s relationship to Mauna Kea, Spielman explains, “Well, it was through my mother, because of course, she grew up in Kohala and spent a lot of time there. And at Pu‘u Wa‘awa‘a and Kiholo, and always loved Mauna Kea. She used to say ‘That’s my mountain.’ And so we got to know it and love it as we do.” (“Tita” Elizabeth Kauikeōlani Ruddle-Spielman, p. A-265 in Maly, 1999)

Teddy Bell and Lloyd Case relay their own personal feelings about Mauna Kea.

“On the slopes of Mauna Kea, there is a ridge there called Pu‘u Nānā. Pu‘u Nānā, if it’s a clear day, you can see all of this Waimea. So that’s where I want my ashes to be scattered.” Theodore “Teddy” Bell Sr., p. A-139 in Maly, 1999)

“Because the one thing I loved about it was just going up there and sitting down under the tree and looking out at space. Looking at everything. That is the most rewarding thing that I ever can say happens to me. When I go up there, it just heals me. That is a place for healing . I come back a different person.” (Lloyd Case, p. A-353 in Maly, 1999)

A gentleman interviewed by Langlas was taught by his great-grandparents that there were two sites of ritual importance on Mauna Kea, the summit peak and the lake and surrounding *pu‘u* Wai‘au. According to this individual, the summit peak was a place to go and pray to the gods for *mana*, to cleanse the person and give him health.

Wai‘au is a place of tradition and a source of inspiration. Located outside the Science Reserve in the Natural Area Reserve, Wai‘au is a focal point for many visitors to the mountain. Many of the individuals interviewed by Kepā Maly discussed their own visits or visits by family members to Wai‘au.

“It [Mauna Kea] brings back memories, you know. But way back, people never used to go up there. They never did go to Mauna Kea except on horse back, and that was very few. And right at Lake Waiiau, had a bottle there. Whoever went up, would write their name and the date, and put it in the bottle.” . . .” Yeah. So, I don’t know what happened to that bottle. My first trip to Mauna Kea was in 1934. And there were a few peoples

names in that bottle already.” (Theodore “Teddy” Bell Sr., p. A-123 in Maly, 1999)

Kepā Maly, “And you mentioned that Waiau was a favorite place [of your grandfather Eben Low].” Tita Spielman, “A very favorite place. Yes, and that’s why his plaque was put there. Because that was one of his favorite places. Although, his ashes were scattered at the top, the plaque was put at Waiau.” (“Tita” Elizabeth Kauikeōlani Ruddle-Spielman p. A-270 in Maly, 1999)

In addition to feelings of *aloha* expressed for the place, numerous oral traditions of the importance of Wai‘au have been handed down through families.

Kepā Maly, “So he [your father] would go *mauka* to Waiau and gather water there?” Anita Lancaster, “And he would bring it, and he had my mom and I drink that water. And if we had it for a week, it never went into the refrigerator, it stayed on the counter, but it was always cold. And that was the sweetest water. It was so pure. I thought nothing of it because I was so young. But as I grew older, I would always remember it because my dad always had this gallon hanging, you know when he didn’t go hunt, the gallon was always hanging in the house. In fact, the last time I saw it was just before he died, and then I don’t know what happened to the gallon...” (Anita Leilani (Kamaka‘ala) Landcaster, p. 245 in Maly, 1999)

“The water they used...the *lā‘au lapa‘au*, the healers went to this particular place, and another place in the Kohala mountains, there is another spring up there which Papa Auwae uses.” . . . “So, I’ve heard of the old ones getting water from Waiau to use for healing. (Lloyd Case, p. A-353 in Maly, 1999)

“And so here, within the Mauna a Wākea, sits this *‘apu wai* [water container] which is Waiau. What they are calling Lake Waiau. And as it hasn’t had a chance to come down to the rest of us, then it is sacred water, like the water that is in the piko of *lau kalo* [taro leaf], and the water that is found in the *‘ohe* [bamboo – interpreted as the meaning of the *ahupua‘a* name Ka‘ohe, within which the summit of Mauna Kea and Waiau are situated]. And the water that is found also in the *niu* [coconut]. So you have all of these different, sacred waters, but to me, 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.” . . . “The most sacred of all the waters.” (Pualani Kanaka‘ole Kanahale p. A-368 in Maly, 1999)

In ca. 1881, Dowager Queen Emma ascended Mauna Kea on a journey of spiritual and physical well-being. At the time, Queen Emma was in competition with David Kalākaua

for the position of ruling chief for the Kingdom of Hawai‘i. Each of the two embarked on journeys to prove their connection to the senior line and connect back to a *wahi pana* (a sacred physical place). Emma went to the top of Mauna Kea to bathe in the waters of Wai‘au, and cleanse herself in the *piko* of the island. (Kanahele and Kanahele, 1997)

For some, Wai‘au has a special family tie. “...Hawaiian members of the Lindsey family have a tradition of taking the *piko* of their children to Wai‘au and the summit of Mauna Kea.”. “Other interviewees who had not heard of the practice of taking *piko* to Mauna Kea all felt that it was likely to have occurred, and they shared similar stories from their own families of the custom at various localities.” (Maly, 1999)

Kanahele explains the importance of this tradition of taking the *piko* to a particular place.

“I don’t personally know any families [who took the *piko* to Waiau]. I know that people took *piko* there, I just don’t know who.” . . . Well, 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 to her mama, and so on. So it takes it back, not only to the *wā kahiko* [ancient times], but all the way to *Kumu Lipo*.” . . . “So, it’s not only the *piko*, but it is the extension of the whole family that is taken and put in a particular place, that again connects to the whole family line. And it not only gives *mana* or life to the *piko* and that child, but life again to the whole family.” (Pualani Kanaka‘ole Kanahele p. A-368 in Maly, 1999)

The Physical Planning Guide (Section IX) incorporates the information gained from interviews, ethnographic, research, and archaeology studies to determine areas recommended for preservation. The Management Plan (Section X) uses this same information in making recommendations for the establishment and operation of a local management authority.

The First European Contact to the Islands

As evidenced by the archaeological evidence and though oral histories, Hawaiian adze-making and worship at Mauna Kea continued through the 1700s.

In 1778, the first foreigner arrived in Hawai‘i. In the decades that followed, life in Hawai‘i changed dramatically with the introduction of new technologies, religion, diseases, animals, and industry. The population of Hawaiians was decimated by the effects of diseases that had never been seen before in the islands. Port towns such as Kailua, Kealahou and Hilo developed into commercial centers accommodating Western ships. Adze quarrying on Mauna Kea ceased to exist as stone adzes were soon replaced by metal tools after European contact.

In the late 1700s and through the 1800s several Europeans led expeditions to Mauna Kea. The names Goodrich, Baldwin and Alexander are well-known to students of the

mountain. Their maps and documents are the earliest written descriptions of Mauna Kea. Early in the 20th Century, the Board of Agriculture and Forestry designated the Mauna Kea Forest Reserve.

In 1793 the first cattle were brought to Hawai‘i and offered by Captain George Vancouver to King Kamehameha. By the early 1800s more cattle had arrived and escaped to forested areas where, in the absence of natural predators, their populations multiplied (Juvik and Juvik, 1984). In addition to wild cattle, sheep and goats thrived on the mountain. In 1809, John Palmer Parker settled in Hawai‘i and became friends with King Kamehameha I. The king placed Parker in charge of the wild cattle. With a land grant from King Kamehameha III in 1845, Parker established a ranch, Parker Ranch, which has been in continuous operation until the present. Other ranches also operated in the mid-1800s, however, much of the cattle and sheep continued to run free on the mountain’s slopes destroying the native vegetation. By this time, hunting had become a vital lifestyle for many island residents. Hunters continued to pursue the animals for their hides and meat which were consumed locally and bartered for goods from visiting ships.

After the decline in adze making on Mauna Kea, there was limited human activity on the mountain. On the lower portions of the mountain animals grazed and hunters pursued them. On the higher slopes a few Western explorers conducted expeditions up to the summit region. The next major phase of activity began in the early 1960s with the exploration of Mauna Kea as a potential site for astronomy observations.

The travel journals of the first Westerners to explore the mountain’s summit region highlight some of the first information on the physical evidence of past activity. McCoy (1999) shares some of these earliest observations. The first documented trip to the summit of Mauna Kea was that of Reverend Joseph Goodrich in 1823. Later writings of this trip record some of the observations and thoughts about the summit region:

“Rev. Joseph Goodrich, who, on this occasion, was unfortunately laid up with mountain sickness, had on 26th August, 1823, reached the summit of Mauna Kea. This is the first recorded instance of the ascent of this mountain, although Mr. Goodrich mentions that on reaching the top of one of the terminal cones that encircle the main plateau of Mauna Kea, he discovered a heap of stones, probably erected by some former visitor. Who this former visitor was is unknown, but he was probably one of the white men that in the early years of the nineteenth century got a living by shooting wild bullocks that roved on the side of Mauna Kea. It is very unlikely that any native had reached the top of the terminal cones on the summit, owing to being unprovided with warm clothing to resist the great cold and also to the fact that the natives had a superstitious dread of the mountain spirits or gods.” (Macrae 1922)

An account of Alexander’s journey in 1892 mentions the presence of a cairn at the top of a cinder cone:

“Messrs. Muir and Alexander ascended the second highest peak on the northwest, overlooking Waimea, 13,645 height to continue their survey. In the cairn on the summit a tin can was found, which contains brief records of the visits of five different parties from 1870 to the present time, to which we added our own.” (Alexander 1892)

Reflecting this notion, Ellis (1979) looked back to the travels of Goodrich and Blatchely, who ascended the peak about six months after Goodrich, and provided this description of Hawaiians’ view of Mauna Kea.

“The snow on the summit of the mountain, in all probability, induced the natives to call it Mouna-Kea (mountain white), or, as we should say, white mountain. They have 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)

The early exploration of the summit region and the subsequent development of the astronomy industry on the mountain is detailed further in the Education and Research section of this report.

Cultural Practice Today

In their ethnographic work Maly, Langlas, and Kanahale and Kanahale describe some of the practices that individuals and families conduct on Mauna Kea today. Several of the individuals interviewed by Maly stated that “they still go to Mauna Kea for prayer and restoration”. All interviewees attributed spirituality and healing qualities to being on Mauna Kea. (Maly, 1999)

Dr. Langlas interviewed a woman of the Poli’ahu line, meaning that Poli’ahu is one of her family’s *‘aumakua*. This family has designated an individual as their *kahu* for worship of Poli’ahu. This individual has constructed a shrine on Mauna Kea to worship Poli’ahu and has incorporated a stone given to her by the family. She considers the whole mountain to be sacred and feels that it is appropriate to worship anyplace on the mountain if one is spiritually guided there. Thus, worship should not be limited to traditional sites. The shrine placed by this *kahu* is not located in a traditional site but rather in a place that she was guided to.

Maly's interviewees also report of the practice of taking ash remains to the summit of Mauna Kea for release. Two of the individuals interviewed by Maly have instructed that upon their deaths, their ashes are to be taken to specific places on the slopes of Mauna Kea.

While the ethnographic research provides few accounts of actual cultural practices on the mountain, other individuals and groups may visit the mountain for worship on special occasions or on a regular basis. Many more carry with them an esteem and respect for Mauna Kea.

“In both its genealogical associations and its physical presence on the island landscape, Mauna Kea is a source of awe and inspiration for the Hawaiian people. In Hawaiian practice elders are revered – they are the connection to one's past – and they are looked to for spiritual guidance. Because of its place in the Hawaiian genealogies, Mauna Kea, the landscape itself is a sacred ancestor.” (Maly, 1999, p. D-25) This is the spirit with which many view the mountain today.

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

VI. EDUCATION AND RESEARCH

EDUCATION AND RESEARCH

Searching for a New Industry

As ranching operations dominated the inland areas, the port towns of Kawaihae, Kailua, and Hilo continued to grow.

In May of 1960, a powerful tidal wave washed through the town of Hilo, destroying property and severely damaging the economy. In looking for a new industry to help save the island's economy, the Hawai'i Island Chamber of Commerce, with the support of Governor John Burns, approached universities in the United States and Japan with the idea of developing Mauna Kea and Mauna Loa as astronomy locales.

What started as a search for a new industry has resulted in new knowledge, expertise, and learning opportunities in a variety of fields.

Evolution of Astronomy on Mauna Kea

Dr. Gerard Kuiper, of the University of Arizona, was already working with NASA and the Department of Defense to test sites on Haleakalā and was eager to explore possibilities on Hawai'i Island. While Haleakalā was considered a good site, and telescopes were subsequently developed there, Kuiper preferred to find a site further above the cloud layer. Having flown over Mauna Kea, Kuiper became interested in its potential and developed a plan for site testing. Mauna Loa was less favored because of the possibility of volcanic activity (Parker, 1994).

To support this testing, Dr. Kuiper persuaded then Governor John Burns to provide funds to establish a jeep trail to the summit area. In 1964, a NASA-funded 12.5 -inch telescope was installed on Pu'u Poli'ahu and Kuiper's team began "seeing" studies. Kuiper concluded that "The mountaintop is probably the best site in the world – I repeat – in the world - from which to study the moon, the planets, and stars." With this exclamation, a new industry was born in Hawai'i.

Many now understand what Dr. Kuiper first saw. Mauna Kea is one of the finest locations in the world for ground-based astronomical observations. Because of its location high on an island in the Pacific, the sky above the mountain is generally cloud-free. This gives Mauna Kea one of the highest proportion of clear nights in the world, an important factor given the number of researchers requesting observing time. The stability of the atmosphere at Mauna Kea, free from disturbance caused by neighboring land forms, allows more detailed observations than available elsewhere. Finally, the summit's height above the tropical inversion cloud layer provides summit skies that are pure, dry and free from atmospheric pollutants.

During 1965, Dr. John Jefferies' team from the University of Hawai'i and Gerard Kuiper's team from the University of Arizona conducted extensive tests of the skies at Mauna Kea. The two universities, along with Harvard University, applied to NASA for funding of a new telescope on Mauna Kea. In 1965, NASA accepted the University of Hawai'i's proposal and agreed to fund the design and construction of the telescope. Construction of the UH 88-inch (also known as the UH 2.2-meter) telescope began in the Fall of 1967. Images of some of the early work on the mountain are presented in Figure VI-1.

The University of Hawai'i Institute for Astronomy was founded in 1967 and is responsible for carrying out research in astrophysics and planetary science and for the development and management of the Mauna Kea Science Reserve. University of Hawai'i scientists have access to a guaranteed fraction of viewing time on all of Mauna Kea's telescopes.

In 1968, the State Board of Land and Natural Resources recognized the importance of Mauna Kea for astronomy observations and leased an area of land to the University of Hawai'i for a 65 year period. (In 1998, the lease area known as the Mauna Kea Science Reserve was modified to exclude the Natural Area Reserve parcels [designated in 1981] leaving a total area of 11,288 acres under the agreement.) The Science Reserve includes the lands from approximately 12,000 foot elevation to the summit. The Natural Area Reserve contains two parcels. The largest is a pie shaped area of land extending from the Summit Access Road to Pōhakuloa Gulch and containing the main adze quarry and Wai'au. The second Natural Area Reserve parcel on Mauna Kea contains Pu'u Pōhaku, a cinder cone that contains evidence of the ice age in permafrost.

Working astronomy on Mauna Kea advanced at the close of the decade with the construction of two 0.6-meter telescopes, provided to UH by the U.S. Air Force and by NASA in 1968 and 1969.

The 1970s brought a flurry of interest in Mauna Kea from the international astronomy community and the first comprehensive planning steps for the mountain. Development of four telescopes marked a decade of new beginnings on the mountain. Infrastructure planning for the mountain was also active during this time, as Hawai'i took its place among the world's top astronomy centers.

On the summit, the UH 2.2 meter Telescope, the Canada-France-Hawai'i Telescope, NASA's Infrared Telescope Facility, and the United Kingdom Infrared Telescope were constructed to support optical and infrared astronomy.

In 1975, the jeep trail to the summit was realigned to eliminate some of the steep grades and sharp turns in the original alignment. Power was supplied to each telescope facility by on-site generators. In 1977 the first management plan for the mountain was adopted. This and subsequent plans are discussed in the Issues chapter of this plan.



Governor Burns at Mauna Kea Observatory Dedication (1970)



Original Survey Work



Road Work (1988)

Evolution of Facility Development

Photos: Institute for Astronomy

**Mauna Kea Science Reserve
Master Plan**

To support the development of these facilities, five temporary buildings were erected at the mid-elevation level. Here construction workers slept, ate, and acclimated to the altitude and weather.

Ever since the testing and construction of the first telescopes on Mauna Kea began during the late 1960s, temporary buildings and the original stone cabins at Hale Pōhaku have been used as a construction camp and astronomy support facility. The high elevation of the summit of Mauna Kea creates conditions that are difficult and potentially dangerous for those working at and visiting the mountain. Traveling directly from sea level to almost 14,000 feet can cause short-term high altitude effects such as light-headedness, shortness of breath, headaches, nausea, and dehydration. In extreme cases, life-threatening conditions can occur. The mid-level facilities, located at approximately 9,200 feet, provide a place to rest and acclimate for those who are visiting or working on the summit.

The Mid-Level Facility was completed and dedicated in 1983. Astronomers working at the summit facilities for a few days were able to stay in the dorms at Hale Pōhaku to maintain their acclimatization to the altitude. Dining and lounge areas provide rest and relaxation for the scientists and telescope operators. Offices, a library, and small labs support the scientific activity which draws the astronomers to Mauna Kea.

Along with construction of the Mid-Level Facility, a Visitor Information Station (VIS) was constructed below the main lodging facilities and stone cabins. The 950-square foot facility serves as an interpretive center and as the control point for visitors to the mountain. It also provides a transition point where visitors can acclimate to Mauna Kea's altitude. The VIS was developed approximately 650 feet below the main food and lodging facilities' nearest dorm. The entire area is designed to separate the visitor and construction activities from astronomy support activities. Astronomers and support staff work at night and must use the daytime hours to sleep and analyze the data that's been collected during the night. Visitors are accommodated in other facilities to allow the scientists to rest.

Below the VIS, a Construction Camp area has been developed. With the construction of the main food and lodging facility to support active astronomy observations, construction support was moved further down the mountain. Two temporary buildings were relocated from the main lodging area down to the Construction Camp area to support the construction of the W. M. Keck Observatory. One building is a dorm housing 24-29 people. The other was used as a common building and includes a kitchen, dining room, and recreation area. Four 4-bedroom cabins, built to support the Subaru Telescope construction crews, accommodate a total of 32 individuals. If the 1970s represented the beginning of this new industry, the 1980s was a period of maturation with the adoption of the first comprehensive physical and management plan for the Science Reserve and Hale Pōhaku in 1983, and the development of mid-elevation facilities.

The 1990s, then, have been a decade in which astronomy at Mauna Kea has leapt forward with the development of some of the finest telescopes in the world. This decade has been unsurpassed for astronomers as new discoveries and new facilities have been realized. The decade has also brought new international partners to the mountain such as Japan (Subaru), Taiwan (Submillimeter Array), and Chile, Australia, Argentina, and Brazil (Gemini). Five telescope facilities began operations this decade so far, and one more will do so in the year 2001.

The Very Long Baseline Array (VLBA) consists of ten identical radio telescopes, each 25 meters in diameter, spread across the United States from Hawai'i to the U.S. Virgin Islands. The Hawai'i component of the VLBA is located at approximately the 12,000 foot elevation within the Mauna Kea Science Reserve.

Envisioned in the 1983 Complex Development Plan as the University of California 10-meter Telescope, the W. M. Keck Observatory (Keck I) was completed in 1992. Subsequently, a second 10-meter telescope, Keck II, was constructed, and shortly thereafter, NASA joined the Keck team.

The most recent facilities to come on-line include Gemini North, an 8-meter optical/infrared telescope and Subaru, an 8.3-meter optical/infrared telescope (Figure VI-2). In addition to the telescopes already described, the 1983 Complex Development Plan projected the development of a single-dish millimeter-wave or radio telescope in the 1990s. This facility was expected to be 10 to 25-meters in size and located in millimeter valley with the James Clerk Maxwell Telescope and the Caltech Submillimeter Observatory. Astronomy technology has advanced since the Research Development Plan and Complex Development Plan were published in the early 1980s. As a consequence, a submillimeter interferometer was proposed for Mauna Kea to achieve the scientific objective of a millimeter-wave telescope. The Smithsonian's Submillimeter Array, a complex of 24 antenna pads and up to 12 movable antennas, will begin operations in 2001. Existing and proposed astronomical facilities are discussed in Section IX.

New Astronomical Discoveries at Mauna Kea

Astronomers come to Mauna Kea in search of scientific answers to some of humanity's most fundamental questions: How and when did the stars, planets, and galaxies form? What threats do we face from the Sun and other celestial bodies? What will be the ultimate fate of the Universe?

Improvements at existing facilities and the operations of new facilities will help to answer these questions. Scientists are now working on the interferometry technology to link the two Keck telescopes and provide the resolving power of a telescope with a mirror 85 meters in diameter. Pointing both telescopes at stars that are several hundred trillion miles away, and then combining the observations using sophisticated technology, the Keck interferometer will provide measurements and images that will be a quantum leap beyond those made by single telescopes.



CFHT, Gemini Northern, UH 2.2-m and UKIRT Telescopes (Photo: Group 70)



Subaru Telescope (Photo: Group 70)



Mauna Kea Observatory with Haleakalā in Background (Photo: Richard Wainscoat)

Astronomy Facilities

Mauna Kea Science Reserve Master Plan

The Keck Interferometer will search for planets beyond our solar system. Because even nearby stars are far away, and because planets are much smaller and fainter than stars, powerful telescopes are needed. In the last few years, astronomers have observed definitive signs of planets in other solar systems, however, no direct images have been produced. Rather, scientists have observed the effects of the gravitational pull between a star and neighboring planet. The NASA's Origins program seeks to capture direct images of Earth-like planets, if they exist, and study their planetary atmospheres in an effort to determine whether life exists on other worlds. Combining the images through interferometry will vastly improve the ability to distinguish the faint motion of two distant objects, such as a star and a planet, that are actually very close to each other in space.

Support Facilities

Hale Pōhaku Today

Today Hale Pōhaku continues to serve as the main base for astronomers and technicians. Sleeping accommodations are provided in 72 units, designed with blackout shades and other accommodations tailored to daytime sleepers. Astronomers, technicians and support staff gather in the common building which includes a kitchen, dining area, lounges, offices and a library. A maintenance area serves as a headquarters for Mauna Kea Support Services (MKSS) repair and maintenance activities. MKSS staff at Hale Pōhaku include 12 persons supporting food and lodging and 5 persons in the utility area. The latter perform road maintenance, snow removal and facility maintenance at Hale Pōhaku.

Over time, the use of the mid-level facilities has changed. At one time they were often filled to capacity with visiting astronomers and construction crews. Technological advances have made remote viewing a practical alternative to working at the summit and astronomers do not necessarily need to be at the summit to analyze data collected at some of the observatories. The W. M. Keck Observatory, for example, has designed its Waimea headquarters with control rooms linked with data and video lines to the observatory on Mauna Kea. Astronomers using the Keck facilities can stay in the Keck dorms in Waimea and perform their work without traveling to the mountain. The VLBA is operated remotely from the VLBA headquarters in New Mexico. It can be expected that, over time, more and more astronomers will be able to obtain their data without going to the summit of Mauna Kea and perhaps even without coming to Hawai'i. As a result, the lodging facilities at Hale Pōhaku may experience less demand from the astronomy community.

Currently, the facilities at Hale Pōhaku average 3,400 reservations a year (Koehler, 1999). On average, 34 of the 72 rooms are occupied. During special astronomical events, such as an eclipse or comet collisions with Jupiter, the facilities are often full. Demand also increases when significant milestones are achieved in telescope development. For example, most of the lodging units were occupied with first light preparations for Gemini and Subaru telescopes in early 1999.

Base Support Facilities

The development of the astronomy facilities on Hawai‘i extended from the top of Mauna Kea to the island’s coast. While telescopes are constructed on top of the mountain, and common facilities provided in the mid-elevation area, base facilities have been developed in Hilo and Waimea. Built in population centers, base facilities for each observatory are located near the workforce, in comfortable climates, and near business, schools, and housing. Typically, these base facilities contain offices, laboratories, and computer facilities to support the observations on the mountain. While most base facilities are located in Hilo, the W.M. Keck Observatory and Canada-France-Hawai‘i Telescope have chosen to located their headquarters in Waimea. Mauna Kea Support Services (MKSS), the organization responsible for the food and lodging accommodations and road maintenance on Mauna Kea, also has a base facility in Hilo.

Infrastructure

The sophisticated astronomy complex atop Mauna Kea is supported by an infrastructure system designed to meet state of the art communication needs, address personal safety concerns, and impact the natural environment as little as possible while accomplishing these goals.

Over time, the roadways and other infrastructure systems have been improved to provide safer and more efficient service to the astronomy facilities. As mentioned above, the original jeep road to the summit built in 1964 was improved for safety purposes in 1975. The gravel road that served the summit for the next decade was better, however, it still was dusty, which interferes with observations, and can be unsafe for vehicles.

In 1985, funded by State funds and the Keck Observatory’s infrastructure contribution, the State Department of Transportation began the design process for a 20-foot wide roadway beginning at Hale Pōhaku and looping around summit facilities. To date, two of the six phases of construction have been completed, including pavement of the roadway from the 11,800 elevation to the summit facilities. When funding is available, future phases will include the paving of the road from Hale Pōhaku to 11,800 feet, construction of additional parking areas, and two runaway truck ramps.

Water for Hale Pōhaku and the summit is regularly trucked from Hilo. Two-40,000 gallon water tanks are located at Hale Pōhaku. Currently, 25,000 gallons per week are trucked to the Mid-Level Facility. An additional 15,000 gallons per week are trucked to the summit to supply the various observatories. These quantities have remained fairly constant throughout the development of the telescope facilities. However, during heavy construction periods additional water is consumed by the construction crews.

All sewer disposal and treatment is handled by individual cesspools and septic tank/leaching field systems that serve each facility. All existing facilities have been approved by the State Department of Health. There is no plan to construct a sewer system to collect and treat wastewater from each facility.

During the early years of telescope development, power was provided to individual facilities by on-site generators. The first phase of bringing power lines to the summit began in 1985 with the construction of a 69KV overhead system from the Humu'ula Radio Site to a substation located just below the mid-level facilities. There, the voltage is reduced to 12.47KV, and the power distributed via underground distribution system to the summit. The initial construction of the distribution system was completed in 1988. In 1995, the electrical system was upgraded to complete the loop at the summit and provide service to the Submillimeter Array.

Development of the communications system required many phases of construction to complete. The first phase began during the construction of the underground power distribution system in 1985. The addition of summit communications system continued into the 1990's, with the installation of fiber optic lines.

A project to add fiber optic lines to the existing 69KV overhead power system began in 1995. The lines were added to the existing system of poles from the Humu'ula Radio Site to the substation near Hale Pōhaku. In 1996, the construction began on the final phase of the fiber optics communication system, which completed the linking of all the telescope facilities and the mid-elevation support facilities.

Other Research and Education

The first research activities on Mauna Kea are documented in the journals of some of the early explorers of the mountain. The first confirmed ascent of Mauna Kea by a foreigner was made in 1823 by Joseph Goodrich. Botanist David Douglas scaled the mountain summit in 1831. Like Goodrich, Douglas made observations of the summit cinder cones and desolate landscape. In 1892 W.D. Alexander led a surveying party to Mauna Kea. They spent time on the summit of Līlīnoe and made observations of stone cairns and unique land forms. On one of the summit cones, they found a tin can that contained records of five different parties that had visited between 1870 and 1892 (in McCoy, 1999). In 1937, Gregory and Wentworth wrote of the evidence of Mauna Kea's glaciation, describing the character of the bedrock that has been shattered and shaped by the glacial ice.

Explorers, educators, and scientists have long appreciated the unique natural and cultural features of Mauna Kea. The development of a road to the summit provided vehicular access to the region's rich resources that had not been available before. Some of the first formal archaeology surveys took place in the Natural Area Reserve and Science Reserve in the mid 1970s.

Much of the detailed archaeological and scientific research was conducted as part of the comprehensive planning process for the Science Reserve in the early 1980s. Botanical studies and arthropod studies were conducted of the summit area. During this time the first discovery of the Wēkiu bug was made. Archaeological surveys of the summit

identified shrines and workshops that tell the story of the mountain's earliest use by man. Biological and archaeological surveys of the Hale Pōhaku area were also undertaken in the early 1980s.

With the development of the astronomy complex has come a wealth of educational outreach programs. Thousands of high school and elementary students each year receive an introduction to astronomy's wonders through field trips to the mid-elevation facilities and through contact with the scientists and educators from the various observatories. University professors take their students to the mountain to study astronomy, geology and climatic processes, and Hawaiian culture and language.

Up to the present time, education and research activities have focused largely on astronomy. Other research activities have resulted largely from astronomy planning efforts. However, there is great potential for much broader educational and research use on Mauna Kea independent of astronomy activities. There is a sentiment among educators that non-astronomy education should be encouraged and promoted. So, in addition to programs to train Hawai'i's young people in the science and technology of astronomy, there is a need for K-12 and remote learning programs statewide, together with learning centers at University of Hawai'i at Hilo and Hawai'i Community College to provide balance between science and culture through education.

In a proposal (14 January 1998) for the creation of a management structure, Dr. James Juvik, Ph.D., lists some of the research projects undertaken by University of Hawai'i-Hilo faculty as examples of the many areas of study that can be supported and enhanced through use of Mauna Kea as a laboratory and classroom. Among the many possibilities is study of Hawaiian culture and archaeology, high altitude atmospheric research, earth processes and quaternary studies, montane terrestrial ecology, and human biology and response to high altitude.

Currently the University of Hawai'i at Hilo is working with NASA and the Bishop Museum to develop the Mauna Kea Astronomy Education Center. This facility will be constructed in University Park and will serve as a science and education resource for astronomers, students of all ages, and the general public. Plans for the Center will include a planetarium and theater, displays of astronomy, natural history, cultural history, classrooms and laboratories, distance learning facilities, and visitor amenities. The purposes of the Education Center are multi-faceted. The complete proposal for the Center can be found in Appendix B; and an excerpt is presented below.

(Excerpt from the UH-Hilo Proposal for the Mauna Kea Astronomy Education Center)

“Education, with an emphasis on outreach to indigenous community members, is a central feature of the Master Plan. Much of the philosophical framework for this finds expression in the proposed Mauna Kea Astronomy Education Center at the University of Hawai'i at Hilo. The Center will serve to facilitate formal astronomy education and the integration of science into indigenous cultures at all

levels. It also will serve as the principal center in the world demonstrating how the latest science can be integrated with indigenous cultures of great antiquity to maintain unique cultural identity and knowledge while participating at the scientific forefront of the international global society. The Center will help to train the next generation of space scientists and to raise the overall level of science literacy in our nation. Students, teachers and college instructors, and community college/ baccalaureate students locally, nationally, and worldwide. Programs to support formal astronomy education will include:

- School class visitation programs, for visiting school groups from Hawai‘i and throughout the world, utilizing all the Center observatory visitor facilities and some of the academic support facilities.
- Professional development experiences for teachers and college instructors in the forms of year-round workshops, on-site and distance learning courses and programs, curriculum development, and research opportunities in collaboration with University of Hawai‘i astronomy faculty.
- Enhancement of classroom astronomy instruction throughout the State of Hawai‘i by in-class programs presented by Center staff and affiliated University of Hawai‘i astronomy pre-service education students.
- Collaborative use of Mauna Kea telescopes to enhance astronomy instruction in cooperating community colleges, universities, and K-12 schools, locally, nationally and world-wide.
- Summer astronomy workshops and courses for astronomy students from secondary schools, community colleges, and universities using the Center’s facilities and the Mauna Kea observatories.
- Electronic dissemination of scientific data from Mauna Kea telescopes and live images, to schools and universities world-wide.
- Development of a national Astronomy Scholars Program in conjunction with the University of Hawai‘i at Hilo.
- Year-round Hawaiian and indigenous culture workshops.
- Development of curriculum materials on Hawaiian and indigenous cultures.
- Academic programs in Hawaiian and other indigenous languages and cultures at the community college, baccalaureate and graduate levels.”

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

VII. RECREATION

RECREATION

Enjoying Mauna Kea's Unique Natural Resources

Before the first road to the summit was built in 1964, only hardy recreationalists hiked Mauna Kea's slopes. During this time, hunters were active on the mountain's lower slopes. Stone cabins built by the Civilian Conservation Corps (CCC) in the 1930s served as the base camp for hunters, hikers, and explorers. The name of the mid-elevation area, Hale Pōhaku, derives from these cabins.

Ever since the first road was developed to the summit, people have come to Mauna Kea to hike, play in the snow and sightsee. Hunting is also an important activity which may be viewed as recreation but for many is an integral part of their lifestyle, subsistence and culture. Hunting continues to occur at the lower elevations of the mountain outside the Science Reserve.

Residents and visitors alike come to Mauna Kea simply to experience this place that is unlike any other in Hawai'i. Many are drawn to the mountain to witness the world class telescopes, feel the chill of the air, and appreciate the desolate beauty and natural land forms of Mauna Kea. What they must also keep in mind is that the extreme weather conditions on the mountain make all recreational activities potentially dangerous.

Hiking

Hikers visit Mauna Kea for an experience that is unmatched in the Hawaiian Islands. The clear skies, cool air, and awe-inspiring landscape draw experienced and novice hikers alike. The factors that make Mauna Kea such a uniquely appealing place to hike are also cause for health and safety concerns. Hikers must be prepared for the affects of high altitude on their bodies and the possibility of a sudden and severe change in weather.

Hiking is most popular in the Ice Age Natural Area Reserve and along existing roads. Individuals typically drive up the mountain for a distance before parking and hiking. The Humu'ula-Mauna Kea trail runs from the old sheep station at Humu'ula to Wai'au. A few individuals brave the low temperatures and swim in Wai'au.

Snow Play

Big Island residents and visitors look forward to those winter periods when snow falls at the higher elevations of Mauna Kea. Families and individuals visit the mountain to ski, snowboard, and play in the snow. Often, people load their pickup trucks with snow to take down to Hilo and other towns so that others can enjoy the snow.

The Summit Access Road is kept clear of snow by Mauna Kea Support Services staff. Private vehicles typically park along the roadways and visitors play nearby. The most popular ski and snowplay areas are those easily accessed by roadways. The ski run known as Poi Bowl is the most popular because it is accessible by roads at both the top and bottom of the run. Skiers typically establish an informal shuttle system where the skier is dropped off at the top of the run and then met at the bottom. If the snowfall is heavy enough, the area to the east of the summit, known as King Kamehameha run, is used for longer ski runs although the bottom of the run is not accessible by vehicle and the skier must hike back to a roadway. At times it is possible to ski from the summit to the edge of the Science Reserve. Once or twice a year, depending on the snow conditions, a skiing or snowboarding competition is held on the mountain. Popular ski areas are shown in Figure IX-25.

The weather patterns for any particular year will determine how much and where snow falls. Snow typically falls first and melts last from the northern slope of Pu'u Hau Kea (also known as Goodrich). At times it is the only place on the mountain with snow. When snowfall is light, people tend to hike between snowy areas.

Sightseeing and Stargazing

Sightseeing is another favorite activity for residents and visitors alike. Before proceeding up the mountain visitors are asked to spend time at the Visitor Information Station (VIS) to view the exhibits and acclimate to the altitude. A number of visitors use private vehicles to explore the summit on their own. Visitors will drive up to the summit possibly stopping along the way to walk around a bit and take photographs. At the summit, the public can visit the Keck Visitor Gallery to view exhibits and see the inside of one of the Keck domes. Other visitors will join MKSS-led tours twice a week. In 1998, an estimated 38 visitor vehicles traveled to the summit of Mauna Kea daily (Koehler, 1999). Another 100 to 150 vehicles visited the VIS only each week. Approximately 100 students visit the VIS each month during the school year and even more visit in the summer months.

While many residents and visitors drive to the summit area themselves, others join commercial tours. DLNR issues a limited number of Commercial Activity Permits to tour operators who pay annual and per customer fees. Commercial tours register at Hale Pōhaku each time they ascend the mountain. In 1999, eleven Commercial Activity Permits were active (Unoki, 1999). Of these, ten allowed tours to the summit and one provided commercial access to Hale Pōhaku only. Tour operators take visitors for six to eight hour trips which can include an observatory tour, lunch, hikes to Wai'au, and narratives on the area vegetation and natural history. In the Fall of 1998, an estimated 30 tours per week went to the summit (Koehler, 1998).

Taking sightseeing to a higher level, the MKSS offers stargazing programs at the Visitor Information Station seven evenings a week. These stargazing programs drew an average of 80 participants per evening (320/week) in 1998 (Koehler, 1998).

The same factors that make Mauna Kea a premier spot for major astronomy research also provide excellent conditions for amateur astronomy. Many of the evening visitors to the mountain, especially the VIS area, are amateur astronomers.

Hunting

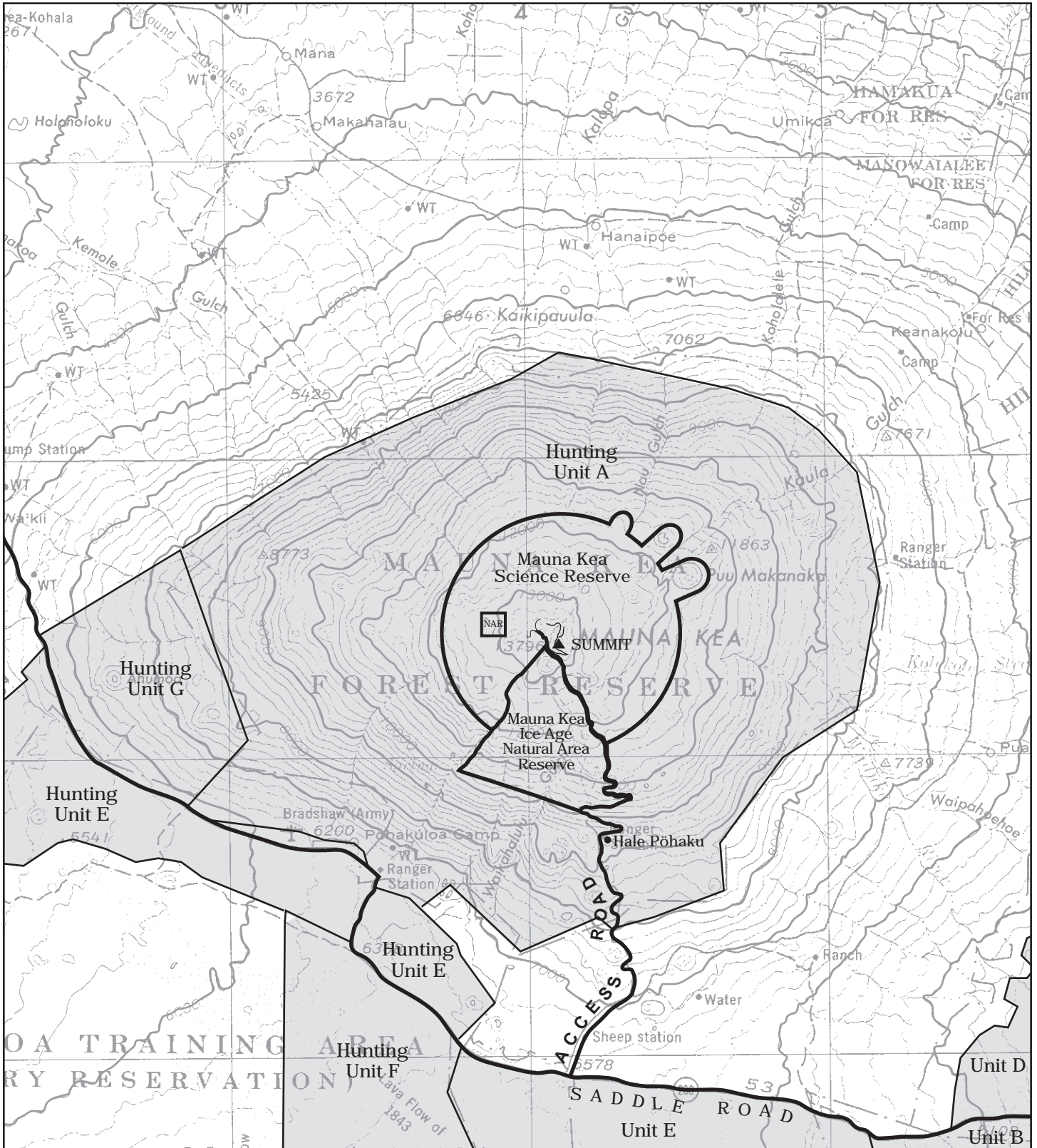
Long a tradition on the island, hunting continues on Mauna Kea in a managed structure. Hunting on Mauna Kea occurs largely outside of the Science Reserve on the mountain's lower slopes. Today, pigs, sheep, goats, and a variety of gamebirds are hunted by rifle or archery in three dozen hunting units concentrated in the central portion of the Island of Hawai'i (Figure VII-1).

Lloyd Case, interviewed in Kepā Maly's oral history study for Mauna Kea, describes hunting with his family on Mauna Kea.

“I started going hunting with my brothers, from five years old, I went out several times. Then later on, from eight years old to ten, I started going more and more with my brothers. But Mauna Kea was one of our particular areas that we liked to hunt. One of our favorite places because it had a variety of game. You could go there and get your *pua'a* (pig), you could get your *hipa* (sheep), there were goats in those days too. But our family, we grew up on sheep, so Mauna Kea was a place that I always went to gather sheep.” (p. A-345 in Maly, 1999)

“What we used to do is, we'd sleep right there, and in the morning, the sheep would come down for eat. So what we would do is go right above and wait for them to come back up.” . . . “They come down to eat. So what we'd do is walk up a little bit and intercept them on their way back up. And it's all down hill then, so we'd pack 'em right down to the road yeah.” (p. A-345 in Maly, 1999)

Gamebirds including turkey, pheasants, quails, chukars, and francolins are also present on Mauna Kea's slopes. There are over 3,000 licensed hunters living on the island. The Mauna Kea Forest Reserve (elevations over 7,000 feet) is a hunting unit where pigs, goats, sheep and birds can be hunted with archery and firearms. Sport hunting is a popular activity which contributes to the island's economy. While sheep, goats, pigs and some game bird species sometimes enter the Science Reserve area, most of the birds and mammals are hunted on the mountain's lower slopes.



Source: Saddle Road (SR 200) Mamalahoa Highway (SR 190) to Milepost 6 DEIS, Technical Appendices, Volume V, 1997

DLNR Hunting Units

Mauna Kea Science Reserve
Master Plan

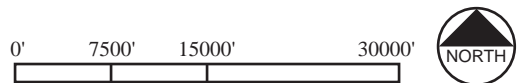


Figure VII-1
Page VII-4

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

VIII. ISSUES AND OPPORTUNITIES

ISSUES AND OPPORTUNITIES

Management and use issues are not new to Mauna Kea. Soon after the introduction of the first cattle, goats and sheep, these animals roamed the slopes of the mountain, contributing to the decline of vegetation in the *palila* habitat. Wildfire has also been a source of habitat destruction. Hunting was and is an important way of life for many Hawai'i Island residents; however, even the hunters could not keep pace with the rapidly growing animal population. In destroying portions of the *māmane-naio* forest, the animals impacted the only habitat of the *palila* bird. Territorial and State government agencies have attempted to control the population of ungulates through formal hunting efforts. However, the long-standing issue of balancing habitat protection and hunting traditions exists to this day.

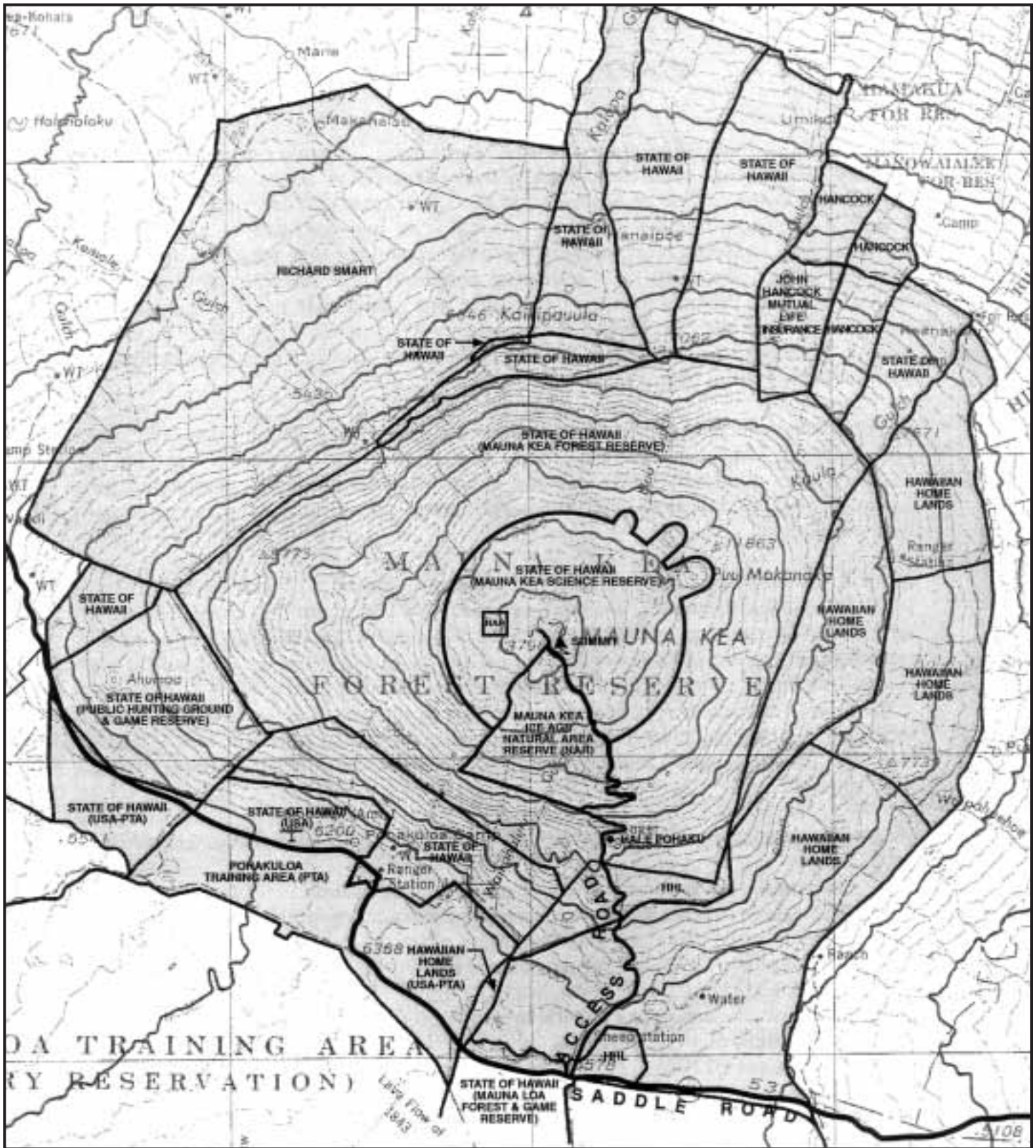
With the development of the astronomy facilities and supporting infrastructure on Mauna Kea in the late 1960s, access to the summit area increased and the number and types of mountain users multiplied. As a response to user conflicts and concerns regarding the natural and cultural resources of the mountain, several management and planning efforts were undertaken.

In 1968, the Board of Land and Natural Resources approved a 65 year lease (General Lease No. S-4191; January 1, 1968 to December 31, 2033) to the University of Hawai'i for a 13,321-acre circular area (2.5 miles in radius) centered on the Mauna Kea summit (approximately all the lands above 12,000 feet elevation) and referred to this land as the Mauna Kea Science Reserve (Land ownership is presented in Figure VIII-1). As stated in the Lease: "The land hereby leased shall be used by the Lessee as a scientific complex, including without limitation thereof an observatory, and as a scientific reserve being more specifically a buffer zone to prevent the intrusion of activities inimical to said scientific complex."

Most of the broad responsibilities of the University of Hawai'i stem from this Lease:

1. Maintenance of the premises in a clean and orderly fashion.
2. The right to develop improvements upon review and approval by the BLNR.
3. General liability resulting from negligence of UH.
4. Compliance with DLNR regulations and all other federal, state and county laws affecting land or improvements.
5. UH must not damage any cultural or historic site of value.
6. No planting of trees, shrubs or other vegetation except those approved by the Chairman of BLNR.

In addition to the general retention of regulatory authority, the BLNR specifically identified and retained all water rights, rights to access through the Science Reserve, hunting/recreation rights, rights to use any part of the Science Reserve or permit another party to use parts of the Science Reserve with the mutual consent of the University.



Source: City and County of Honolulu,
 Real Property Assessment Division
 Tax Maps Branch, 12/31/98

Land Ownership Map

Mauna Kea Science Reserve
 Master Plan



Figure VIII - 1
 Page VIII - 2

1970s Planning

As astronomy development expanded in the early 1970s, concerns about further telescope developments were raised by hunters and conservationists. It was generally recognized that an overall Mauna Kea plan was necessary in order to control development on the mountain and to resolve the conflicting interests of the various users. Recognizing the increased scientific and recreational activity on Mauna Kea and expressing concern for native Hawaiian ecosystems, Acting Governor George Ariyoshi directed the Board of Land and Natural Resources to develop a master plan for all of Mauna Kea. DLNR initiated the planning study in 1975 and The Mauna Kea Plan was approved by the BLNR and published in 1977. The plan provides a policy framework for the management of the mountain from the Saddle Road area at 6,000 feet to the summit (DLNR, 1977).

The plan identified areas of responsibility for DLNR, the University of Hawai'i and the State Department of Transportation. According to the plan, the University is responsible for management and upkeep of Hale Pōhaku area astronomy facilities and management and upkeep of Mauna Kea Science Reserve.

All other management functions were retained by DLNR except for control of the Summit Access Road which was designated for the State Department of Transportation.

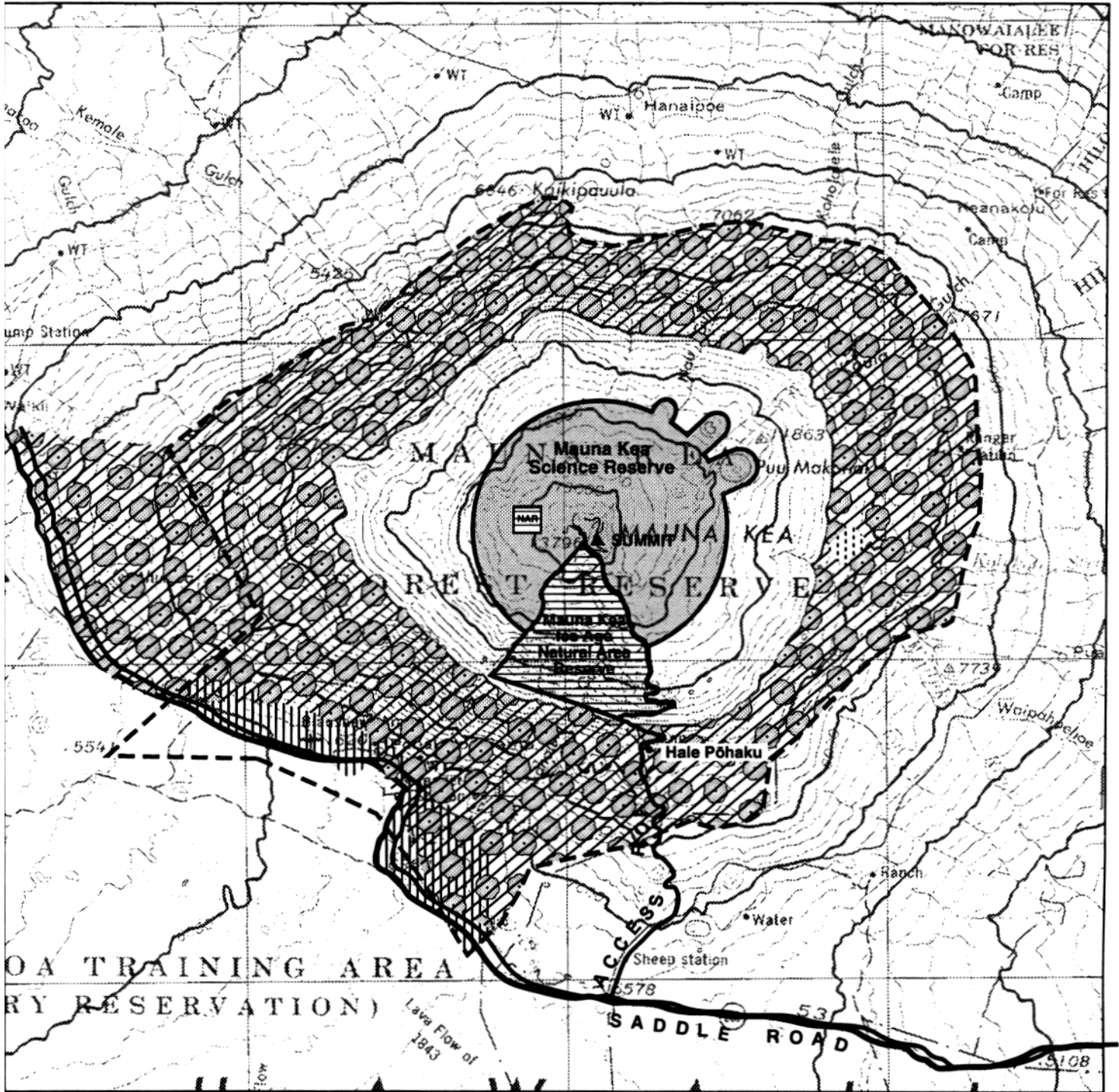
The 1977 Plan established five management areas and described acceptable use and management controls for each area (Figure VIII-2).

1. *Māmane-naio* Forest Ecosystem Management Area
2. Science Reserve Management Area
3. Special Natural Area and Historic/Archaeological Management Area
4. Silversword Management Area
5. Military Management Area

1980s Planning

During the initial years of increased astronomy support activity at Hale Pōhaku, other mountain users expressed concern about that area's development. Hunters worried about the potential loss in the size of the hunting range. Environmentalists expressed concern that the *palila* habitat would be damaged by new construction. Recreational users asked that park facilities be included for public use.

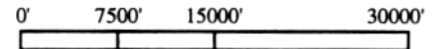
Recognizing the concerns raised by various interest groups, and a need to replace temporary structures with permanent astronomy support facilities, the Hale Pōhaku Complex Development Plan was prepared by Group 70 in 1980. The report recommended specific siting, organization, and general characteristics of the permanent facilities proposed for Hale Pōhaku in support of the six telescopes developed on the summit at that time. The CDP also provided design guidelines which call for minimized



Source: The Mauna Kea Plan
Hawai'i Department of Land
and Natural Resources, 1977



1977 Mauna Kea Plan Management Areas



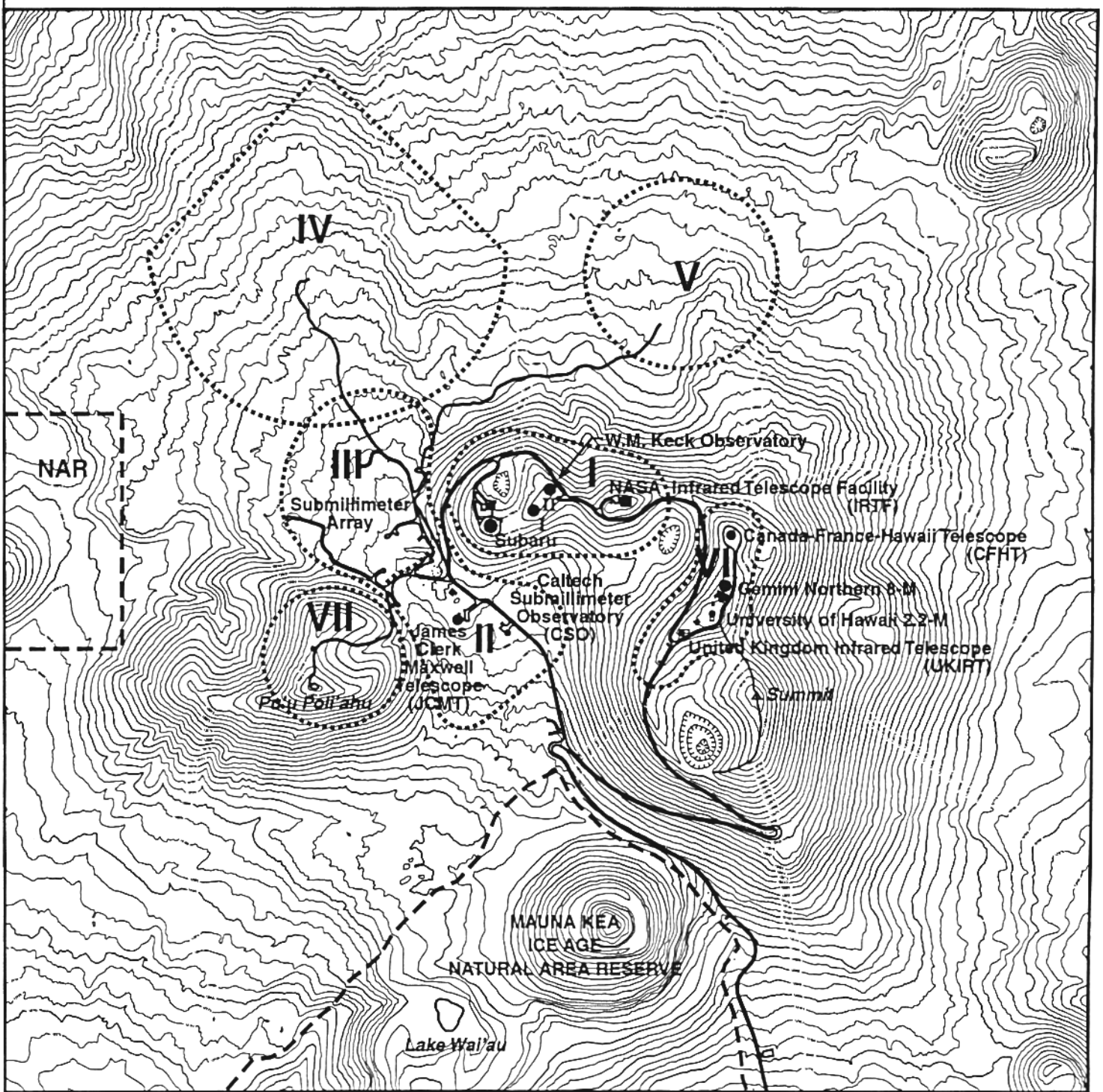
disturbance of the *māmane-naio* ecosystem and integration of facilities into the landscape. These guidelines were followed in the development of the main food and lodging complex. These facilities are built on pier type foundations following the natural terrain. Building colors blend into the landscape and surfaces are designed to be only minimally reflective. The entire complex was designed to incorporate the area's vegetation with minimum disturbance of the *māmane-naio* ecosystem.

In an administrative action that occurred during this time, Executive Order No.3101 dated November 16, 1981 identified two Natural Area Reserve parcels to be set aside from the Science Reserve and placed under the management of the DLNR. Parcel 1 was a 1,889.7-acre pie-shaped parcel encompassing much of the adze quarry and Wai'au and the other was a 143.5-acre rectangular parcel surrounding Pu'u Pōhaku. The formal withdrawal of the parcels from the general lease occurred on March 23, 1998. These actions removed the University from responsibility for management of these areas.

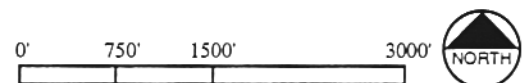
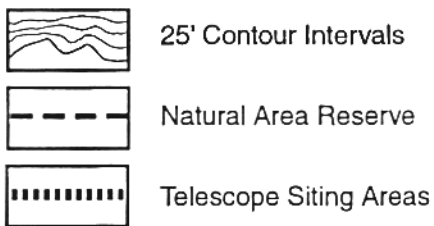
While the Hale Pōhaku facilities were being constructed, the University of Hawai'i was also looking towards the future of ground-based astronomy at Mauna Kea. The University of Hawai'i Research Development Plan (RDP) was adopted by the UH Board of Regents in 1982. The RDP provided the programmatic basis for the continued development of the Science Reserve and Hale Pōhaku with the goal of developing a pre-eminent state, national, and international resource for astronomical observations. The Research Development Plan called for future development of telescopes, infrastructure improvements and expansion of the mid-elevation facilities at Hale Pōhaku to support proposed telescope development.

The Mauna Kea Science Reserve Complex Development Plan (CDP) (1983) was prepared by Group 70 to provide the physical planning framework and management guidelines necessary to implement the UH Research Development Plan. The CDP serves as a guide for development which preserves the scientific, physical and environmental integrity of the mountain. It also provides proposals for managing the mountain's resources and visitor use. During this planning effort, the summit's biological and archaeological features were scientifically documented for the first time. Extensive flora and fauna studies, in addition to further archaeological work, were undertaken. As a result of the analysis of this information, a mixed use plan was developed for the summit and mid-elevation areas.

In the plan, areas of the summit plateau above 13,000 were analyzed using scientific, natural resource, and cultural resource criteria. Areas selected for potential facility development met scientific wind turbulence and obscuration requirements, were in areas where the ground was suited for construction, and where the impacts to recreational uses, visibility, biological resources, and archaeological sites would be minimized. The seven areas (Figure VIII-3) initially analyzed were refined to four planning areas to accommodate development of appropriate proposals through the end of the 1990's. The plan specifically identified proposed new telescopes which became the facilities now known as CSO, JCMT, and Keck I. It also envisioned proposals for additional



Source: 1983 Mauna Kea Science Reserve Complex Development Plan



Analysis Areas for Telescope Siting (1983)

Mauna Kea Science Reserve
Master Plan

Figure VIII - 3
Page VIII - 6

optical/infrared and millimeter telescopes. In addition to defining four siting areas and supporting infrastructure requirements, the plan called for parking, trash, and toilet facilities at the summit to support recreational users of the mountain. This plan also called for the expansion of the Hale Pōhaku facilities to accommodate the new astronomy facilities proposed for the summit. The plan called for these facilities to be consistent with the mid-level facilities that had just opened. One new dormitory was subsequently developed.

Much of the 1983 plan has been implemented. The astronomy facilities that were projected have been realized. Policies were laid out for non-astronomy research and educational use for the mountain. Guidelines were established for such activities as commercial use and off-road vehicles.

The plan encouraged the University to hold open nights at the Visitor Information Station to share astronomy with the public. Today, the MKSS sponsors star-gazing programs seven nights a week. With respect to infrastructure, the plan called for the paving of the entire road from Hale Pōhaku to the summit. To date, the upper half (approximately 4 miles) of the road has been paved with further work awaiting funding.

While much of the 1983 plan was carried out, a number of the plan's recommendations have not been implemented. For example, the plan recommended that rangers be hired to patrol the mountain and, in fact, the Institute for Astronomy established these job positions at one time. However, the unfilled positions were eliminated during budget cuts that affected all University programs.

With respect to recreational uses, the plan called for visitor parking and trash facilities in the summit area, and established enforcement guidelines aimed at encouraging visitors to use the designated parking areas. Other facilities proposed in the plan included a multipurpose research laboratory in the summit area and a permanently installed telescope for visitor use in the Hale Pōhaku area. These facilities have not been developed.

In an effort to remedy the difficulties caused by multiple jurisdictions, the plan called for the establishment of a management committee that would be advisory to the Department of Land and Natural Resources and the University of Hawai'i. This committee has never been formed.

1990s Planning

In 1995, a joint revised management plan was adopted by the University of Hawai'i and the DLNR. This plan clarifies and redefines the rights and responsibilities of the two organizations in the Science Reserve. The UH retained the following rights and responsibilities:

-
1. Mauna Kea Science Reserve Access:
 - The right to control, maintain and manage access in the Science Reserve; including the Access Road and associated parking areas.
 - The right to limit vehicle type or impose driving requirements.
 - The right to restrict hours of access.
 - The right to close the road for maintenance, hazards, snow removal or road repairs.
 - The right to ask others to assist in crowd control (similar to deputizing).
 - The right to require liability waivers.
 - The right to comment on commercial permit applications.
 - The right to control visitor activities around astronomy facilities.
 - The right to limit commercial vehicles in the Science Reserve.

 2. Activities at Hale Pōhaku Visitor Information Station:
 - The right to limit 14 passenger commercial vehicles.
 - The authority to enforce rules and institute crowd control policies at the Visitor Information Station.
 - Authority to set the hours of operation at the Visitor Station.
 - The right to issue special permits for the use of the Visitor Station.

 3. Commercial Activities at UH Facilities:
 - The right to operate concessions.
 - The right to contract for shuttle service to the summit.

Approval of this management plan came with several conditions. The following identifies major or special responsibilities of the University:

1. Historic Preservation Plan to be completed and implemented by UH IfA.
2. This management plan replaces the plan identified in CDUA HA-1573.
3. Include cultural uses that do not involve physical impacts.
4. MKSS (Mauna Kea Support Services) staff be educated and instructed to report violations of the Mauna Kea Plan.
5. Additional specifications on protection of historic sites intentionally or otherwise.
6. Reporting back to the BLNR after the completion of archaeological and biological studies to review possible needs for change.
7. Additional signage for various purposes.
8. 7 day a week Visitor Station hours and DOCARE for Mauna Kea (not exclusive), subject to funding.

Under the current conditions, DLNR retains the following responsibilities:

1. Authority to determine permitted public and commercial uses of the UH management areas (Science Reserve, Access Road, Hale Pōhaku).
2. Authority over recreational uses and commercial tours within the Science Reserve.
3. Authority over research and education, natural resources, historical and cultural resources, recreation, and commercial use on State land, including the Natural Area Reserve.
4. Statutory responsibility for treatment of historic sites.
5. The responsibility to make sure commercial permits have consistent fees, set terms and are subject to review and renewal by DLNR. These permits may be superseded by Land Division permits in the future.

These existing management responsibilities, based on the latest plans and statutory requirements are depicted in Table VIII-1.

Auditor's Report

In 1997, the State Legislature, through Senate Concurrent Resolution No. 109, requested that the State Auditor conduct an audit of the management of the mountain. The Auditor's report was issued in February 1998 as Report No. 98-6. Both the University of Hawai'i and the Department of Land and Natural Resources were criticized in the report which concluded that new technology impacted development of the Science Reserve and management of the summit area did not adequately protect cultural and natural resources. The audit concluded with the following recommendations to address issues raised in the report:

Management

- Develop rules and regulations for summit area and Hale Pōhaku
- Hire ranger/guides at Hale Pōhaku who will be there on a daily basis
- Require registration of visitors for education and safety reasons
- Develop milestones, specific timeframes & other controls to ensure implementation
- Develop a forum for continuous community input
- New method for measuring impact
- Measure impacts individually and cumulatively
- State specific carrying capacity
- Require management plans that have time frames
- Ensure internal deadlines prior to release of land or leases.
- Make sure all responsibilities are assigned; either UH or DLNR

Historic/Cultural Resources

- Address cultural and historic issues
- Complete the Historic Preservation Plan

**Table VIII-1 MAUNA KEA RESPONSIBILITY MATRIX
EXISTING AUTHORITY**

Responsibility	Science Reserve (Includes Summit Road)	Hale Pōhaku	State Land (Includes NAR)
Research/Education			
Astronomy	UH	UH	DLNR
Other Disciplines	UH	UH	DLNR
Public Education	---	UH	---
Natural Resources			
Ice age/Periglacial	DLNR/UH	---	DLNR
Wekiu Habitat	DLNR/UH	---	DLNR
Palila Habitat	---	DLNR/UH	DLNR
Endangered Species	---	DLNR/UH	DLNR
Feral Ungulates	DLNR	DLNR/UH	DLNR
Alien Species	DLNR/UH	DLNR/UH	DLNR
Ecosystem Restoration	DLNR/UH	DLNR/UH	DLNR
Historical and Cultural Resources			
Historic Sites	DLNR/UH	DLNR/UH	DLNR
Burials	DLNR-BC/UH	DLNR-BC/UH	DLNR-BC
Cultural Practices	DLNR/UH	DLNR/UH	DLNR
Recreation			
Skiing and Snow Play	DLNR	---	---
Hiking	DLNR	DLNR/UH	DLNR
Camping	---	DLNR/UH	DLNR
Sightseeing/FIT Tourism	---	DLNR/UH	DLNR
Hunting	DLNR	DLNR	DLNR
Other Recreation	DLNR/UH	DLNR/UH	DLNR
Commercial Uses			
Tours	DLNR	DLNR	DLNR
Concessions	DLNR/UH	DLNR/UH	DLNR
Movies/Commercials	DLNR	DLNR	DLNR
Cabin/room accommodations	---	UH	---
Access			
Summit Road	UH	UH	UH
Trails	DLNR/UH	DLNR/UH	DLNR
Safety and Security			
Road Conditions (above HP)	---	UH*	UH
Dangerous Weather	---	UH*	---
Altitude Education	---	UH*	---
Medical Emergencies	UH/CTY	UH/CTY	CTY
Fire	UH/CTY	UH/CTY	CTY
Crime	CTY	CTY	CTY
Maintenance			
Road (above HP)	---	---	IfA
Utilities	UH/Utilities	UH/Utilities	UH/Utilities
Trash Removal	UH	UH	DLNR
Removal of Old equipment	UH	UH	---
Graffiti	UH	UH	DLNR
Community Participation			
Public Restrooms	Keck*	UH	---
Programs	---	UH	---
Notification	UH	UH	---
--- = None or not applicable UH = University of Hawai‘i at Manoa (Includes IfA) BC = Burial Council * = Done but not required DLNR has rights to authorize other uses of the Science Reserve as long as it does not interfere with lease conditions			

Maintenance

- Periodic inspection and documentation of trash control
- Remove remnants of old equipment

Physical Planning Guidance

- Identify areas suitable for astronomical development
- Identify critical habitats for plants, invertebrates and other endangered species
- Identify no build zones
- Include facilities besides telescopes.

Statutory Recommendations/Lease Agreements

- Incorporate EIS mitigation measures as CDUA conditions
- Relate permit conditions to leases
- Adopt rules for Chapter 6E, Historic Preservation Program.

Planning Today

This Mauna Kea Science Reserve Master Plan will serve to address current concerns and guide the planning for the Mauna Kea Science Reserve for the next 20 years. While the projections of the 1982 Research Development Plan and 1983 Complex Development Plan have largely been implemented by 1999 as scheduled (the planning period was to the year 2000), the goals of balanced use and protection of resources have not been fully achieved. Issues and opportunities for the future use and management of the mountain beyond 2000 are explored below. Recommendations concerning these issues are detailed in the Physical (Section IX) and Management (Section X) plans that follow.

Management Authority

The joint responsibilities and layers of historical leases, plans, permits and written or verbal commitments have created a complex and often confusing pattern of management responsibility.

ISSUES

Unclear Responsibility: The legal and constitutional mandates to various agencies are articulated in the general lease, Hawai'i Revised Statutes and various plans and permits that have been adopted. Over the years, changes in plans, permits and personnel have resulted in a complex web of responsibility. Table VIII-1 summarizes the major areas of responsibility at the current time. A quick glance at this matrix shows the complexity of the arrangements. DLNR has had no permanent personnel on the mountain while UH has a number of people. UH IfA also has control and responsibility for the Summit Access Road. Therefore, some assume that UH has had *de facto* control and responsibility over the whole summit region even when it has no statutory authority to manage all the resources

and activities in the Science Reserve. Management of the whole summit area requires management of both the Science Reserve and the Natural Area Reserve. There has been no authority that has been fully responsible for the whole summit area. As a result, some concerns were not addressed or were only addressed after much delay. This lack of functional clarity has created a situation which sometimes frustrates the general public because it is unclear to them who can address their concerns.

Lack of Confidence in Current Organizations: At the present time DLNR and the University are the key agencies with authority and management responsibilities for the mountain. Both entities will continue to be key stakeholders in all future scenarios. The problem is the lack of confidence held by some members of the general public in the ability or will of these agencies to protect the natural and cultural resources of the mountain. While some of this lack of confidence is, arguably, a matter of perception rather than fact, there are some real shortcomings. DLNR's current structure and priorities are not likely to provide improved management or significant resources to address these shortcomings. IfA, by mission and expertise, is not focussed to provide overall property management services. Another management structure with the specific charge to manage the Science Reserve is perceived by many to be an appropriate alternative to IfA/DLNR management.

Local Control: A commonly held perception on Hawai'i Island is that a major source of problems is the lack of local control. Decision makers for both IfA and the DLNR are headquartered in Honolulu. The representatives of IfA who interact most with the Hawai'i Island public are mostly with Mauna Kea Support Services (MKSS), the organization which provides support services for the observatories. As service providers, MKSS does not have the authority to speak for the University. In late 1998, the IfA began construction of a Hawai'i Island headquarters building in University Park at UH Hilo.

The DLNR has offices for the Division of Forestry and Wildlife, State Historic Preservation Division, and the Land Division in Hilo but these offices often do not have the authority or resources to respond to the concerns that are raised regarding Mauna Kea. The lack of decision-making on Hawai'i Island makes it difficult for people to have their concerns addressed in a timely manner. Mauna Kea often does not receive the priority or attention it deserves because it must compete with other state-wide issues and priorities.

Staff Presence on the Mountain: There are currently no designated rangers stationed in the summit area to educate visitors about the resources and safety requirements of the mountain. However, MKSS does have astronomy support personnel on the mountain who are able to provide some of this guidance. In addition, a number of IfA and MKSS staff are concentrated at Hale Pōhaku during the day. Three ranger positions were once included in the Institute for Astronomy

budget but were cut during University-wide budget reductions in the early 1990s. These positions could have been used to address many of the management concerns that subsequently arose. Today, if an IfA or MKSS staff member witnesses a vehicle driving off-road or any dangerous activity, he or she will talk to the individual about safety and the rules on the mountain and provide assistance as needed. Litter pick-up also occurs on an ad hoc basis.

Unfunded Mandate: A persistent concern is the lack of adequate funding for management of the mountain. The 1983 plan recommended a policy advisory committee and baseline studies of natural and cultural resources. These activities were either not conducted or late in receiving funding. General lease S-4191 sets conditions for trash clean-up and removal of old facilities. The Auditor's report identified many problems that require changes but did not identify sources of financing to implement the changes. In any case, management responsibilities must be funded. Potential sources for funding are contributions from astronomy facilities, appropriations within the University of Hawai'i or the Department of Land and Natural Resources and fees from commercial activities.

Unbalanced Priorities: Some feel that management of the summit area has been excessively dominated by astronomy. While official UH policy does not restrict other uses, critics have felt that academic programs outside of IfA have not been supported. The perceived dominance of astronomy research has evolved into a criticism that cultural and natural resource values and programs, and astronomy education programs, have been neglected and that in some cases resources have been damaged.

Unmanaged Access: Currently, access is loosely regulated and hardly managed. It has been stated repeatedly that the creation of the Summit Access Road for astronomy opened the summit to general use and potential environmental degradation. If the road had not been built, the reasoning goes, the impacts would not have occurred or would have been minimal because the numbers of users would have been much lower. Additionally, the rise in popularity of off-road vehicles has increased the potential impacts and conflicts of uses arising from unrestricted access. Concerns related to access, particularly off-road vehicle use, include destruction of archaeological sites, impacts to sensitive environmental areas, increase dust, conflicts of use and increased hazards to visitors.

Maintenance: The University and the astronomy community has been criticized for creating trash on the mountain and not cleaning it up in a timely manner. In the past, construction debris has been scattered in the summit area by high winds. Recently, the University has conducted clean up days to remove this debris. Litter is also left on the mountain by non-astronomy users.

Financial Issues: The Science Reserve is comprised of ceded lands. Some claim that the Office of Hawaiian Affairs deserves 20% of all revenues. It is also noted

that education is also an equal beneficiary of ceded land revenues under State law. Other charges include the criticism that astronomy facilities are being undercharged and that the resource (the mountain) is being unfairly exploited without benefits to the broader community.

OPPORTUNITIES

With the Auditor's report and current planning process, management problems and concerns have been comprehensively articulated. With the preparation of this Master Plan, the University, DLNR, and the community now have the opportunity to redefine management responsibilities and priorities for the Science Reserve. The resulting recommendations are presented in the physical planning guide (Section IX) and management plan (Section X).

Access

ISSUES

Safety: Unmanaged access increases concerns about safety. Hazards in the Science Reserve include accidents in wilderness places, brake failures and loss of vehicle control on the steep Summit Road, quick changes in weather that could lead to hypothermia and disorientation, pulmonary edema and various physiological problems that could arise from high altitude and reduced oxygen environments. Brake failures and vehicular malfunctions are a common occurrence in the summit area. These conditions raise potential safety and liability concerns. Over the past few years there have been about six accidents each year where a vehicle must be towed down the mountain (Koehler, 1998). In several cases, vehicles have run off the road and overturned. People have also been injured while snowboarding and skiing.

Increased Access and Traffic: The Mauna Kea Access Road and Summit Access Road are increasingly busy roads used by observatory crews, construction workers, cultural practitioners, recreational users, and Mauna Kea Support Services staff.

Because of the steep grade and sharp turns on the Summit Road, only four-wheel-drive (4WD) vehicles are recommended above Hale Pōhaku. The MKSS-led summit tours require that participants drive 4WD vehicles. In the Fall of 1998, an average of 560 vehicles per week drove to the summit area (Koehler, 1998). The following user breakdown is estimated for the period.

Construction Projects (Gemini/Subaru/SMA)	150 per week
Observatory Day Crews	150 per week
Observatory Evening Crews	85 per week
Commercial Tours	30 per week
MKSS Vehicles	20 per week
Tourists and Local Traffic	125 per week

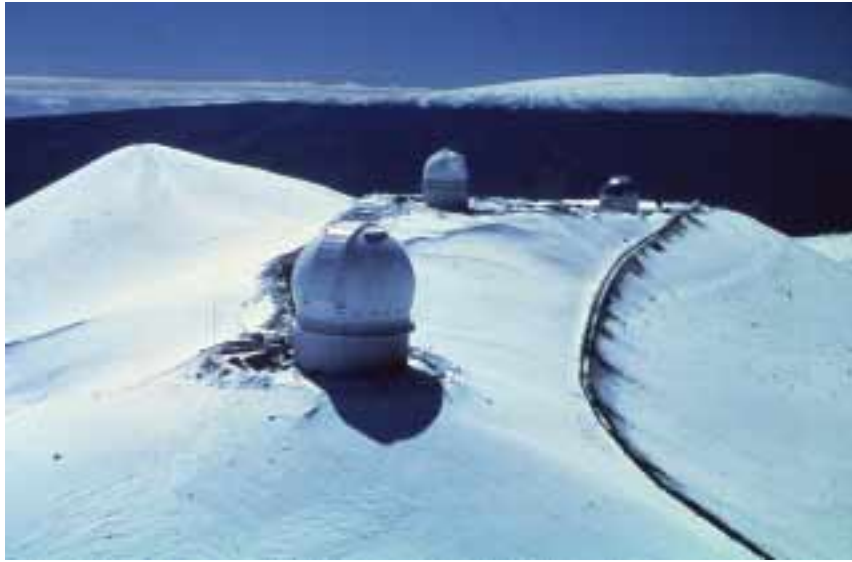
Another 100 to 150 vehicles per week visited the Visitor Information Station only during the day and for evening stargazing programs. During the 1999 periods of snowfall, it was estimated that over 200 vehicles drove beyond Hale Pōhaku during the busiest days (Koehler, 1998). Snow removal and road conditions during inclement weather are presented in Figure VIII-4. While it is recommended that only four-wheeled-drive vehicles go above Hale Pōhaku, there are no staff assigned to prevent two-wheel drive vehicles from using the summit road.

Beyond permitted vehicular access, individuals occasionally take their vehicles off of the paved roads. In seeking their own thrills, these people risk damage to archaeological sites, arthropod and flora habitats, and to the serenity of the natural landscape. Prominent signage advises visitors that off-road driving is prohibited. Although there are no permanent barriers preventing vehicles from leaving the summit access road, access points are blocked with rocks where instances of off-road driving occur.

Improvements to the Saddle Road and further publicity about Mauna Kea's resources and astronomy complex are likely to increase the number of individuals who visit the mountain. On the other hand, the development of the Mauna Kea Education Center in Hilo's University Park may serve to decrease traffic to the summit of Mauna Kea by providing displays and programs that explore the mountain's astronomical, natural and cultural resources.

OPPORTUNITIES

With the understanding that Mauna Kea will continue to be a popular destination for large numbers of people, the opportunity to manage access for the health and safety of people and the environment is clear. Education can be provided by personnel stationed on the mountain and at the Visitor Information Station. Furthermore, education can take place at the Mauna Kea Education Center proposed for Hilo and in those observatory base facilities which have visitor galleries.



Natural Resources

ISSUES

Astronomy Facility Development: Concern has been expressed about the impact of the development of astronomy facilities and supporting infrastructure on the mountain's natural resources, to include specific habitats and the overall landscape.

Arthropod Habitat: In the summit area, research done by Dr. Francis Howarth in 1982, 1997, and 1998 has shown a dramatic decline in the population of the Wēkiu bug. The cause of the difference has not been determined and could be due to any of several factors including sampling methods, changing weather patterns, habitat disturbances, presence of harmful alien species, and long-term population cycles. The latest arthropod research, theories, and management recommendations are addressed in the Environmental Impact Statement, prepared for this Master Plan.

In all but one case, arthropod activity on Pu‘u Hau‘Oki was greater than or equal to that found on Kūkahau‘ula. Kūkahau‘ula is supposedly less disturbed, although substrate disturbance was evident, apparently caused by the greatly increased foot traffic along the ridge and within the crater since the 1982 study. Trap capture rates for Wēkiu bugs were significantly higher in disturbed areas than in undisturbed areas. These results raise the possibility that observatory construction and other human activities have not impacted the Wēkiu bug distributions at the summit, outside of the immediate vicinity of the paved and covered areas.

In an effort to preserve the habitat and encourage growth in the Wēkiu's population, Howarth and team recommend caution during activities such as hiking and trash collection efforts. They also recommend monitoring and additional field work to track population and assess reasons for the population decline (Howarth, 1999).

Increased Access: There is concern that recreational users may have a negative impact on natural resources on the mountain. Off-road vehicles and unmanaged hiking can crush loose cinder and create dust, damaging arthropod and flora habitat in the summit area.

OPPORTUNITIES

The extensive flora and fauna information gathered in the early 1980s and subsequent studies of arthropods provide a foundation of knowledge about the natural resources of the mountain. Future research and monitoring will increase

knowledge about the mountain's resources and aid in the protection of these resources.

In addition, understanding of potential damage caused by vehicles, hikers, and skiers should encourage management policies that educate and provide guidance to mountain users.

Culture

The Auditor's report emphasized the neglect of cultural resources and cultural practices. There has been one verified case of damage to an archaeological site by astronomy-related development (destruction of a lithic scatter near Hale Pōhaku). However, changes in historic preservation policies and the growth of the Hawaiian cultural renaissance have brought new sensitivity toward cultural values and issues. As a result, issues of current cultural practices and the significance of the mountain have emerged. Ethnographic studies have become a standard part of cultural interpretation in the last 10 to 15 years and the values that emerge from such studies have contributed new knowledge and sensitivity to our attitudes toward the land and its culture. Cultural landscapes, geophysical forms and associated cultural attachments, have also emerged as a resource of value. These perspectives require a re-evaluation of the archaeological, geophysical and ethnographic dimensions of the mountain.

ISSUES

Cultural Resources: Cultural associations with Mauna Kea and specific archaeology sites are important cultural resources. Important archaeological and cultural features of the mountain are located in both the Natural Area Reserve (NAR) and the Science Reserve, with Wai'au and most of the adze quarry located in the NAR. Concern has been expressed regarding the access made available by the summit road and the potential for uninformed individuals to inflict damage on resources in both the Science Reserve and the NAR. There is concern that astronomy facility development and other uses of the mountain may harm these features. Some have expressed the sentiment that the presence of telescopes upsets the views of the natural and cultural landscape of the summit plateau. Off-road driving, uninformed hikers and impacts of snow play have all been highlighted as concerns to specific archaeological sites and broader respect for the mountain.

Another potential issue is the modification of archaeology sites for modern cultural practice. As an example, concern has been expressed that an individual or family may add stones or modify an existing shrine in their own practice of worship. It is not clear how much of a concern this would actually be as a number of Hawaiians have stated that other Hawaiians will not alter an *ahu* that is not associated with their own family.

Cultural Practice: There is a perception among some that modern practice of traditional Hawaiian culture is not welcome on Mauna Kea. There are no existing or proposed restrictions placed on this activity. Isolated interference with the cultural practice of one individual, which was caused by ignorance of the significance of a site, has led to concern in the larger Hawaiian community that undue interference could be a problem.

OPPORTUNITIES

Numerous archaeological and ethnographic studies have been conducted for Mauna Kea. During this master planning process several studies were conducted or initiated to include the State Historic Preservation Division's Mauna Kea Historic Preservation Management Plan, Kepā Maly's oral history and archival research study, and PHRI's archaeological study.

This wealth of written and recorded information provides a base from which others, including mountain staff, can be educated about Mauna Kea's cultural resources. Education and management strategies will play an important role in the preservation of these resources over time.

Education and Research

ISSUES

Development of Astronomy Facilities

Ever since the first telescopes were proposed for Mauna Kea, there have been mixed sentiments in the community concerning development on the mountain summit. Some members of the community ask that development upon Mauna Kea continue no further. Others see Mauna Kea as one of the real success stories of economic development in Hawai'i.

Economic Impact of Astronomy

SMS Research analyzed the economic impact of astronomy conducted on Mauna Kea for the Master Plan. In addition to established facilities, new facilities Subaru, Gemini Northern, and the Submillimeter Array are considered as operating facilities in the economic analysis. Construction costs for all facilities built or to be built prior to the year 2000 total approximately \$826 million. Approximately one fourth of this sum is spent in Hawai'i County.

From the construction of new facilities, to the employment of a trained technician, to the purchases made by a visiting scientist, the astronomy industry contributes widely to the Big Island economy.

Approximately 400 full-time positions will be supported by Hawai'i's astronomy industry in the year 2000. These include astronomers, engineers and engineering

technicians, software programmers, equipment technicians, and administrative personnel.

SMS Research (1999) estimates the direct impacts of Mauna Kea astronomy in the State to include:

Operating Budget	\$51.9 million/year
Workforce	397
Visiting Researchers	3,755 trips/year
Visitor Spending	\$0.7 million/year

Total economic impact of astronomy, assuming operation of Subaru, Gemini, and the SMA, is estimated at \$130.9 million annually for the County and \$141.7 million annually for the State. Direct impacts include employment and expenditures directly associated with the operation of the astronomy industry and represent \$61.1 million for the County and \$63.0 million for the State annually. Indirect impacts occur when astronomy-related firms purchase goods and services from other firms. Induced impacts are due to spending by the astronomy workforce in the local community.

Over the next two decades, two trends may have large economic effects. First, with continuing support of science education and internships, and continuing need for staff, the observatories will encourage development of a local pool of skilled technical personnel. Second, tourism on the island may draw more extensively on astronomy as a resource. This activity does not necessarily have to occur on Mauna Kea as it can be encouraged in the new Mauna Kea Education Center being proposed in Hilo.

Future Astronomy Facilities

It is the hope of the University of Hawai‘i and many in the State that Mauna Kea continues as the leading astronomy complex in the Northern Hemisphere or even the world and remains a driver of the Hawai‘i Island economy. It is envisioned that because of the sensitive environment and cultural landscape that only world class telescopes should be located on Mauna Kea. Mauna Kea is not the place for just any instrument. It is a premier location and environment that should host only those facilities that are unique.

The world astronomy community is looking forward to the next decade with a focus toward space telescope development and complementary ground-based telescopes. Recent developments in astronomy technology have led to greater ability to identify previously unknown objects. The world astronomy community now projects the need for additional state-of-the-art 10-meter instruments (such as the Keck I and II), as well as specialized instruments to address defined research objectives. The following categories of telescope facilities are foreseen for the future:

Conventional Optical/Infrared Telescopes: These telescopes would have mirror sizes of 2 to 12 meter diameter. The smaller 2 to 6 m telescopes could be modern versions of the UH 2.2m, CFHT and IRTF. Larger telescopes with 6 to 12 m mirrors would be similar to Keck, Subaru and Gemini.

Next Generation Large Telescope. Planning for a large optical/IR telescope (aperture 25-50 m) is advancing. This instrument is significantly bigger than any existing telescope and would have much greater light collection potential than a space telescope which would be much smaller. One major goal is to study a spectra of galaxies as they were forming approximately 10 billion years ago. This telescope would also provide the capability to study planets around nearby stars.

Submillimeter Interferometer. The creation of additional and larger submillimeter interferometer arrays is also being contemplated by the world astronomy community. There will be a need to expand the viewing capabilities in the submillimeter band to support growing research efforts in this area of astronomy (radio interferometry).

Optical/IR Interferometer. An optical interferometer could contain a number of telescopes at separations up to several hundred meters. Prime objectives of this type of telescope are the detection of planets around nearby stars and the study of star formation.

Large Array/Millimeter Array. The world astronomy community is planning to develop a large array for millimeter astronomy during the next decade. This facility is not likely to be located at Mauna Kea due its large area requirement (6-10 km) and the large number of antenna (about 50). A consortium of U.S. and European astronomy organizations is currently planning to develop this large millimeter array in Chile.

Non-Astronomy Science and Education: Currently there is the perception that educational opportunities are limited to programs related to the Institute for Astronomy or individual telescope facilities. A process for proposing other educational programs or activities is not widely communicated or understood.

OPPORTUNITIES

The environmental and technical qualities of the Mauna Kea Science Reserve make it the superior site in the Northern Hemisphere for most types of ground-based astronomy. First, the natural conditions are ideal for astronomical observations. Second, there is now the critical mass of world class telescope facilities for Mauna Kea to continue to be at the forefront of ground-based

astronomy. Third, the astronomy and astronomy support technologies that have been developed on Hawai'i Island can be the catalyst for other research and education programs.

Mauna Kea's unique natural and cultural resources provide a wealth of opportunities for research and education that is coordinated and conducted in a manner that is most appropriate for the resource. Supporting facilities could include the construction camp cabins below the Visitor Information Station.

Recreation

Issues related to recreational use include safety concerns and possible inadvertent damage to archaeological sites. Off-road driving is also a major concern because of the cultural and natural resources which may be damaged.

ISSUES

Snow Season Activity. While hikers and other recreationalists are active throughout the year, the greatest number of recreational users come to the mountain during snow season. With so many people on the mountain enjoying the snow, cars must park on the side of the road. The large number of people skiing, hiking, snowboarding and sledding in the snow at such a high elevation, can be hazardous to individuals and to cultural resources such as *ahu*.

A portable toilet and the facilities at the Keck Observatory are the only public restrooms available above Hale Pohaku, and often these do not meet demand or are inconvenient to access. As a result, individuals often relieve themselves on the side of the road or wherever is convenient, resulting in unsanitary conditions.

Safety. The high altitude environment hosts natural resources that provide recreational opportunities that are unavailable anywhere else in Hawai'i. Skiing and various forms of snow play attract large numbers of people when conditions are right. Recently, there have been requests for more extreme sports on the mountain such as hang gliding and cycling down the summit. Hikers are attracted to the summit area for its natural and scenic qualities. With easy access and increases in numbers concerns about safety, liability, resource impact and compatibility with the spiritual values of the mountain have begun to emerge.

OPPORTUNITIES

Recreational activities need to be managed to reduce potential conflicts of use, enhance recreational opportunity, avoid damage to cultural and environmental resources, and improve safety. Facilities could be provided in the summit and mid-elevations areas to support the safe use of the mountain.

The discussion above highlights many of the issues that have persisted in the Mauna Kea Science Reserve over time and reviews past plans for the management of the area. The physical and management plans which follow (Sections IX and X) will offer solutions which are aimed at resolving problems/issues that exist today and enable the potentials of tomorrow to be realized.

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

IX. PHYSICAL PLANNING GUIDE

PHYSICAL PLANNING GUIDE

The following are the four objectives of the Master Plan for the Mauna Kea Science Reserve:

- 1. Prepare a Master Plan consisting of a physical planning guide, maps, geographic information system, and criteria, which manage the use of the resources of the Mauna Kea Science Reserve.**
 - **Protect natural resources (e.g. Wēkiu bug habitat, alpine ecosystems);**
 - **Protect historic and Hawaiian cultural resources and practices (e.g. archaeological sites, cultural landforms);**
 - **Protect and enhance education and research (e.g. astronomy, ecology, geology);**
 - **Protect and enhance recreational opportunities (e.g. skiing, hiking).**

The physical planning guide will enable the sustainable use and enhancement of these four resource components. The natural resource component documents the extent of significant habitat areas and unique geology areas, and delineates preservation areas. The historic and Hawaiian cultural component identifies archaeological sites and culturally significant landforms to be preserved. Appropriate sites for the future locations of astronomy facilities are identified, with respect for natural and cultural resource preserve areas. Lastly, the recreational uses of the mountain are defined.

- 2. Analyze and depict the physical implications of uses and address and propose mitigation of environmental impacts.** The Master Plan considers the physical presence of astronomy facilities, and other buildings and infrastructure on the mountain. A Geographic Information System (GIS) is utilized to provide a resource-based siting analysis of environmental conditions.
- 3. Guide the planning of physical development in the summit area, not only in terms of the location of facilities, but in regard to character, size, mass, color, and other physical attributes.** The plan locates proposed new facilities and includes design criteria, which are intended to mitigate potential visual and environmental impacts. These include topographic shielding, setbacks, scale and colors. A three-dimensional simulation program is used to evaluate the potential visual impacts and effectiveness of mitigation proposals that guide the siting and design of new facilities.
- 4. Define the infrastructure and support facility elements required for natural and cultural programs, education and research programs, and recreation uses.** The plan addresses the infrastructure support elements for facilities in the Science Reserve, including the roadways, electrical power supply and communications network.

METHODOLOGY FOR THE PHYSICAL PLANNING GUIDE

The updated Physical Planning Guide for the Mauna Kea Science Reserve consists of four components, including: (1) Natural Resources, (2) Cultural Resources, (3) Education and Research, and (4) Recreational Resources. Resource elements were overlaid upon each other to create a base for the master plan, identifying opportunities for both preservation and uses.

This resource overlay process employs a Geographic Information System (GIS) format. A Geographic Information System is a computer-based tool for mapping and analyzing resource data that integrates spatial and non-spatial information to provide tailored analytical and mapping capabilities. Resource data are compiled in the GIS to show the extent of resources and uses. New information is obtained directly from government and consultant surveys, field research, and literature studies conducted since the 1983 master plan. Additional information is derived from the meetings of the Mauna Kea Advisory Committee, the findings of consultant studies, individual interviews, and meetings with authorities with expertise in relevant disciplines.

Criteria are developed for each of the resource maps to delineate boundaries for areas to be proposed for preservation and areas for potential use. The key factors considered in recommending areas either for preservation or compatible use are the presence or absence of important natural, cultural, education and recreational resources. The methodology used in creating individual plan components is described below.

Natural Resources Components. This component of the master plan delineates the presence of unique geology, flora and fauna resources within the Science Reserve. Significant natural resource areas are identified in the plan. GIS mapping is used to produce composite studies of each resource layer, including a graphic overlay of natural resources. Refer to Section IV for detailed information on the natural resource components of the Science Reserve.

Cultural Resources Components. GIS mapping is used to present each cultural resource component, including archaeological sites, places of cultural importance, and culturally significant landforms in the Science Reserve. Refer to Section V for detailed information on the cultural resource setting.

Educational and Research Components. Sites for new education and research facilities are determined utilizing the natural and cultural resources GIS layer components. The boundaries of a proposed development area are defined by balancing the sites needed by proposed astronomy facilities and specific natural and cultural resource elements, being limited to those areas where impacts to important natural and cultural resources can be avoided or minimized. The Hale Pōhaku mid-elevation facilities are also studied for

potential future improvements to facilities and infrastructure. Refer to Section VI for detailed information on the education and research components of the Science Reserve.

Recreational Resources Components. The component for the recreational resources in the Science Reserve addresses areas for skiing, snow play, and hiking. This component addresses the suitability of areas for continued or expanded recreational use, with recommendations for area limits and support facilities. Refer to Section VII for detailed information on the recreational resource components of the Science Reserve.

NATURAL AND CULTURAL RESOURCES COMPONENTS

The first integration in the Physical Planning Guide is the relationship of natural resources and cultural resources. From a Hawaiian perspective, there is not a differentiation between the natural and cultural resources of the land, rather they are a unity. In this plan, the natural and cultural resource elements are addressed in an integrated approach to carry equal importance in the Master Plan.

Overall objectives for natural and cultural resources:

1. Promote a greater knowledge base and understanding through the planning process, focussed on:
 - Critical natural resources, to include flora, fauna, and natural landforms, and
 - Archaeological and cultural resources, Hawaiian cultural practices, modern practices and significance of sites, names, and geophysical elements.
2. Protect and preserve, through planning and management:
 - Unique geological features and biological communities, recognizing the symbiotic relationship between the two in the Science Reserve which form unique ecosystems, and
 - Cultural resources in a sustainable manner so future generations may share in the understanding and knowledge of the mountain's archaeological sites and culturally significant landforms and places.
3. Enhance opportunities and protect:
 - Natural resource areas for recreation in a manner that both sustains the resources and promotes the safety of individuals, and
 - Opportunities for individuals and groups to engage in cultural practices.
4. Allow for current and future use of natural resources for educational programs and cultural practices for the community, schools and universities, and visitors.

-
5. Protect the mountain's natural landscape to preserve its scenic values, and preserve the cultural landscape to enhance meaning, relationships, and resources for modern appreciation, research, and practice.
 6. Define specific areas and criteria for natural resource use and cultural resources and practices, as applicable, to allow for sustainable, integrated planning and management.

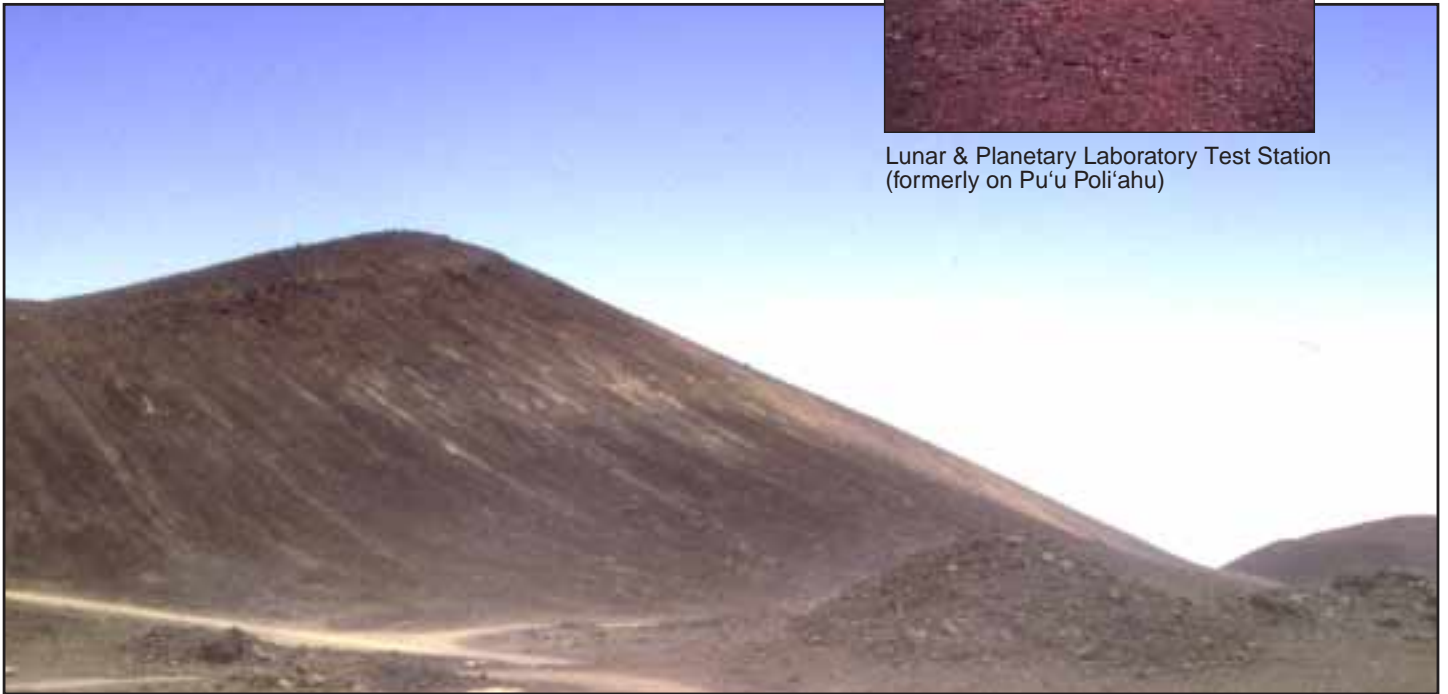
Natural and Cultural Resources Map. The objectives and goals for the natural and cultural resources map arise from the issues surrounding the past and present uses of the mountain. In the recent past, the mountain's natural and cultural resource issues have each been handled in an isolated manner, whether it has involved the Wēkiu bug population, archaeological sites, or the use of the *pu'u* to locate astronomy facilities. We now have better knowledge of these resources and understand that they are inter-related and need to be planned in an integrated fashion, not individually. For example, the natural direction for past astronomy development has been to utilize the highest elevation locations found at the tops of the *pu'u*. Years ago, Pu'u Poli'ahu was tested for its qualities as an astronomy site, and from a technical basis, it is considered to be a prime potential site (See Figure IX-1). However, our increased understanding of the Hawaiian cultural importance of the mountain's *pu'u*, as well as their unique ecological components, now guide future planning toward preserving these important features.

From a natural resource perspective, the primary issues concern the Wēkiu bug and scenic views. The major *pu'u* in the upper slopes of Mauna Kea provide the only known habitat area for the Wēkiu bug. Some *pu'u* have been found to contain the Wēkiu bug, while others have similar habitat qualities and have the potential for supporting populations of this endemic arthropod, thereby motivating plans to preserve all *pu'u*. Scenic views of the summit are experienced within the Science Reserve and from off-mountain locations. All major cinder cones which are undeveloped will be protected from future development by astronomy or other interests. These include the following *pu'u*: Ala, Hau Kea, Hoaka, Kūkahau'ula, Lilinoe, Mahoe, Makanaka, Poepoe, Pohaku, Poli'ahu, Ula, and Wai'au. Prohibition of development of modern man-made features on all the currently undeveloped *pu'u* will protect the scenic natural views to and from these landforms (See Figure IX-2). Preservation of each *pu'u* will also retain the integrity of a cultural landscape spanning from Kūkahau'ula (the summit) through Poli'ahu, including Lake Wai'au and the adze quarry at Keanakāko'i in the adjoining Natural Area Reserve. A principal recommendation of this plan is the preservation of the natural and cultural landscape of the Science Reserve by protecting all of the major undeveloped *pu'u* and the intervening areas from disturbance.

The Master Plan also envisions the preservation of the natural cultural landscape in the Science Reserve (See Figure IX-3). Archaeological sites are found with the greatest frequency in a band below the summit area, mostly evident at about the 13,000 ft. level.

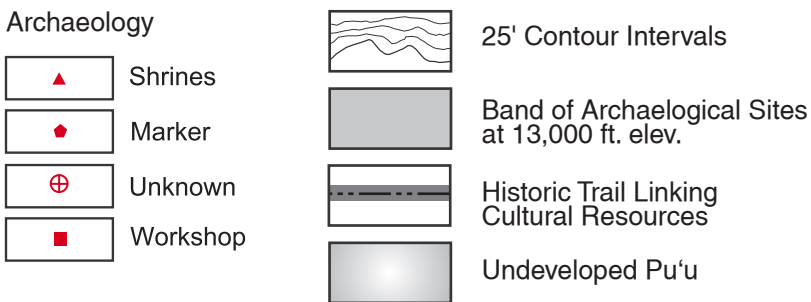
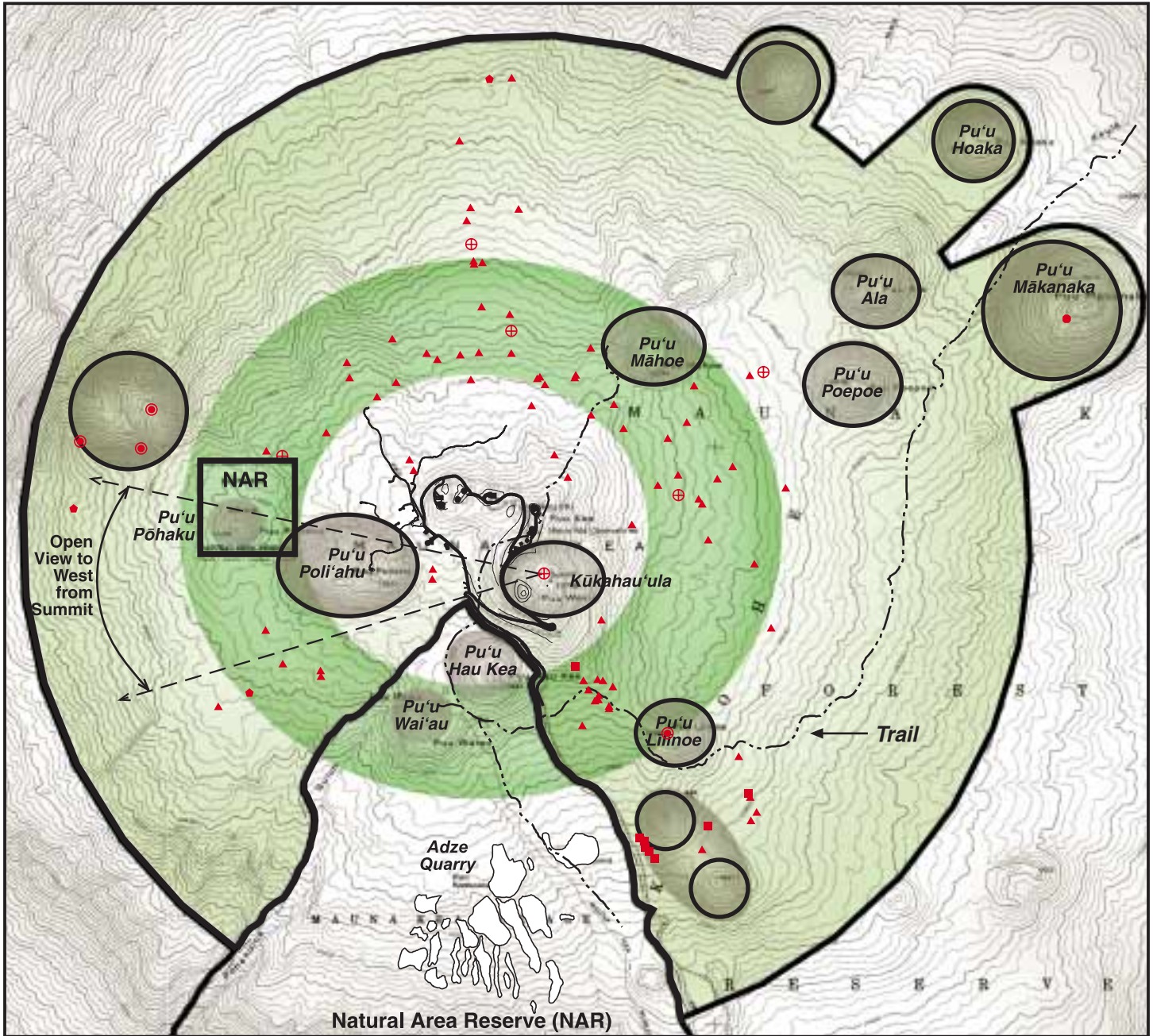


Lunar & Planetary Laboratory Test Station
(formerly on Pu'u Poli'ahu)

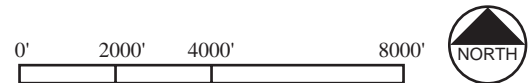


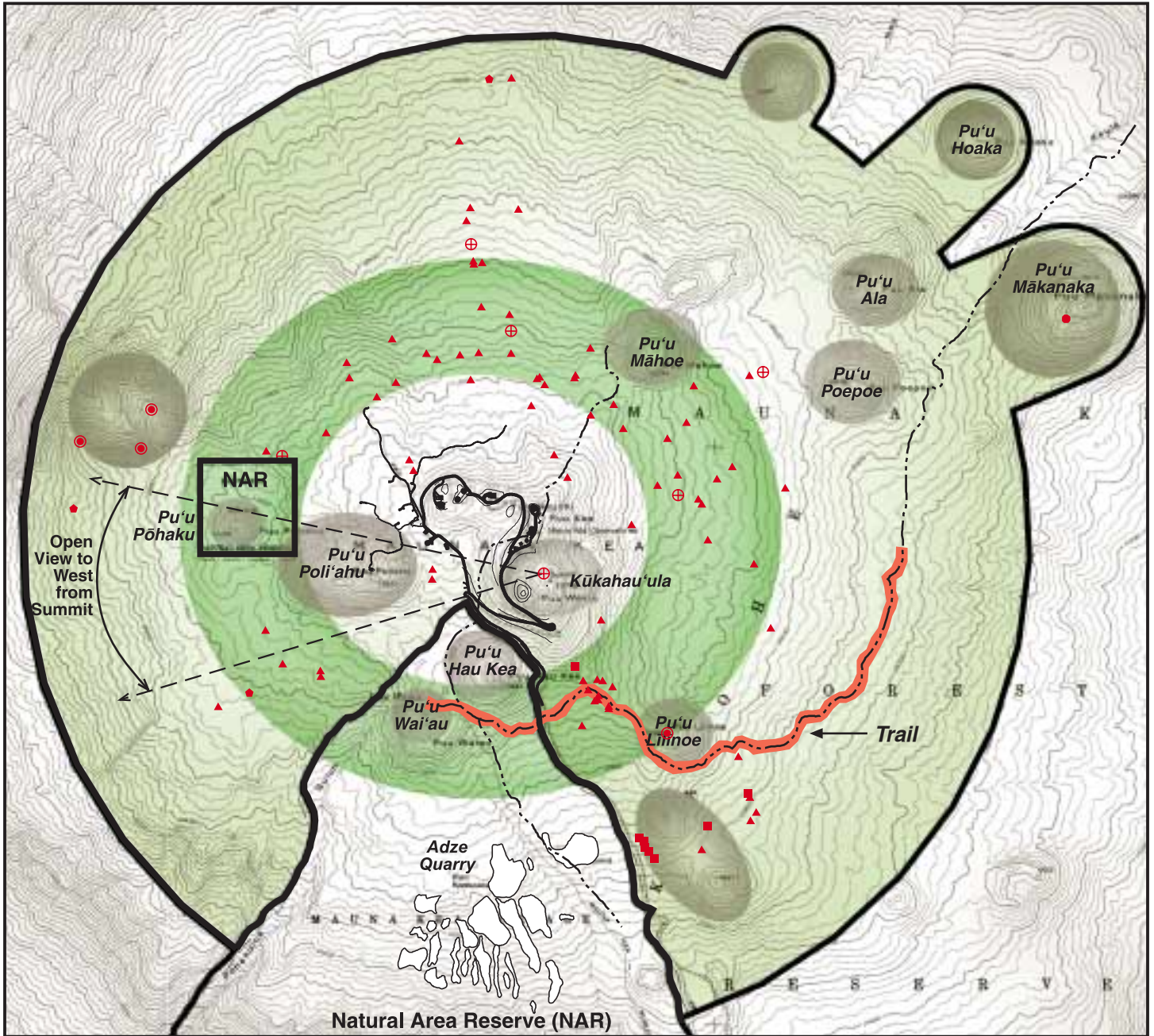
Pu'u Poli'ahu

Pu'u Poli'ahu and Lunar and Planetary Laboratory Test Station



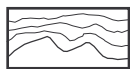
Undeveloped Pu'u





Archaeology

- ▲ Shrines
- ◆ Marker
- ⊕ Unknown
- Workshop



25' Contour Intervals



Band of Archaeological Sites at 13,000 ft. elev.



Historic Trail Linking Cultural Resources



Undeveloped Pu'u

Cultural Landscape Map



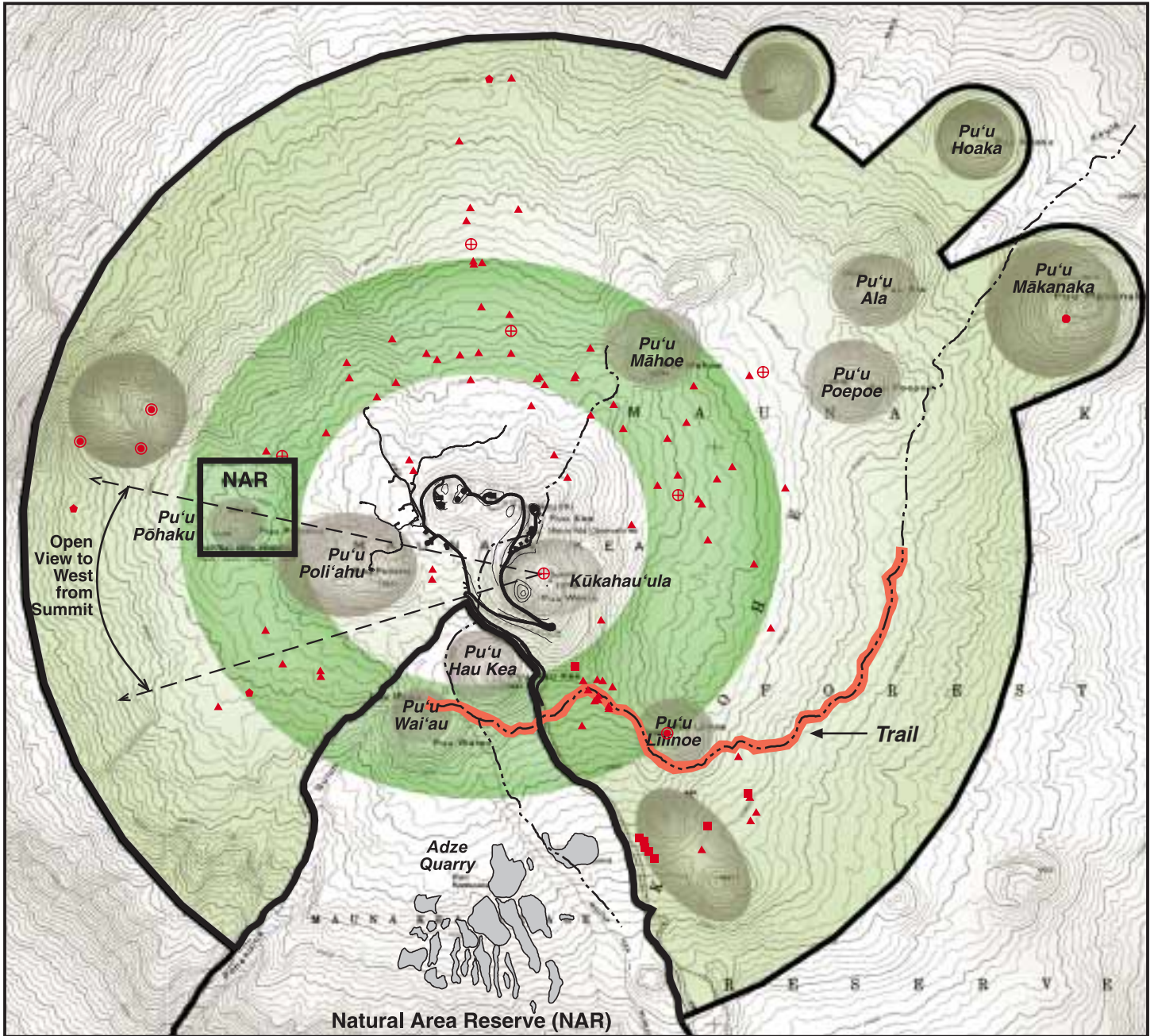
According to cultural sources, Lake Wai‘au (in the NAR) and its surroundings, including the *pu‘u* within the Science Reserve, are all culturally significant places. The Plan views the archaeological sites of the summit region as a whole rather than in an isolated context. According to McCoy (February 1999), the abundance of shrine complexes and the accounts of cultural importance of the *pu‘u* in the upper slopes, indicates that the area was a ritual center. Therefore, the physical plan links the significant landforms with the archaeological sites clusters, Wai‘au and the adze quarry at Keanakāko‘i. There is an historical trail that extends through this area, and the map delineates this trail as providing a linkage between all of these elements (See Figure IX-4). The cultural landscape is thereby preserved within the Science Reserve and to the NAR, in a manner where people may experience the cultural resources of Mauna Kea in the traditional manner at the 13,000 ft. elevation without interacting with the modern astronomy facilities. Simulated views from Wai‘au are shown in Figure IX-5.

GIS Mapping of Natural and Cultural Resources

Unique Surface Geology. There are numerous unique areas of surface geology within the Science Reserve, including cinder cones, glacially scoured rock surfaces, glacial moraines, rock structures formed by sub-glacial eruptions, texturally sorted soils, and an alpine lake. Outcrops of uniquely fine-grained, dense lava found along sub-glacial vents and lava/ice contacts within the Mauna Kea Ice Age Natural Area Reserve and adjacent areas were extensively used as quarries (Keanakako‘i) for ancient Hawaiians to obtain adze materials. The distribution of these features is shown in Fig IX-6. These areas are included in the GIS as unique geological resource areas, and will be protected from disturbance by development and intensive recreational activities. Slopes in excess of 20 percent are shown in Figure IX-7.

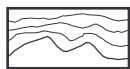
Flora Habitat. Flora species distribution within the Science Reserve relate directly to the surface geology character. Lichens and ferns occur strictly where there are craggy andesitic lava outcrops to provide shade, some soil (ferns), physical protection and moisture collection. Mosses are more widely distributed on rock mounds across the upper slopes. GIS mapping of flora resources shows the general extent of lichens and ferns. As shown in Figure IX-8, areas of concentration of lichen habitat are identified within the andesitic lava flows to the north and west, with the more limited fern habitat on the slopes to the north of the summit (Char, 1999, 2000).

Flora species could be affected by the construction of new paths, roads, and facilities. The natural habitat for concentrations of the unique floral resources of lichens and ferns found in the summit region will be protected in the plan. Site specific surveys would be needed to determine siting choices to minimize effects upon sensitive flora habitat. Selective replanting/reintroduction of silversword is proposed for the cinder cones within the Science Reserve. Upper slope flora species that could also be reintroduced upslope from their current distribution include *pūkiawe* and *‘ōhelo*.



Archaeology

- ▲ Shrines
- Marker
- ⊕ Unknown
- Workshop



25' Contour Intervals



Band of Archaeological Sites at 13,000 ft. elev.

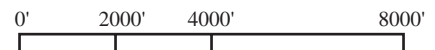


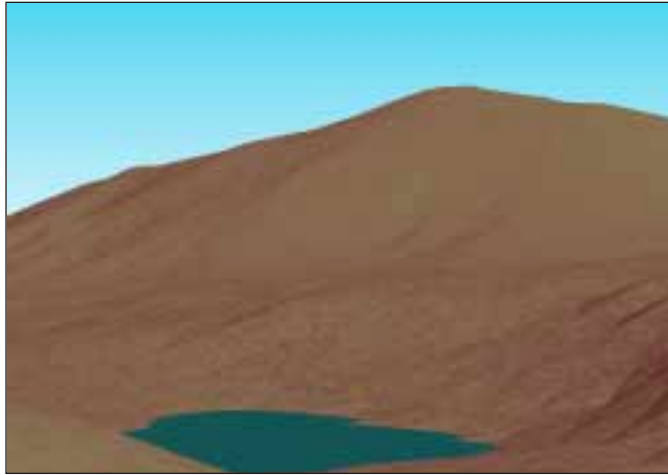
Historic Trail Linking Cultural Resources



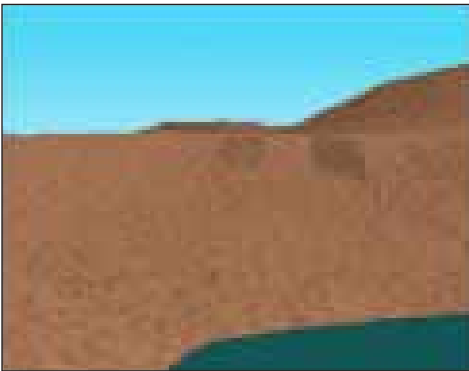
Undeveloped Pu'u

Existing Trail Linking Hawaiian Cultural Resources





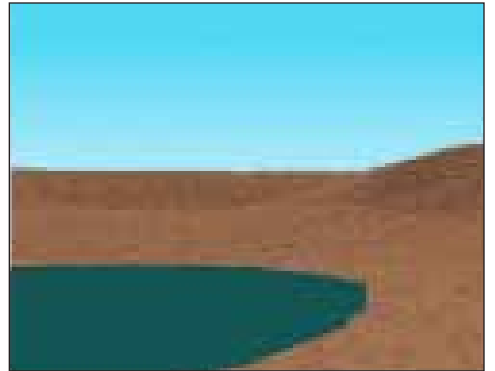
View of Pu'u Poli'ahu



View North

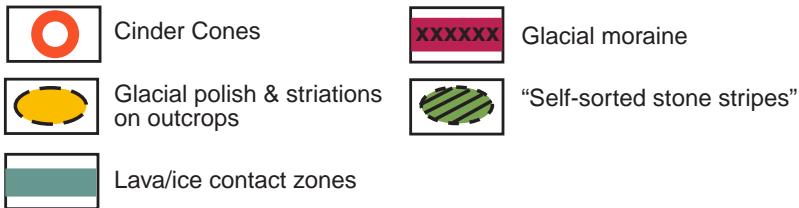
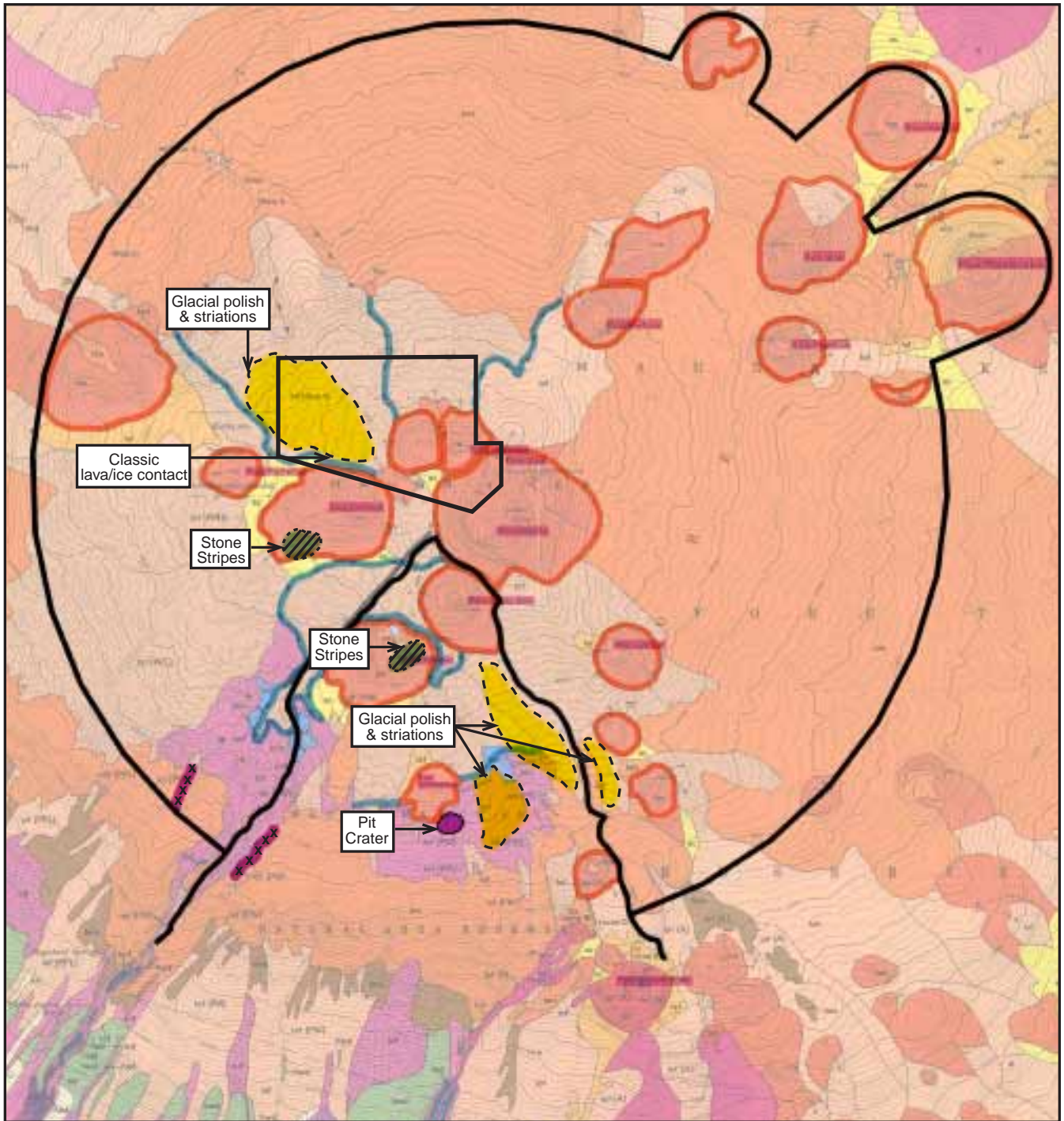


View of Pu'u Hau Kea

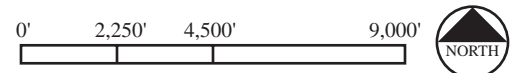


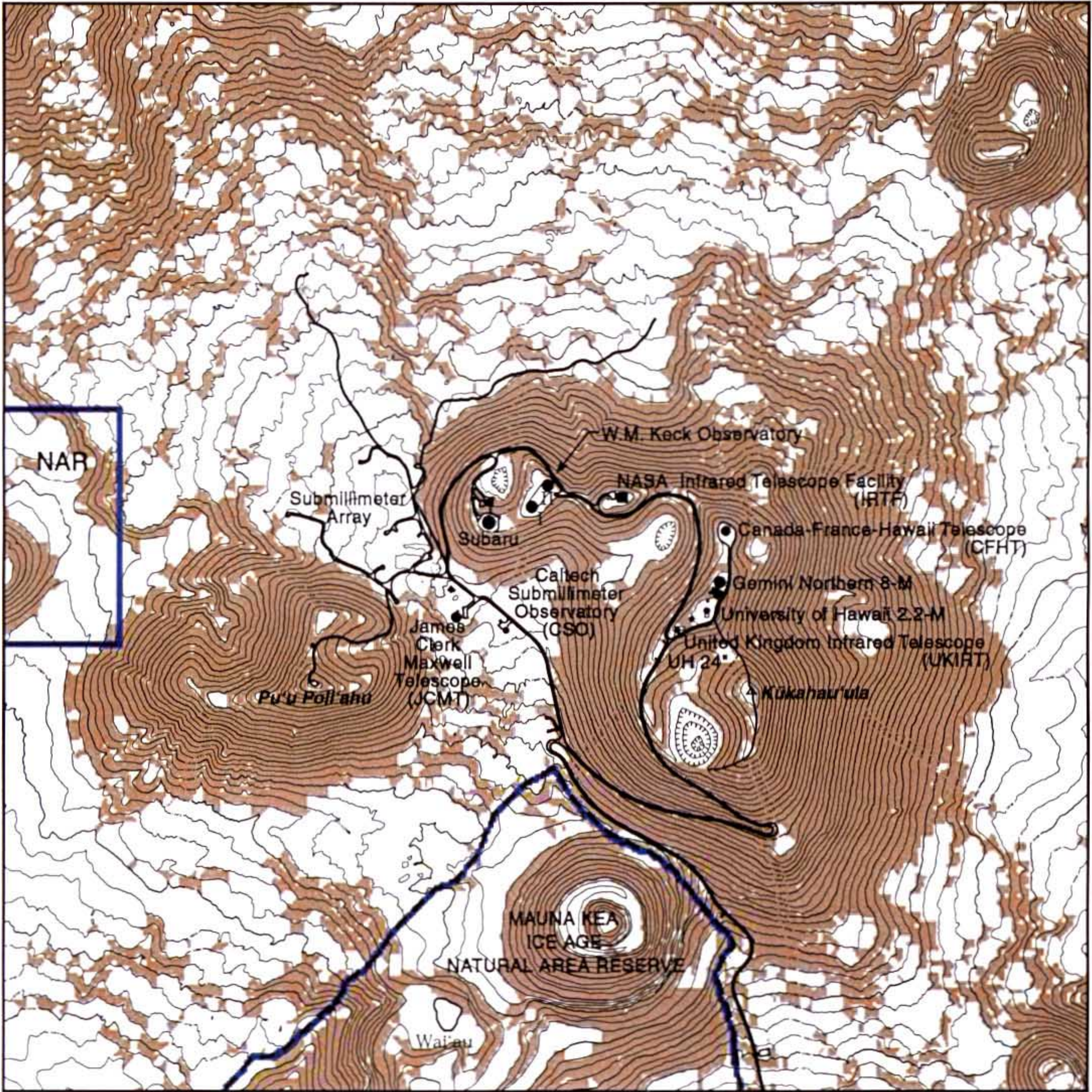
View of Pu'u Wai'au

Simulated Views from Wai'au



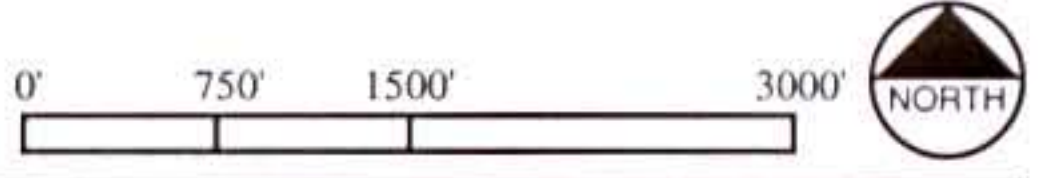
Source: Lockwood (January 2000)
 Generalized map of the Mauna Kea Science Reserve, showing the locations of geologically unique features.



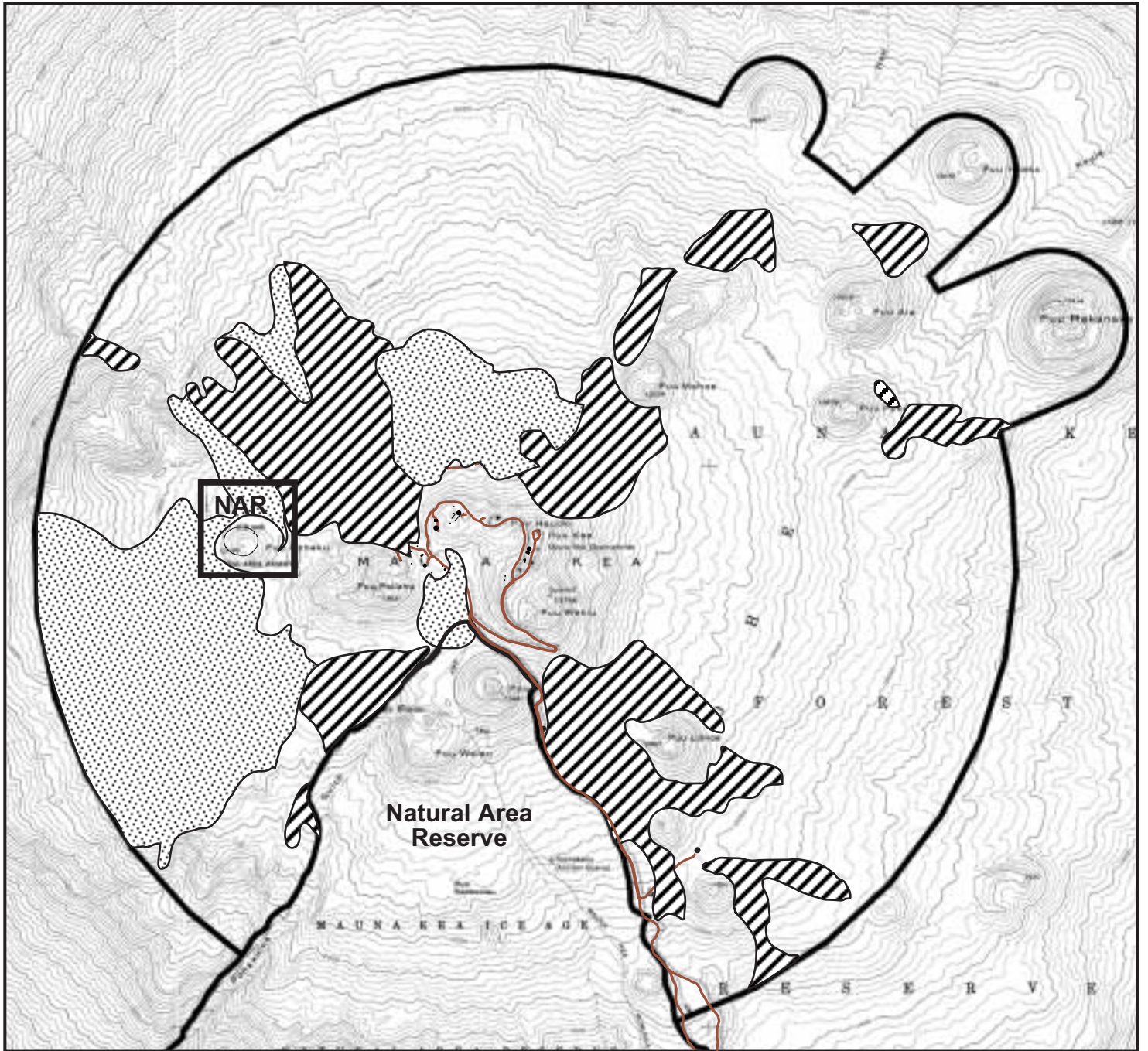


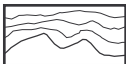


Source: R. M. Towill Topographic Survey, 1997
Group 70, Slope Analysis, 1998

-  Slope 20% or Greater
-  25' Contour Intervals
-  Natural Area Reserve



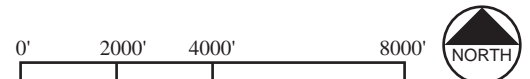
Slope Analysis



-  40' Contour Intervals
-  Potential *Cystopteris* fern habitat
-  Potential lichen habitat

Source: Winona Char, 1999
 Note: Mosses are found throughout the summit area, primarily on rock outcroppings with crevices and fissures.

Summit Flora Habitat

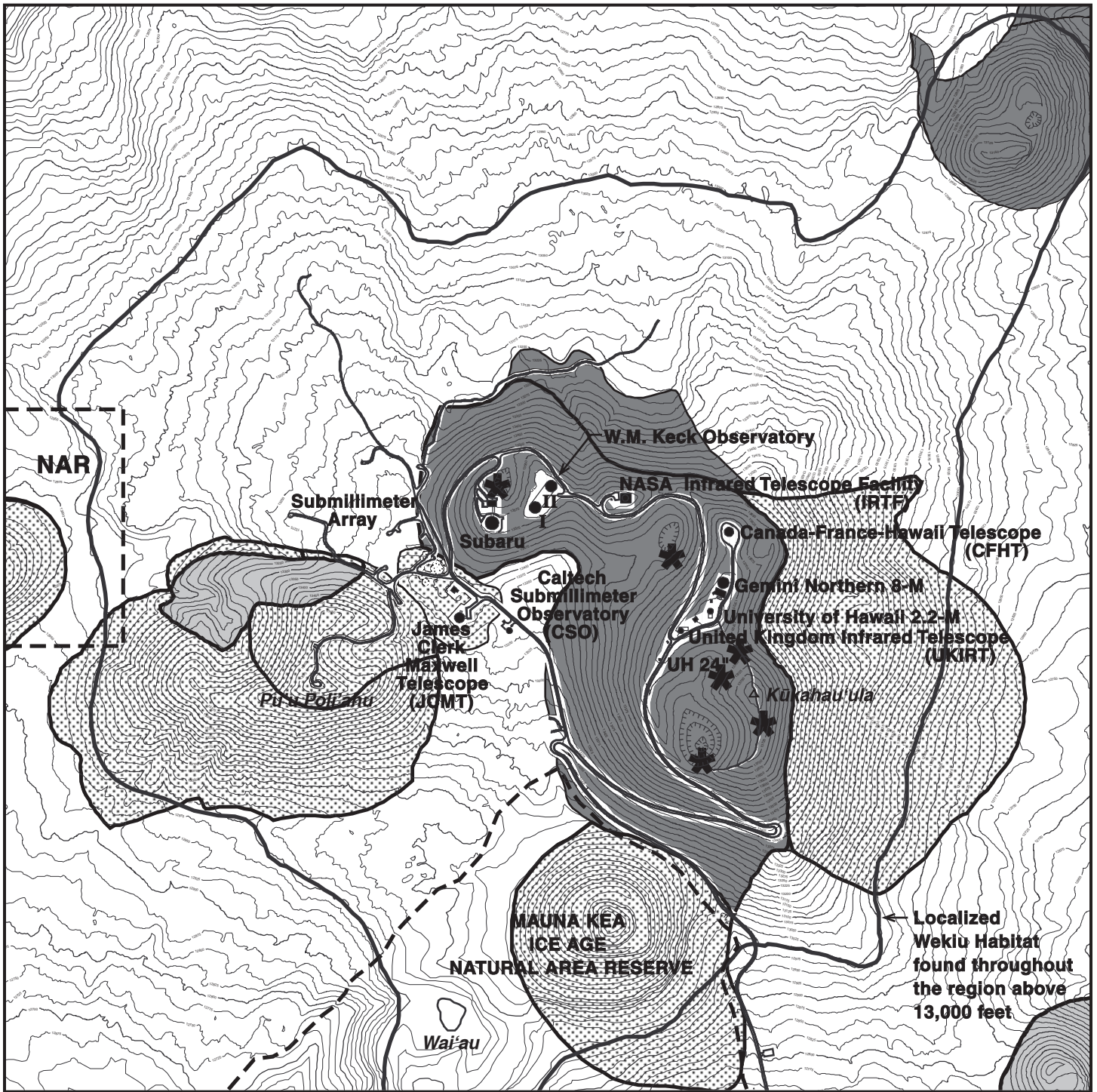


Fauna Habitat. Arthropod distribution on the upper slopes of Mauna Kea relates directly to the surface geology. The Wēkiu bug (*Nysius wēkiucola*) is found primarily in the undisturbed cinders of the large cinder cones at Mauna Kea's summit, as shown in Figure IX-9. Other arthropod species such as the Lycosid wolf spider and Noctuid moths are more widespread within the Science Reserve. Lower elevation areas on Mauna Kea, outside the Science Reserve, include faunal components relating to the *māmane* and *naio* forest ecosystem.

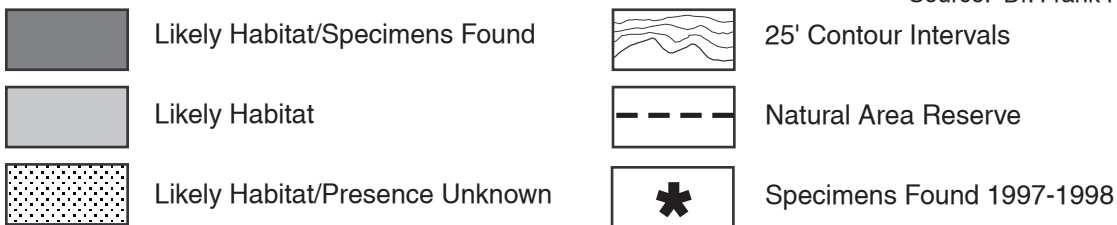
GIS mapping shows the extent of areas of Wēkiu bug concentration, including areas with documented presence of the bug and areas of suitable habitat. The Master Plan will minimize disturbance of the cinder cone habitat for the Wēkiu bug within the Science Reserve. Expansion or redevelopment of existing sites on the summit ridge will have contained localized effects to the cinder cone habitat in the immediate vicinity of the older telescopes. As a result of the overall preservation measures, the habitat of the Wēkiu bug in the Mauna Kea Science Reserve will be protected. A composite of natural resources in the summit area is presented in Figure IX-10.

Archaeological Resources. Archaeological sites are found in the upper slopes of the Science Reserve, yet sites are virtually absent in the proximity of the summit *pu'u*. Shrines are clustered around the summit at approximately the 13,000 ft. elevation. Refer to Section V for more detailed information about archaeological sites. The clustering of sites appears around Lake Wai'au and the adze quarry in the NAR, at site complexes adjacent to the summit access road, and large numbers of shrines on the north slope at the edge of the plateau around the 13,000 ft. elevation. A consistent pattern was found, suggesting that shrines were erected by Hawaiians travelling up the mountain as tributes to their deity. Based on the field research, archival studies and oral histories, there are no burial sites in the vicinity of the summit *pu'u*. The plan preserves the areas near the higher concentrations of archaeological sites, restricting these areas from future development and most activities. Figure IX-11 shows the extent of archaeological sites.

Cultural Properties/Landforms. Culturally-significant landforms and places at Mauna Kea have been identified based on interviews and historical archival research. Refer to Section V for more detailed information about the cultural setting. A Cultural Landscape Map is presented in Figure IX-3. The Master Plan avoids adverse effects to cultural properties/landforms. The area of critical cultural importance encompasses the area of Poli'ahu to Wai'au to Kūkahau'ula at the summit. The *pu'u* within the summit region are the natural cultural landscape of Mauna Kea, with a visual linkage to the area of the sacred alpine lake at Wai'au and the adze quarry at Keanakāko'i. Preservation of the major *pu'u* of the summit in an unaltered state is essential to retaining their cultural significance, and will retain the integrity of vistas and site relationships. This approach is consistent with the perspective taken by the Historic Preservation Plan DLNR (March 2000), that Mauna Kea's numerous shrines and culturally significant landforms along the upper slopes altogether constitute an historic district.

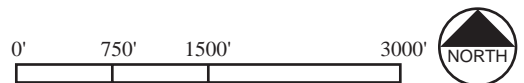


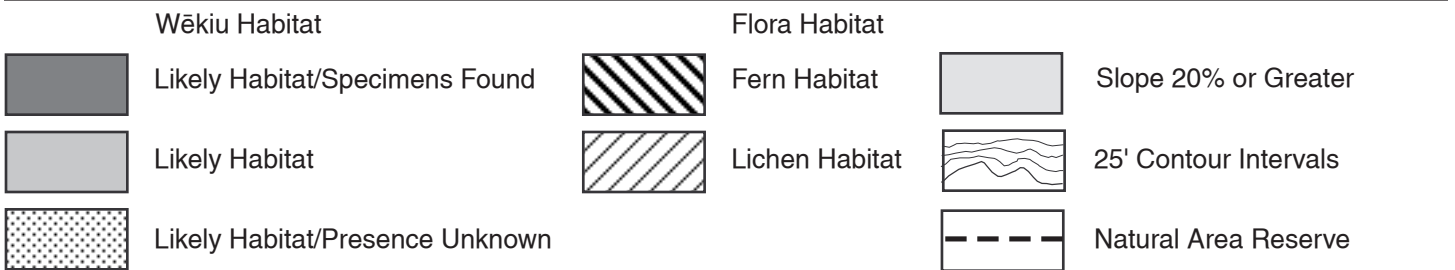
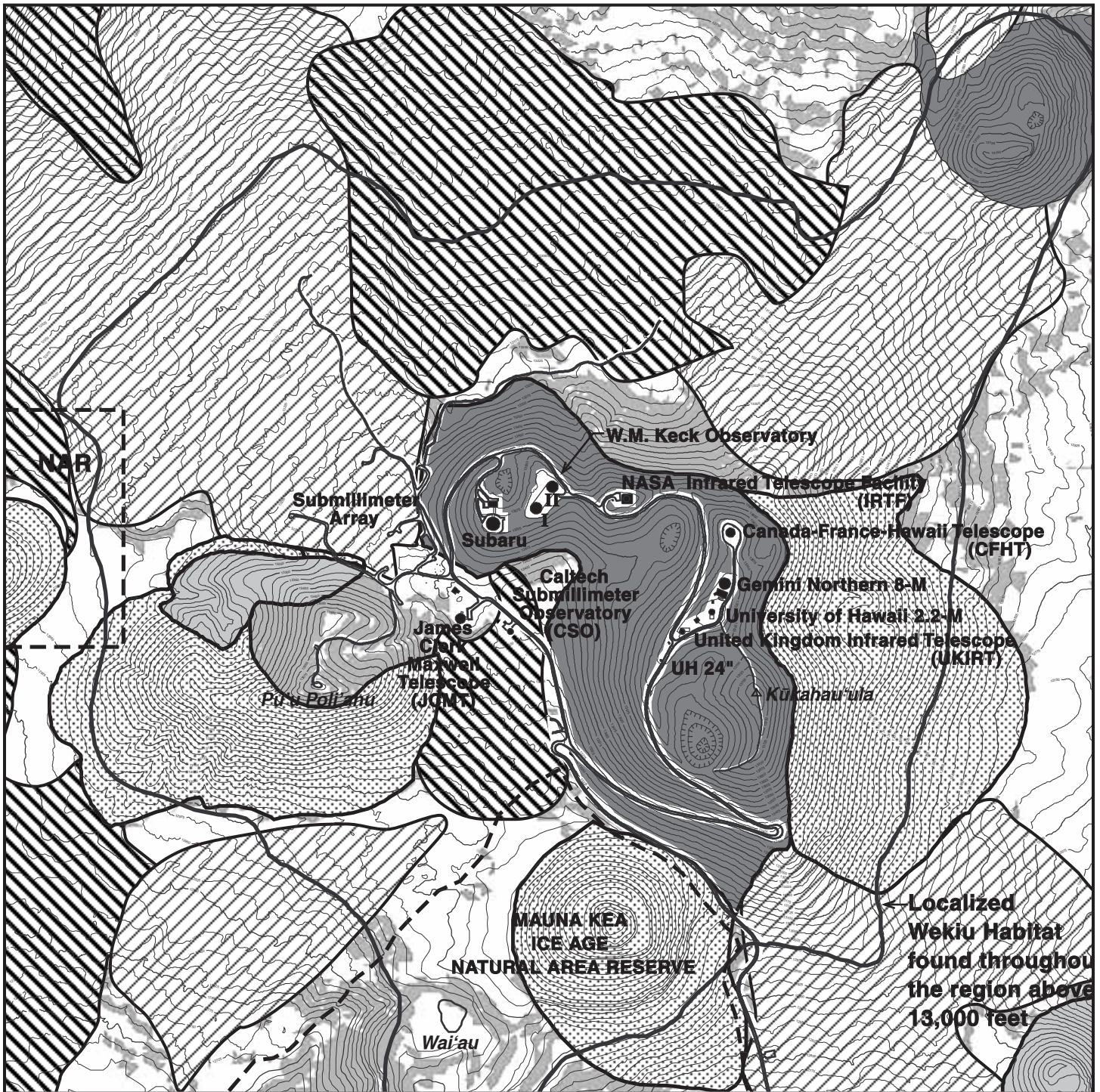
Source: Dr. Frank Howarth, Bishop Museum, 1999

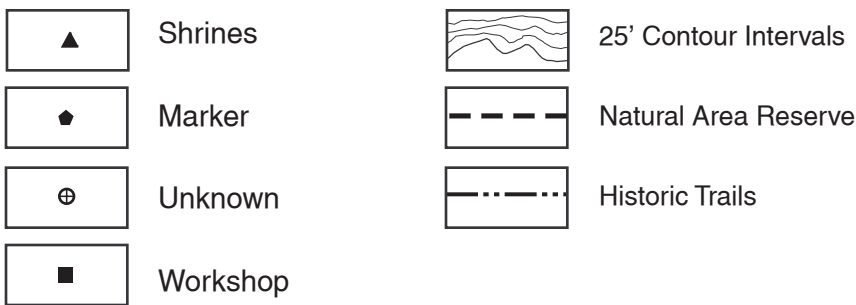
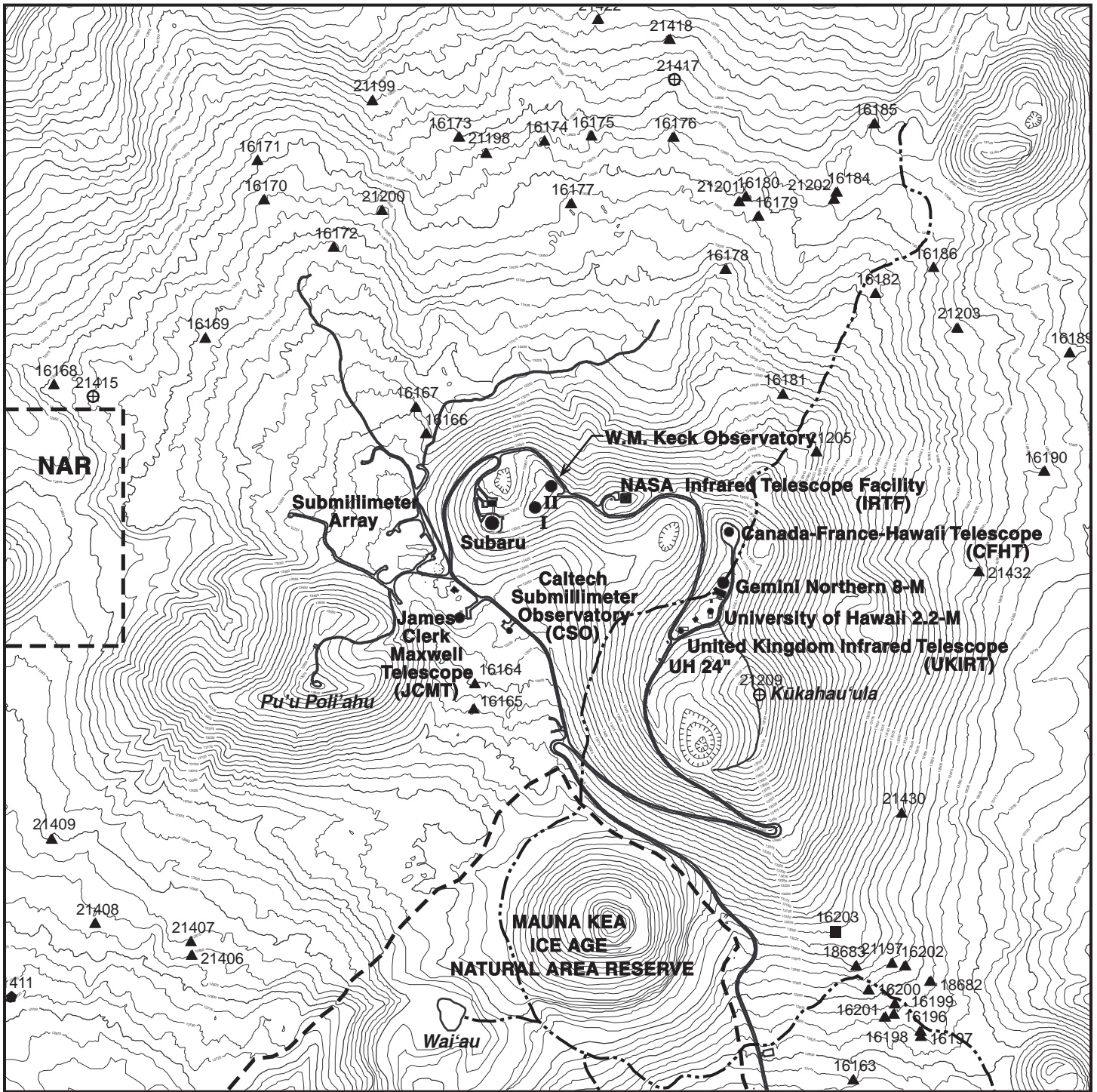


Potential Wēkiu Habitat

Mauna Kea Science Reserve
Master Plan







Source: Hawaii Department of Land and Natural Resources
Historic Preservation Division, Feb. 1999



Archaeology Sites Map

Mauna Kea Science Reserve
Master Plan

Figure IX - 11
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Summary of the Natural and Cultural Resources Physical Planning Guide. The plan provides a clear future direction toward preservation of natural and cultural resources, by directing proposed new development to locations within the summit region where the resource values would not be diminished. A Natural and Cultural Resources Composite map is presented in Figure IX-12. Since these resources are physically adjacent, they are planned and managed together in a living, evolving and sustainable approach. Traditional access to the resources for cultural practitioners is unimpeded, as long as laws are not violated. Natural resources will be preserved consistent with a growing interest in the restoration of the overall mountain ecosystem. The relationship to existing plans and laws regarding natural and cultural resources is addressed in the environmental review (EIS) process.

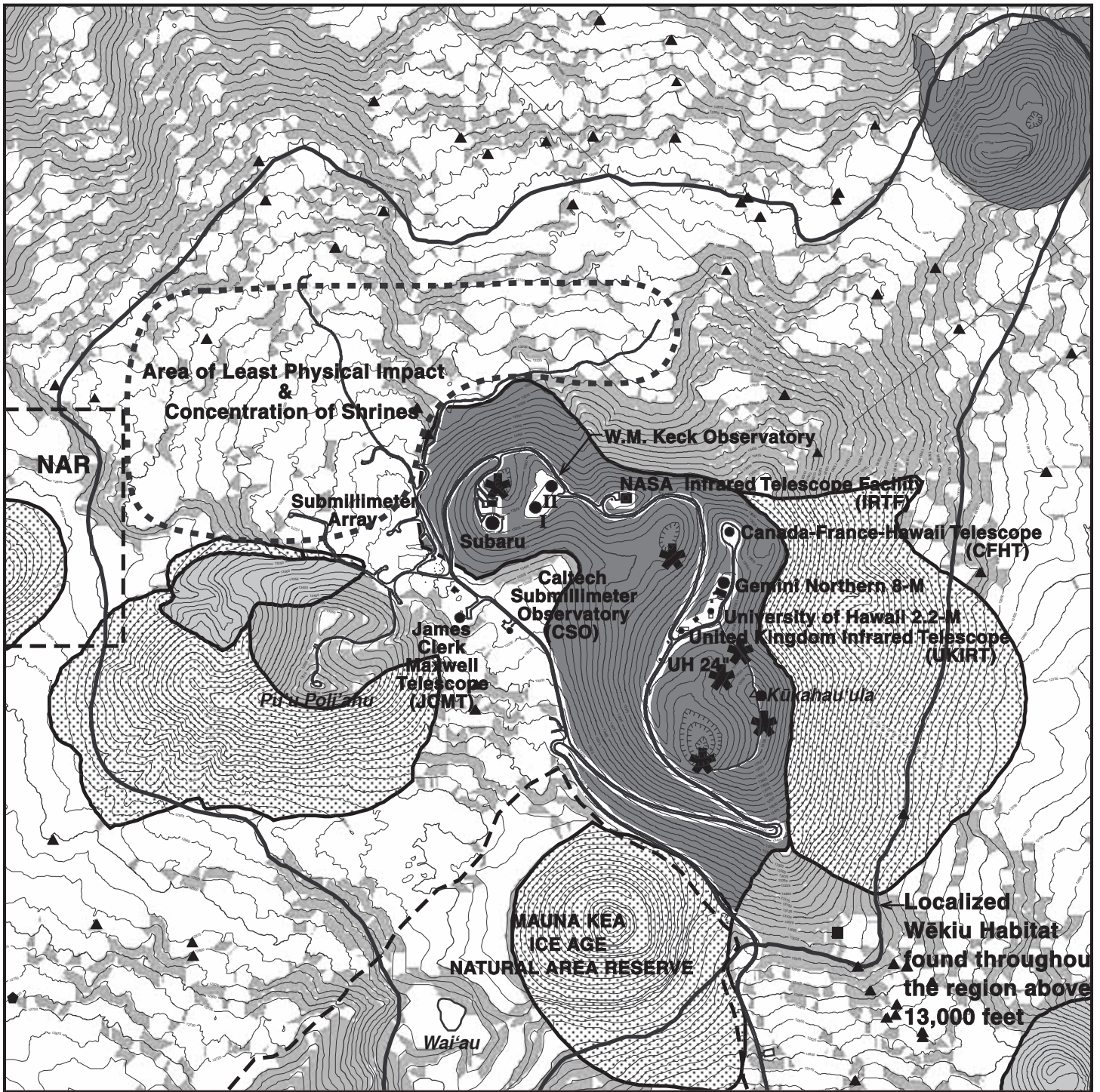
EDUCATION AND RESEARCH COMPONENTS

Mauna Kea has long enjoyed a revered place in native Hawaiian culture, in the lives of those who live on its slopes and all who come in contact with this, one of the world's tallest mountains. Study and research of the cultural and natural features of Mauna Kea are integral to contemporary use of Mauna Kea. Mauna Kea is also the world's premier astronomical research location, and astronomy on Mauna Kea is an essential element of Hawai'i's economy and high technology future. The evolution of astronomy technology, and world-wide interest in astronomy research at this location, presents a current need to upgrade and expand telescope facilities. However, since the time the first telescopes were proposed on Mauna Kea, there have been differing viewpoints about astronomy development, as discussed in the previous section. There is a concern that astronomy development has been distributed across the summit in an unattractive fashion, and that this development might eventually overtake the mountain. There also are concerns about the potential impacts of development to natural resources, such as the Wēkiu bug habitat, archaeological sites and Hawaiian cultural resources.





The education and research component is the second integration of the physical planning guide, which joins the projected education and research uses with the natural and cultural resource component. The natural and cultural resources map identifies the preservation areas where resource values are highest, and development activity is guided elsewhere.

Overall objectives for education and research:





1. Expand knowledge of the Science Reserve as an educational resource for the benefit of the community, students, researchers, and visitors, through the planning process.






Wēkiu

-  Likely Habitat/Specimens Found
-  Likely Habitat
-  Likely Habitat/Presence Unknown
-  Specimens Found 1997-1998

Archaeology

-  Shrines
-  Marker
-  Unknown
-  Workshop

-  25' Contour Intervals
-  Natural Area Reserve
-  Slope 20% or Greater

Natural & Cultural Resources Composite

Mauna Kea Science Reserve
Master Plan



Figure IX - 12
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-
2. Protect natural and cultural resources and insure managed access to the Science Reserve for education and research use.
 3. Protect and enhance astronomy research at Mauna Kea as it is the premier observatory site in the Northern Hemisphere.
 4. Define areas, criteria and support facilities for education and research as applicable, to allow for sustainable, integrated planning and management.

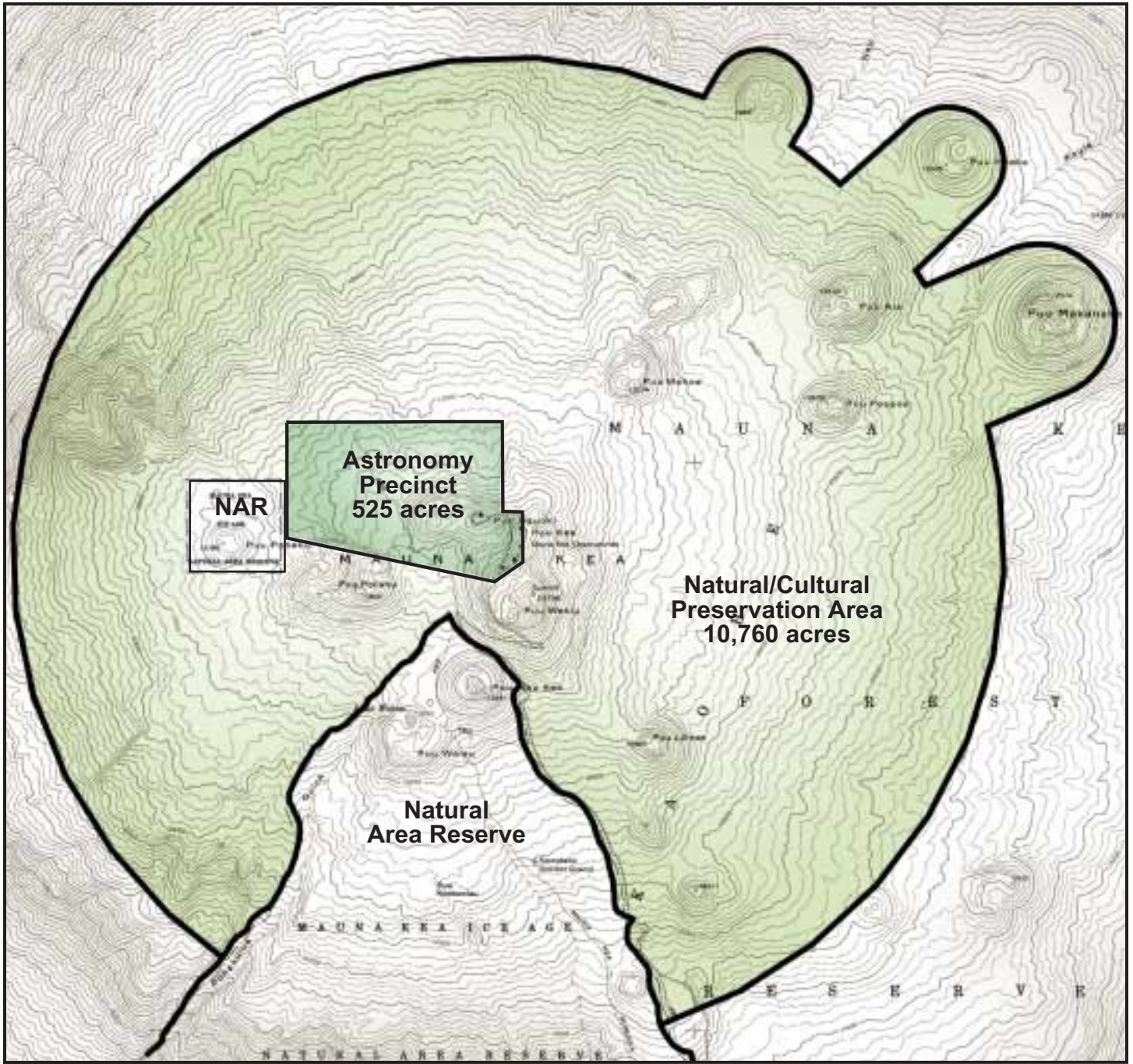
Astronomy Precinct

An “Astronomy Precinct” is defined where development will be consolidated to maintain a close grouping of astronomy facilities, roads and support infrastructure. This approach minimizes the potential impact to the natural and cultural resources of the summit region. The criteria to be followed for new facilities proposed in the Astronomy Precinct include:

- Emphasize the recycling of existing sites so as not to disturb existing habitat areas, archaeology and landforms;
- Limit visual impact and scattering of facilities by clustering within the existing development area, recognizing that facilities have already been built in this area and presently have a visual impact;
- Utilize the natural forms in the summit area to shield views of built facilities, from both off-mountain and atop this mountain;
- Implement design measures to allow facilities to blend in better with the natural landscape, to minimize the sense of disruption to the landscape; and
- Minimize infrastructure development by locating near the existing roadway and utility network.

As shown in Figure IX-13, the Astronomy Precinct is defined by the limits of the critical resource areas identified within the natural and cultural resources component of the Master Plan, as well as by considering the siting needs of future astronomy facilities. The Astronomy Precinct will be approximately 525 acres, or less than five percent (4.65%) of the existing Science Reserve. The boundaries of the Precinct have been established based on the following resources:

- Northern boundary: The boundary to the North avoids clusters of archaeological sites (shrines) found at the 13,000 ft. elevation, providing a minimum 200 ft. setback. This setback distance is 10 times the setback distance required by the Hawai'i Island Burial Council for development near existing burials.
- Eastern boundary: The Eastern slope of the summit is a broad natural area, with no development at present and which is highly visible from the Hilo area. This will ensure no development on this slope.



 40' Contour Intervals

Astronomy Precinct

Mauna Kea Science Reserve
Master Plan

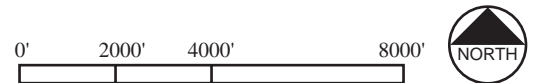


Figure IX - 13
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- **Southern boundary:** The culturally significant places of Poli‘ahu and Kūkahau‘ula, and the intervening area between Poli‘ahu and Wai‘au, set the Precinct limits to the south. This also respects the Wēkiu bug habitat associated with the summit cinder cone. The precinct boundary also retains an open view from Kūkahau‘ula toward the western slope of Mauna Kea, which some have identified as a potentially important resource of cultural and religious significance.
 - **Western boundary:** The NAR and Pu‘u Pōhaku and steep slopes set the western limit.

Included within the Astronomy Precinct are three shrines out of the 93 archaeological features which have been identified in the Science Reserve. The Precinct includes relatively flat areas, and the potential development locations within the Precinct are largely shielded from Wai‘au and the existing roads. In addition, the implementation of design guidelines outlined at the end of this chapter will minimize the visibility of proposed new astronomy facilities within the Astronomy Precinct.

Astronomy Precinct Detailed Plan - Siting Criteria. Specific siting criteria have been set for locating new facilities within the Astronomy Precinct. These criteria include:

1. **Minimal impact on existing facilities.** Existing astronomy facilities require a clear line of sight to approximately 12 degrees above the horizon in a full circle. The location of proposed new facilities cannot obscure the observation function of the existing telescopes on the mountain. Proposed new facilities must be spaced accordingly within the Astronomy Precinct.
2. **Minimum impact of Wēkiu bug habitat.** The major pu‘u in the area of the summit all possess confirmed or likely habitat for Wēkiu bug where the cinder cone surface geology is present. Only the existing disturbed locations on pu‘u or areas outside of the Wēkiu bug habitat will be considered as potential siting areas.
3. **Avoidance of archaeological sites.** There are three existing archaeological shrines within the Astronomy Precinct, and these sites must be avoided in future facility siting. In addition, any new facilities will be set back at least 200 feet from the clustered group of shrines found outside the Precinct boundary on the northern slope. This setback distance is 10 times the setback distance required by the Hawai‘i Island Burial Council for development near existing burials.
4. **Suitability for Observations.** Potential sites for new observatories within the Astronomy Precinct must meet specific standards for conducting astronomical observations, including acceptable obscuration and wind flow conditions.
5. **Minimum visual impact from significant cultural areas.** Views from the pu‘u and archaeological sites will be respected in the siting of future facilities. The location of new facilities will avoid interference with the visual connections between the major pu‘u and the shrine complexes.

-
6. Avoid or minimize views from Waimea, Honoka‘a and Hilo. Sites for proposed new facilities will maximize the use of the existing topography to shield views from the downslope communities. Prominent sites along the ridges or pu‘u will not be selected for new development of astronomy or other research and education facilities.
 7. Close to roads and existing infrastructure. Sites for proposed new development will be selected close to the existing roadways to minimize the amount of disturbance to the natural terrain. Utilities and communications service to new sites will be extended along the existing roadway routes to minimize disturbance.

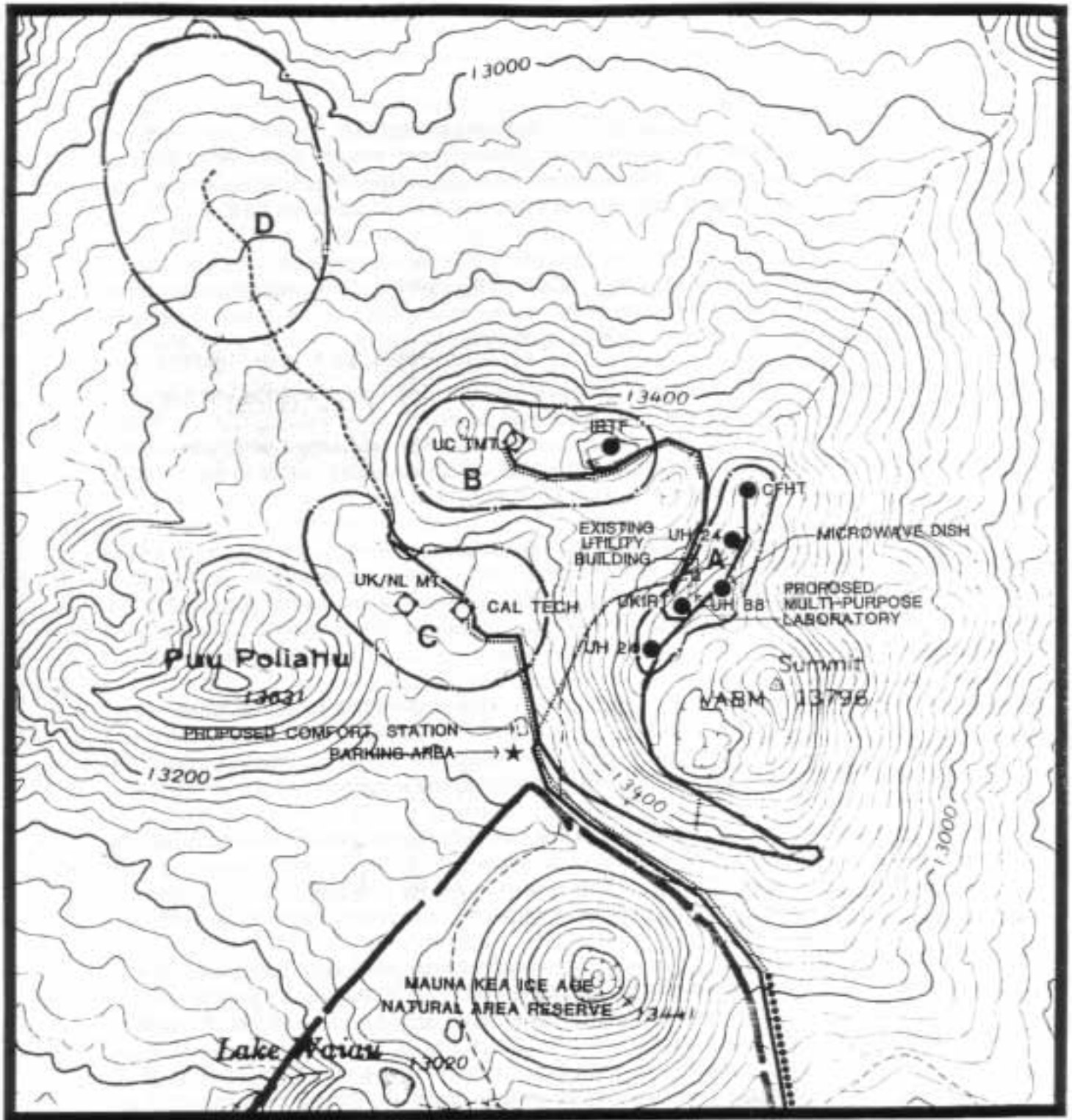
Astronomy Precinct – Telescope Siting Areas. The 1983 plan included seven areas in the Science Reserve that were designated as Analysis Areas, as shown in Figure VIII-3. Of these seven areas, four areas (A-D) were designated as Telescope Siting Areas. There was an ample allocation of space in each of the 1983 Siting Areas, to allow for flexibility in the siting of telescopes that had yet to be designed and built on the summit.

The total area allocated in the 1983 plan for telescope siting in the four areas totaled approximately 160 acres. All of the existing observatories and anticipated new facilities in the 1983 Plan were to be sited within these four areas, as shown in Figure IX-14. Only the Siting Areas A, B and C have been utilized for observatory development up to this point.

The update of the Master Plan enables the refinement of the Telescope Siting Areas within the Astronomy Precinct, to include all existing observatories, proposed redeveloped facilities and new facility sites. Proposed Telescope Siting Areas (2000-2020) are shown in Figure IX-15, consistent with criteria described above.

Siting Areas A, B and C are already developed with observatories. All the instruments proposed in the previous plan are constructed, and the limits of these observatory sites define Areas A, B and C. There is little area available for new telescope development in these three siting areas, however, redevelopment of existing facilities would be possible.

Within the Astronomy Precinct, new telescope siting areas were identified consistent with the siting criteria described earlier. The areas which are anticipated to provide suitable observation conditions with minimum impact on existing facilities, wekiu bug habitat, archaeological sites and minimal visual were selected as the new telescope areas D, E and F, as delineated in Figure IX-15. Each expansion area is linked to the existing unpaved roads, which minimizes disturbance to the natural terrain. In the new plan, Areas D and E are expansion areas that are located in the vicinity of Area D from the 1983 plan; however, the new Areas D & E will avoid sensitive shrines that were previously located in the siting area. Area F is located in the vicinity of an Analysis Area V from the previous plan (Figure VIII-3).

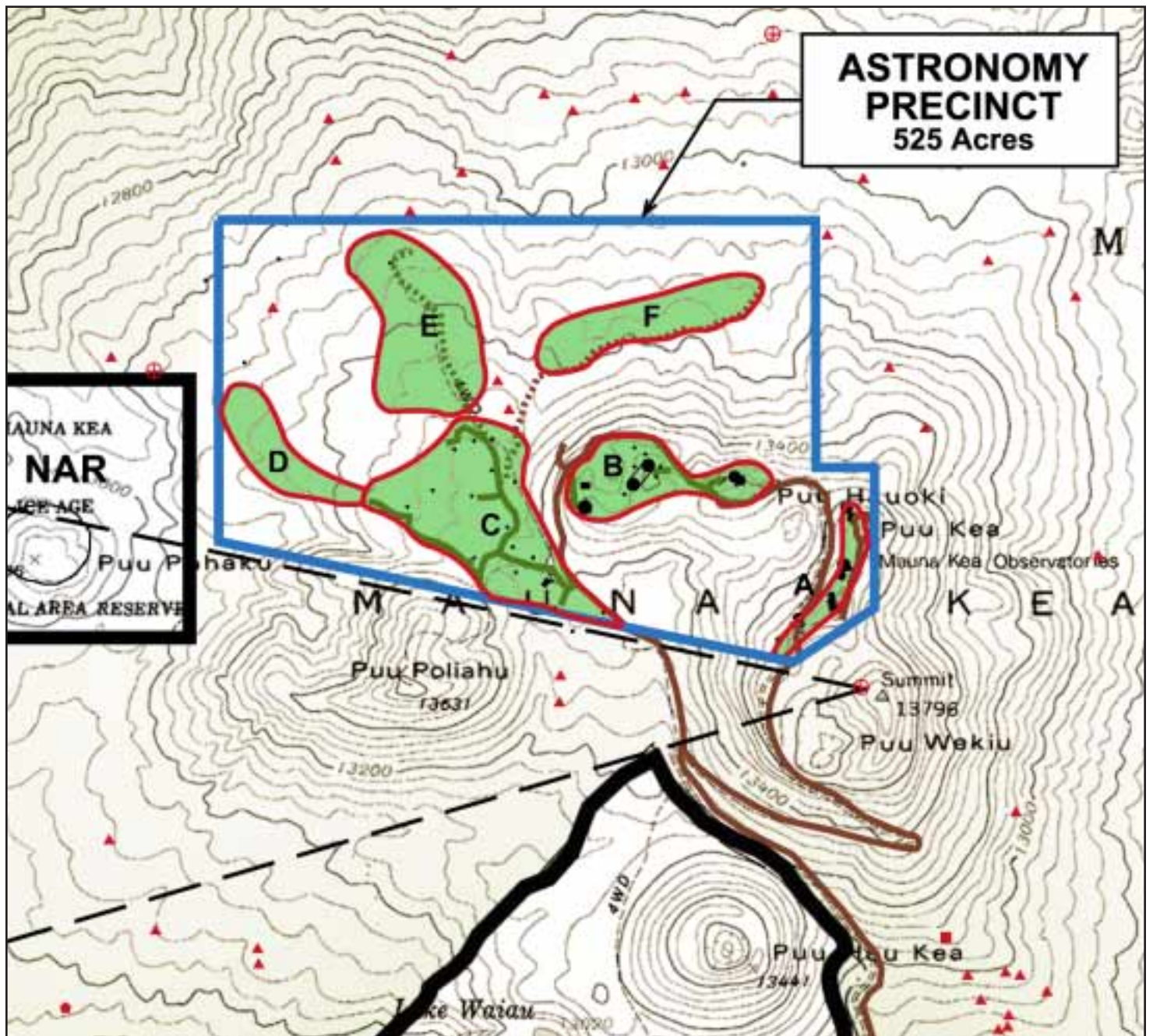




LEGEND

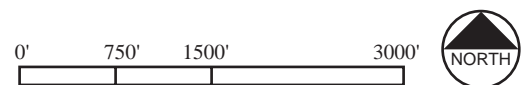
- EXISTING TELESCOPES
- ◊ PROPOSED TELESCOPES
- ROAD IMPROVEMENTS 1ST PHASE
- - - - ROAD IMPROVEMENTS 2ND PHASE
- HELCO POWERLINE
- · - · - UNDERGROUND COMMUNICATIONS & POWERLINE CONDUITS
- TELESCOPE SITING AREAS



Telescope Siting Areas (1983)



-  40' Contour Intervals
-  **A-F** Telescope Siting Areas



Compared to the 1983 Telescope Siting Areas, the current plan reduces Areas A and B, reconfigures Areas C and D, and adds Areas E and F. The current Master Plan reduces the total area allocated for Telescope Siting Areas to approximately 150 acres, as compared to approximately 160 acres in the 1983 plan.

Telescope Siting Areas (1983 Complex Development Plan)		Telescope Siting Areas (Updated Master Plan 2000-2020)	
Area Designation	Approximate Area (ac.)	Area Designation	Approximate Area (ac.)
A	18	A	10
B	34	B	22
C	35	C	43
D	75	D	16
		E	36
		F	23
Total	162	Total	150

Astronomy Precinct - Definition of a Telescope. The 1998 report by the State Legislative Auditor recommends departing from the simplistic counting of “telescopes” at the Mauna Kea Science Reserve. To help clarify the issue of counting telescopes, it is appropriate to examine the definition of a telescope. Webster defines “telescope” as follows: *An instrument for collecting and examining electromagnetic radiation.* This is consistent with the working definition for telescopes within astronomy. A telescope must have the capacity to *collect* as well as *examine* visible light and/or invisible radiation – i.e., it must be capable of making astronomical observations.

By this definition, Keck, Gemini, Subaru, Canada-France-Hawaii, both U.H. facilities, UKIRT, JCMT (Maxwell), VLBA, and Caltech are telescopes. The Submillimeter Array (SMA), when taken as a whole, is a telescope, but not each antenna. Each antenna collects radiowaves, but is not capable of providing astronomy observations. If a control building were attached to each antenna, then these antennas would be considered telescopes. The control buildings would, of course, be larger than the antenna. In the same way, the proposed 4-6 Keck outriggers are collectors which are part of an interferometer and not individual telescopes. When connected to the control building within the existing Keck, they would form one interferometric telescope.

An analogy for an array telescope is a stereo system. Each speaker is not a stereo system in itself but all the components make up one system. Each part is considered a component with a specific name and purpose. The use of the term “stereo” to refer to a speaker, receiver, tape deck, etc. is inappropriate. In the same way, the use of the term “telescope” for components is inappropriate.

The approach taken by the Master Plan is to describe the actual components of proposed astronomy development. This approach provides for full disclosure to the extent possible when viewing the future of astronomy facilities atop Mauna Kea, and is consistent with the Auditor’s recommendation to get away from the simplistic counting of “telescopes”.

Astronomy Precinct - Anticipated Program for Astronomy Development. The projected expansion of astronomy research facilities at Mauna Kea is specified in the Institute for Astronomy’s Research Development Program (2000-2020), which is included in Appendix A. The anticipated program for astronomy development envisions five different categories of facility development projects (Types I-V), as listed below.

Type I. Redevelopment of Existing Observatory Sites on the Summit Ridge:

Redevelopment or “recycling” of up to five existing telescopes, including NASA/IRTF, CFHT, UH 2.2 m, UKIRT, and UH 0.6 m. It is anticipated that up to three or four facilities may be redeveloped over the next 20 years.

Type II. Expansion of Existing Observatories:

Expansion of the Keck Observatory with the addition of four to six 1.8-m. outrigger telescopes. Four are being proposed to start development in 2001. The Submillimeter Array may add up to 12 new antennas and 24 new pads over the next 20 years.

Type III. New Conventional Optical/IR Telescope

A new conventional telescope comparable to the Keck or Gemini Observatories at a currently undeveloped site. An instructional telescope for UH-Hilo is also projected.

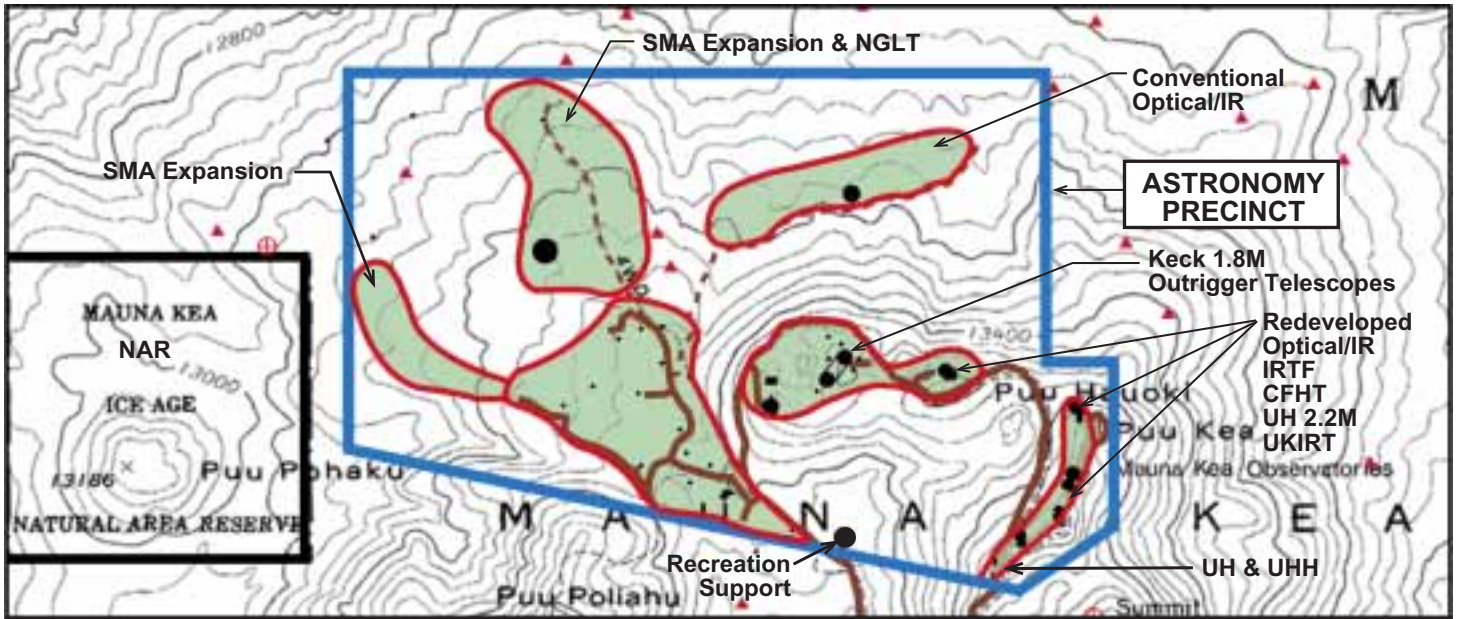
Type IV. Next Generation Large Telescope (NGLT)

A single optical/IR telescope of 25 m. aperture or greater. This is currently only being discussed in the astronomy community and there is a 50 percent possibility that this facility may be developed in the next 20 years.

Type V. Optical/IR Interferometer Array Site

A general area is proposed for this observatory. No facilities are included in this Plan. Facilities must undergo the major Master Plan amendment process for approval.

Given the prescribed criteria for site selection, and UH’s anticipated program for astronomy development in the next 20 years, specific sites or areas within the Astronomy Precinct have been identified. A summary of all proposed research facilities development in the Astronomy Precinct is presented in Figure IX-16. An expanded discussion of each of the proposed facility type and locations is presented below.



EXISTING CFHT					
UP TO 5 POTENTIAL SITES (3-4 PROBABLE)	OPTICAL/IR	NGLT	UHH	UP TO 6 OUTRIGGER TELESCOPES	UP TO 12 ANTENNAS
RE-DEVELOP EXISTING FACILITIES	POTENTIAL NEW OBSERVATORIES			NEW OUTRIGGER TELS EXISTING KECK OBSERVATORY	NEW ANTENNA EXISTING SMA OBSERVATORY

ELEVATIONS DRAWN TO RELATIVE SCALE

Physical Plan and Proposed Astronomy Facilities

Type I. Redevelopment of Existing Observatory Sites on the Summit Ridge.

The most likely type of astronomy development at Mauna Kea would be the replacement or upgrading of facilities at existing sites, as a first preference, or the development of new sites as a second preference. It is expected that the proposed new or upgraded conventional optical/IR telescopes will come in a range of sizes, from 2 to 15 m. mirror sizes. The 10 m. mirrors of the existing Keck, Gemini and Subaru telescopes represent the current state-of-the-art instrument.

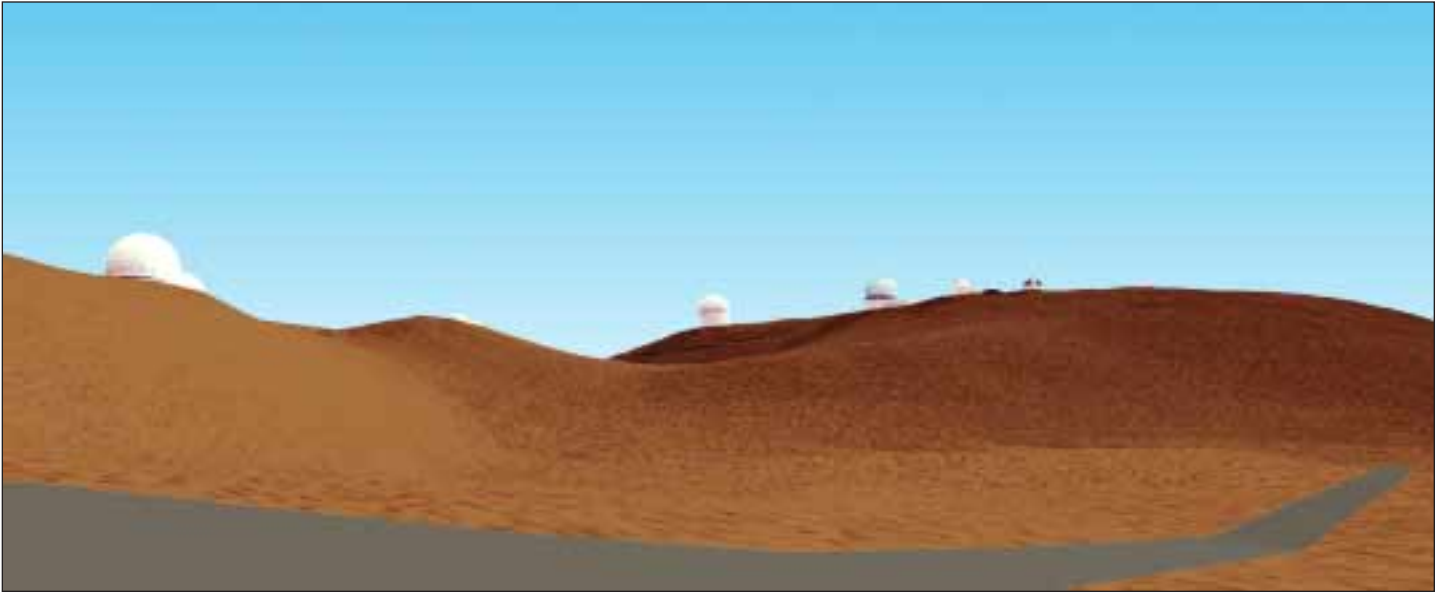
The first priority for siting these facilities will be the recycling of existing facilities that have aging technology, such as the IRTF, CFHT, UKIRT, UH 2.2 m. and UH 0.6 m. These five telescope sites have already been disturbed by development activities, and the facilities are part of the existing visual setting. The IRTF, CFHT, UKIRT, UH 2.2 m. and UH 0.6 m. are all over 20 years old, and the current technology for conventional telescopes is far superior. The present sites on the summit ridge are attractive for locating new or upgraded facilities because of known high quality locations and existing infrastructure. Most of the existing observatory organizations may be unable to operate both a new facility and the existing one, so they will prefer to recycle their existing site.

We expect to see a trend toward specialization for these conventional-size optical/infrared telescopes. For example, one facility may decide to concentrate on wide-field imaging, while another focuses on using adaptive optics to achieve the highest possible angular resolution over a small field. Specialization will allow the telescope facility to achieve the ultimate in performance within the chosen area of research, while at the same time simplifying the operation and thereby reducing costs. Specialization will provide a strong incentive for joint operating arrangements and shared use among the observatory organizations.

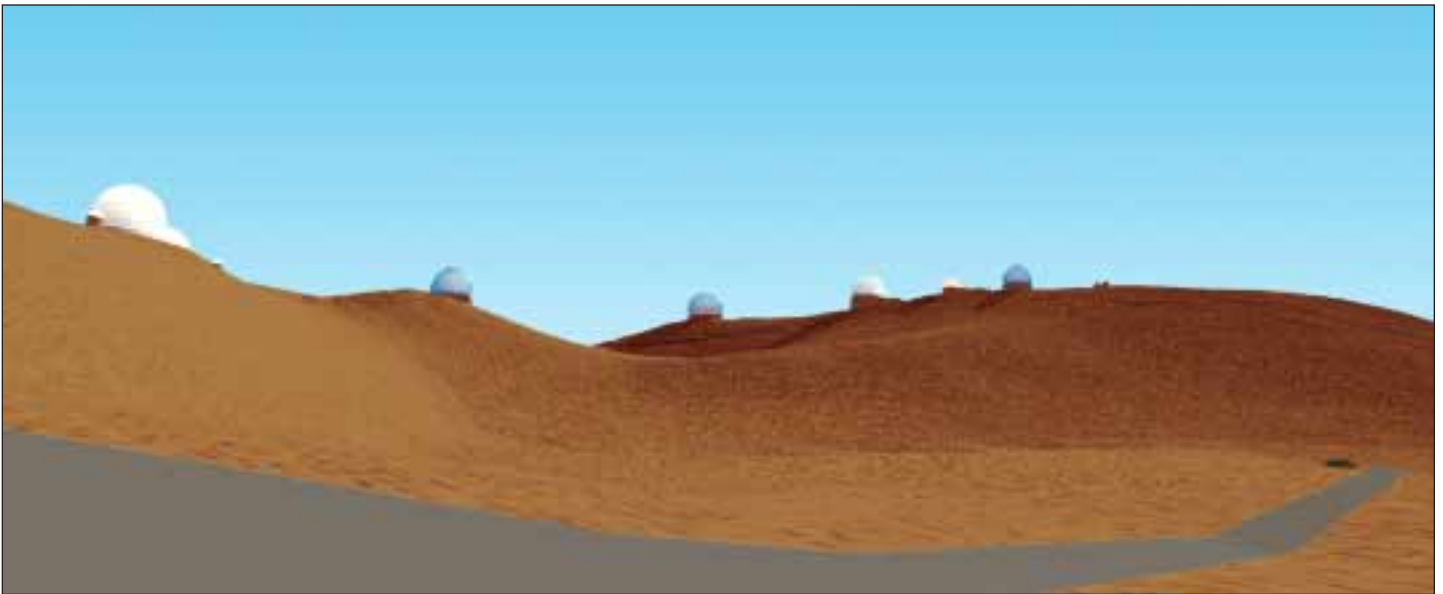
During the 20-year period of this Master Plan, it is expected that there may be proposals to upgrade or replace each of these five telescopes on the summit ridge with conventional optical/IR telescopes. Over the next 20 years, it is estimated that only three or four ridge facility upgrades will actually be constructed over this time period, including the replacement of the UH 0.6 m. telescope with a facility in the 2 to 3 meter mirror size range.

In addition to the replaced/upgraded conventional optical/IR telescopes on the ridge, UH-Hilo plans to construct an instructional telescope (1 m. mirror) adjacent to the existing UH 0.6 m. telescope on the existing site of a utility/storage building. Use of the facility is anticipated to be primarily instructional, with research uses only for programs with substantial academic or other instructional content, or when the telescope is not needed for such programs.

Figure IX-16 identifies the sites with the greatest potential for upgrades, expansion or redevelopment. A perspective view is shown in Figure IX-17.



Existing Summit Ridge Telescopes



Redeveloped Summit Ridge Telescopes

Future telescope redevelopment on the summit ridge will limit these facilities to a maximum height and diameter of approximately 130 feet, to limit the visual impact along the ridge. This standard is derived from the approximate dimensions of the existing Gemini and Keck class of telescope. For more specific standards for these facilities, refer to the design guidelines at the end of this chapter.

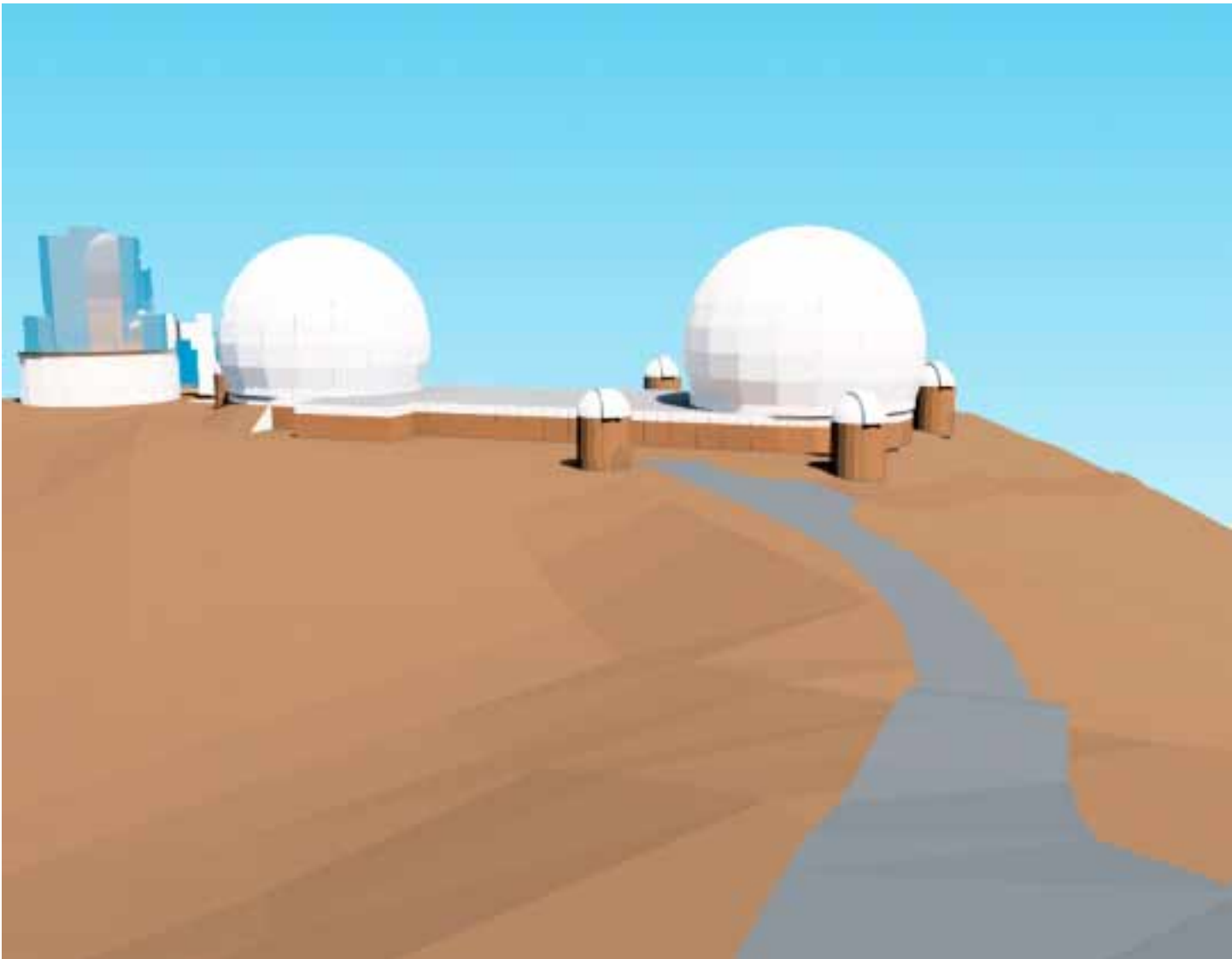
A three-dimensional perspective of the summit ridge under existing conditions and with recycled/upgraded telescopes, as viewed from the access roadway in “Millimeter Valley” near the James Clerk Maxwell Telescope, is included in Figure IX-17. The view from off-mountain locations of the summit ridge with the redeveloped conventional Optical/IR telescopes is shown in Figures IX-22, 23 and 24.

Type II. Expansion of Existing Observatories.

Expansion of the W. M. Keck Observatory. The addition of four to six 1.8-m. outrigger telescopes is planned to create a powerful infrared interferometer on the existing Keck site. The primary purpose is to study planetary systems around nearby stars. Funding is to be provided by NASA, with four of six outriggers already funded. The outrigger telescopes will test the feasibility and capability of IR interferometers, as a precursor to space-based interferometry missions including the Terrestrial Planet Finder. On a tight schedule because of its link to planned space missions, NASA would like to start construction in 2001. The Keck Outrigger Telescopes project is the only new project proposed for Mauna Kea at present.

The location of the Keck outrigger telescopes on the existing Keck site is shown in Figure IX-16. This site is already disturbed from the development of the two Keck facilities, and the outrigger telescopes will not extend beyond the existing site. From a natural and cultural resource perspective, the impact of the project is negligible. There is no better location for this facility since it requires a combination with the existing Keck facilities. The proposed use of the existing site allows for the project to be built without damaging existing Wēkiu bug habitat found in the surrounding area.

A three-dimensional view of the outrigger telescopes is presented in Figure IX-18. The new outrigger telescopes will be much smaller in scale in comparison to the existing Keck telescopes, only about 35 ft. in height. The visibility of the outriggers telescopes from areas at the summit is very limited, and off-mountain views will not be affected. A simulated view of the summit from off-mountain locations at Hilo, Honoka‘a and Waimea, including the completed Keck outrigger telescopes, is shown in Figures IX-22, 23 and 24.



W.M. Keck Observatory with Proposed Outrigger Telescopes

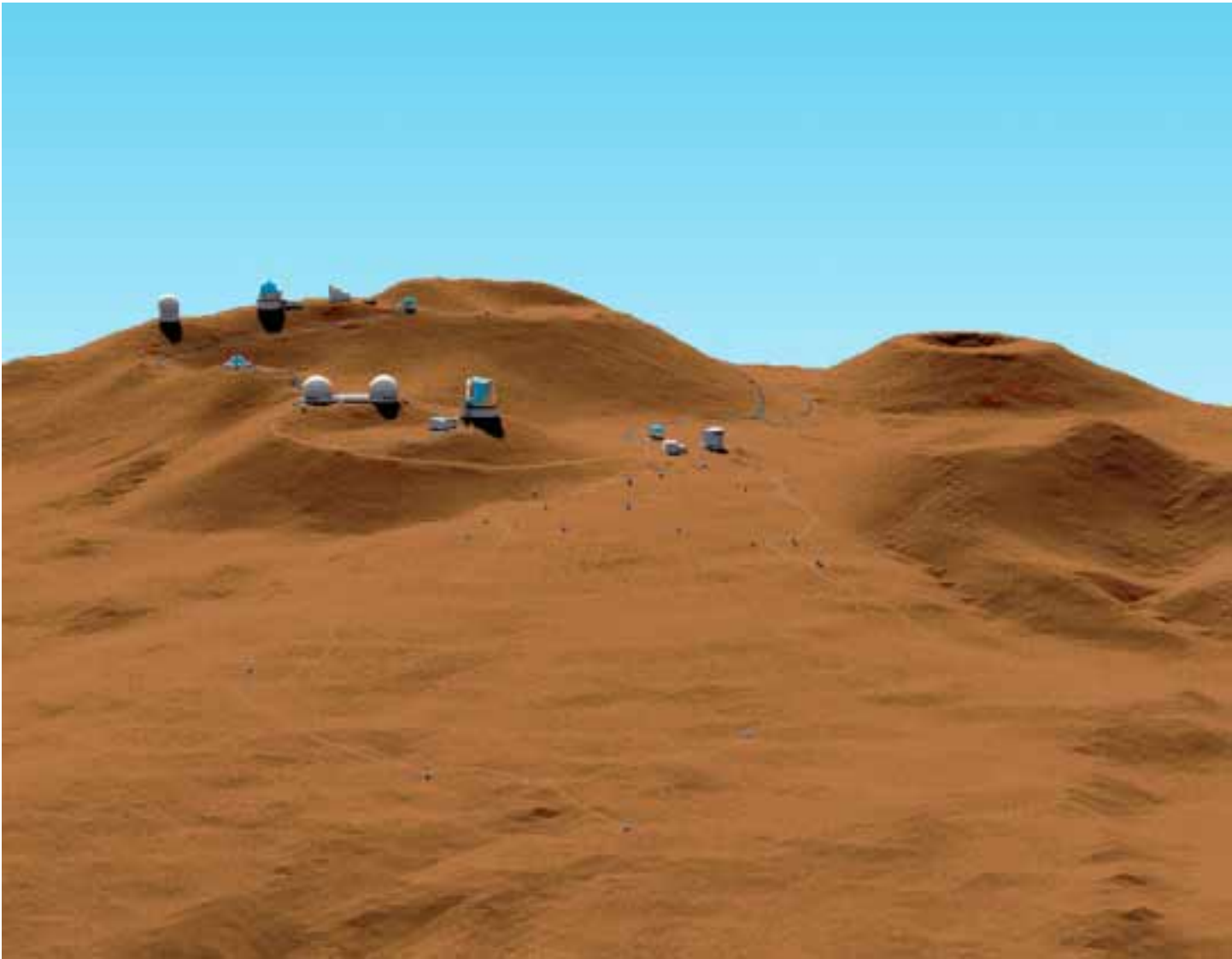
Expansion of the Submillimeter Array (SMA). The existing SMA is anticipated to be operating in 2001. Within the next 20 years, it is likely there will be a need to expand the existing SMA, to include up to 12 new antennas and 24 additional pads. Some of these antennas may differ somewhat in size and structure from the current SMA antennas and operate independently of the others. This expansion will increase the sensitivity and angular resolution of the SMA and will allow for multiple studies to take place concurrently within a densified and elongated array.

Location issues involved with the submillimeter involve technical siting issues (slope and obscuration) and natural/cultural resource constraints. One of the potential array configurations, considered prior to this Master Plan, included the area to the south of the existing array, extending between Poli‘ahu and Wai‘au. Use of this area, however, would not fit with the natural and cultural resource component of the Plan. The inter-relationship between Poli‘ahu, Wai‘au and Kūkahau‘ula (summit) is recognized as culturally significant, and the placement of antennas in the valley between these features would detract from this resource.

The expansion area will extend the baseline for this antenna complex approximately 0.5 km to the north and west of the existing array. Figure IX-16 shows the potential expansion area for the submillimeter array. A three-dimensional perspective view of the expanded submillimeter array is included in Figure IX-19.

The submillimeter array expansion will be concentrated in the area to the north of Pu‘u Poli‘ahu, and will not be visible from Hilo and Honoka‘a. It will probably not be visible from Waimea, as shown in Figure IX-23.

Due to the relatively small size of the SMA antennas (25 ft. in height) they are virtually invisible from a distant perspective. To further diminish the visual impact of the SMA facilities, the concrete pads for the new antennas should be colored in a brown tone to match the surrounding lava/ash landscape. To the extent possible the SMA facilities will be sited to utilize the existing road and pathways.



Type III. New Conventional Optical/IR Telescope

The second priority for siting proposed conventional optical/IR telescopes will be at a new site within the Astronomy Precinct, and only if a suitable summit ridge site cannot be utilized for redevelopment. In the event there is no existing site available, there is an area to the north of the summit ridge that could potentially support a new conventional optical/IR telescope. Infrastructure expansion issues are a potential concern for any new facility that is not accessible from existing roadways. The north shield has not been thoroughly tested for seeing conditions, and a future site for facility development in this area would be contingent on positive findings from seeing analysis.

The proposed site for a new conventional optical/IR telescope is shown in Figure IX-16 and a perspective view is shown in Figure IX-20. The selection of this new site within the Astronomy Precinct generally satisfies the specific siting criteria, including:

1. Minimal impact on existing facilities. A facility proposed at a location to the north of the summit ridge will not cause obscuration for any existing telescopes on the mountain.
2. Minimum impact of Wēkiu bug habitat. The area to the north slope is outside of the known Wēkiu bug habitat with no pu‘u or cinder cone surface geology.
3. Avoidance of archaeological sites. There are no existing archaeological features in the north slope portion of the Astronomy Precinct. The new facility will be set back at least 200 feet from the clustered group of shrines found outside the Precinct boundary further to the north (toward Honoka‘a and Waimea). This setback distance is 10 times the minimum setback distance required by the Hawai‘i Island Burial Council for development near existing burials.
4. Minimum visual impact from significant cultural areas. Telescope sites on the north slope would be visible from archaeological sites when looking toward the summit, but would not obstruct the visual connections between the major pu‘u and these shrine complexes. By locating a new conventional optical/IR telescope site off the summit cinder cones, this will mitigate further diminishment of the integrity of the summit ridge as an historic property.
5. Avoid or minimize views from Waimea, Honoka‘a or Hilo. This location is not a prominent site such as the ridges or pu‘u. The existing topography of the north slope shields views of new facilities from Hilo. A new telescope at this location would be visible from the Waimea and Honoka‘a communities.
6. Close to roads and existing infrastructure. The proposed site for the conventional telescope was selected near to the existing roadways to minimize the amount of disturbance to the natural terrain. Utilities and communications service to the new site will be extended along the existing roadway routes to minimize disturbance.



The proposed site for a conventional optical/IR telescope satisfies the selection criteria. A perspective view of the new conventional optical/IR telescope on the north slope is shown in Figure IX-20. In order for visual impact to be minimized, the enclosure for this new telescope should be colored to match the surrounding lava/ash terrain. Further, if a new observatory is proposing to develop a mirror with an aperture of greater than 10 m., a partial buried strategy must be applied to diminish the visual impact of these facilities. These requirements are specified in the proposed Design Guidelines.

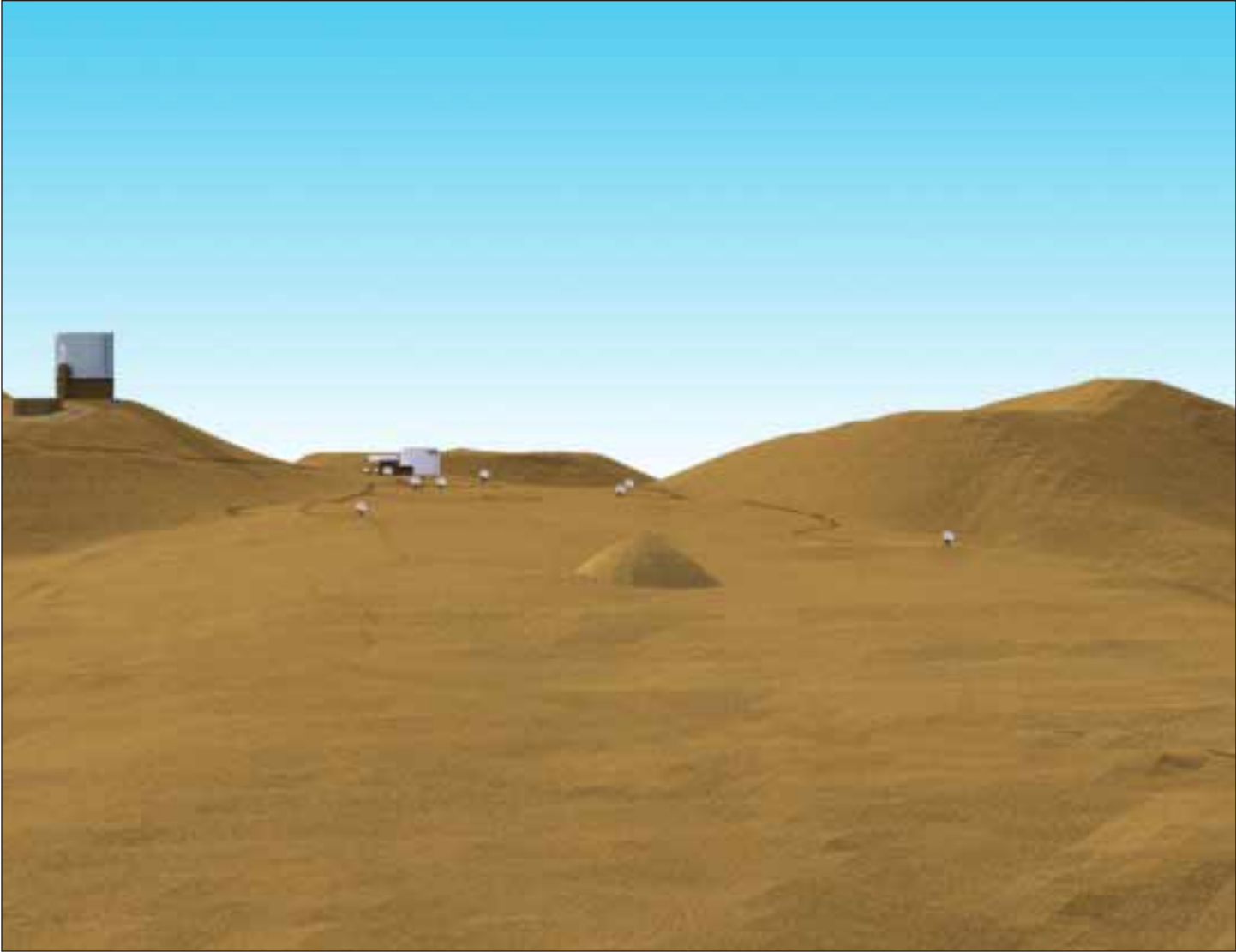
Type IV. Next Generation Large Telescope Site

A single large optical/IR telescope may be proposed for Mauna Kea in the 20-year life of this plan. A ground-based telescope with a mirror of 25 to 50 m. in diameter is being considered by the astronomy community, which would complement the planned Next Generation Space Telescope. This facility would be the largest telescope in the world, and is currently called the Next Generation Large Telescope (NGLT).

The large scale of this instrument makes the visual impact considerations very important in the facility siting and design. The NGLT would not be appropriately located at Mauna Kea's summit ridge, due to the major earthwork requirements that would disturb Wēkiu bug habitat and the visibility of a large telescope placed atop the ridge. In addition, telescope engineers have indicated that wind forces acting on the structure are expected to be severe and problematic. To minimize potential obscuration of existing observatories, the potential site for this facility must also be located in an area that is distant from the prominent topography at the summit ridge and nearby *pu'u*.

A location that would minimize its visibility and reduce wind shear forces, and minimize potential obscuration impacts, would be on the slope to the northwest of the summit ridge. The proposed location of the telescope will take advantage of a northerly extension of the summit ridge to entirely block views of the new facility from Hilo, and partially block views from Honoka'a. Figure IX-16 shows the proposed location for the NGLT, which is located between the SMA service roadway and a jeep road that was built decades ago for preliminary testing of viewing conditions to the northwest of the summit ridge. The presence of the existing roadways will help minimize potential site disturbance for the infrastructure extension to this site.

Strict design guidelines will dictate the size and color of the NGLT. The preliminary design concept proposed for the NGLT employs a unique sliding dome mirror enclosure with a sub-grade foundation, as shown in Figure IX-21. The lower half of this observatory will be built below grade to minimize the apparent height and mass of the facility. The facility shown in the concept has a 30-m. mirror, with a dome shaped and colored to simulate a small *pu'u* to blend well with the surrounding landscape.



Proposed Next Generation Large Telescope (NGLT)

The siting criteria for locating proposed new facilities were applied in selecting the site for the NGLT, discussed as follows:

1. Minimal impact on existing facilities. The observation function of the existing telescopes on the mountain would not be affected by new facilities located to the north or northwest of the summit ridge. The proposed location of the NGLT in the center of the SMA expansion area could potentially obscure some antennas in the SMA expansion. These potential obscuration effects can be minimized or eliminated by cooperative planning for these two facilities.
2. Minimum impact of Wēkiu bug habitat. The proposed site is outside of the Wēkiu bug habitat.
3. Avoidance of archaeological sites. The closest archaeological feature to the proposed NGLT site is a shrine located approximately 1,200 ft. to the east. For reference, this distance is 60 times the minimum setback distance required by the Hawai'i Island Burial Council for development proposed near existing burials.
4. Minimum visual impact from significant cultural areas. The siting of the NGLT respects views from the pu'u and archaeological sites. The NGLT is located to the northwest of the summit ridge, which does not interfere with the visual connections between the major pu'u and the shrine complexes.
5. Avoid or minimize views from Waimea, Honoka'a or Hilo. The existing topography shield views of the NGLT from Hilo, however, the facility will be partially visible from Waimea and Honoka'a. The proposed design guidelines for the NGLT will minimize the visual impact of the facility, as discussed previously.
6. Close to roads and existing infrastructure. The NGLT site is close to the existing SMA service roadway, which will minimize the amount of disturbance to the natural terrain. Utilities and communications service to the NGLT site will be extended along the existing roadway routes to minimize disturbance.

To mitigate the visual impact of the telescope, requirements will be imposed to color the telescope enclosure to blend into the surrounding site. The technology for coloring telescope enclosures has yet to be applied in practice, however, this technology is presently being considered by telescope engineers. This design measure will serve to significantly diminish the visual impact of the telescope from both on-mountain and off-mountain locations. Coloring of the telescope enclosure and other strategies are included in the Design Guidelines.

Type V. Optical/IR Interferometer Array (General Area Only)

Development of an Optical/IR interferometry array requires a large and relatively level area of up to 1.0 km. in diameter. Within Mauna Kea's Astronomy Precinct, there is a plateau area to the northwest of the summit ridge that is approximately 0.8 km in diameter. At this location, this type of facility could extend approximately 0.8 km in diameter, with multiple telescope elements collecting light, arranged in a roughly circular array. The number of collecting elements cannot be accurately quantified at present due to the current state of the technology for optical/IR interferometry. The light collected by these devices would be combined at a central location to resolve the image of the target object.

At present, the technology has yet to be developed which would allow for the light to be combined from an optical interferometer of this scale, without the construction of large light combining structures and miles of vacuum tube being installed. These types of support facilities are deemed inappropriate for Mauna Kea. Advances in the use of fiber optics and light processing technology for this purpose are required before a facility such as this could be appropriately built at Mauna Kea. These advances are currently being studied intensively by telescope development engineers.

In anticipation of the advances of the light combining technology, and to provide direction for telescope designers, the physical plan guides the possible placement of this instrument within the northwestern quadrant of the Astronomy Precinct. There is no Telescope Siting Area defined to accommodate this possible instrument. For general planning purposes, the Master Plan presents a general area to provide an opportunity for possible further study of the instrument at some point in the next 20 years. A lengthy and thorough process of a General Amendment to the Master Plan would be required to advance this project to the facility siting, design and permitting phase, including a full EIS and CDUA.

A proposed design strategy for minimizing the visual impact of the interferometer includes partial burial of the interferometer elements and creating visually-minimized enclosures. A clamshell enclosure with "pop-up" collecting device should be considered. Along with these design measures, the enclosures should be colored to match the surrounding landscape. Together with the low profile of the instruments, these measures would essentially shield and camouflage the interferometer from view.

Due to the unspecified project characteristics at this time, only a general area for the optical/IR interferometer is proposed within this master plan. If an optical/IR interferometer proposal is advanced in the next 20 years, the project will require a major master plan amendment, involving the full range of planning analysis, visual impact analysis, and preparation of an environmental impact statement (EIS), and final review by the UH Board of Regents.



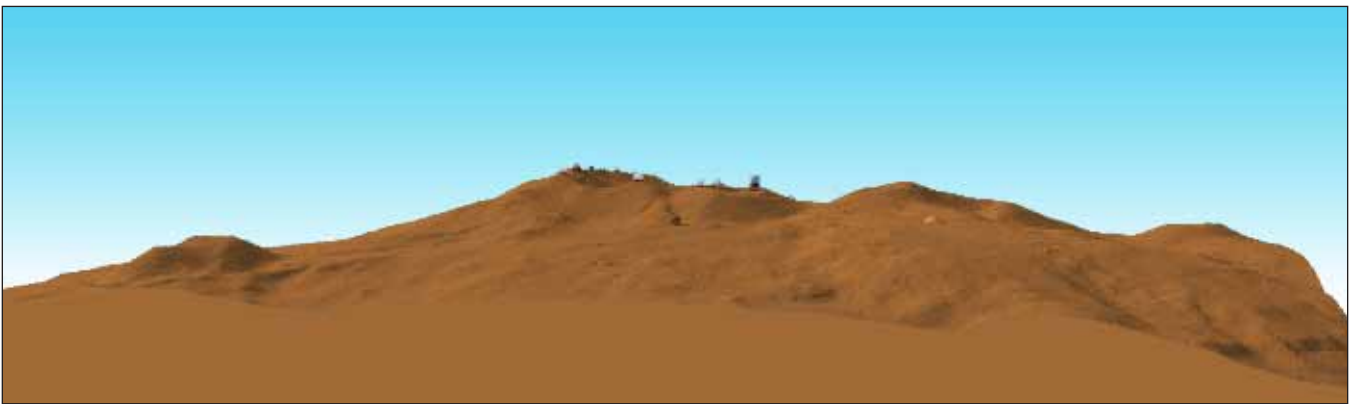
Existing View from Hilo



Future View from Hilo



Existing View from Honoka'a



Future View from Honoka'a



Existing View from Waimea



Future View from Waimea

Planning Guide Summary and Approval Process for Astronomy Precinct

A list of the existing and proposed future observatories for which there are identified siting areas in this master plan is shown on Table IX-1 (page IX-45). The likelihood of all of the identified facility upgrades and proposed new facilities being developed is extremely remote, and the expected scope of development is 50 to 75 percent of the observatories listed. The timing for future development is undefined at present, except for the Keck Outriggers project. For some of the proposed new projects, significant technological advancements are needed before they could move forward. This is particularly true for the Next Generation Large Telescope.

As described in Chapter XI, the University of Hawai‘i Board of Regents and the President retain project approval and design review authority over all developments within the Science Reserve. To assist the University in its evaluation of proposed new development, all applications will be reviewed by the Office of Mauna Kea Management, the Mauna Kea Management Board, and the Kahu Kūpuna Council (see Figure XI-2, page XI-8). In making any decisions on project approval, the Board will carefully consider the advice received from the above three groups.

Each of the redeveloped or proposed new facilities, including any non-astronomy facilities, will undergo individual project reviews, which include an environmental analysis pursuant to Chapter 343 Hawai‘i Revised Statutes and a comprehensive analysis of the potential cultural impact. The Kahu Kūpuna Council will assist in establishing the criteria for these analyses. It is expected that some of the criteria will be specified by State requirements.

In addition, each new facility will be required to present a detailed justification addressing, but not limited to, questions such as the following:

- (1) Why is the facility needed?
- (2) Why is Mauna Kea the best site for the facility?
- (3) What other location options are available?
- (4) What are the expected benefits: research and education, employment and economic activity, potential revenues?
- (5) What is the expected facility lifetime and term of the sublease agreement?

Table IX-1

**EXISTING AND PROPOSED OBSERVATORIES AT
MAUNA KEA SCIENCE RESERVE**

<u>Observatory (Aperture Diameter)</u>	<u>Proposed Master Plan Action</u>
University of Hawaii (0.6 m.)	Redevelop: 2-3 m.
University of Hawaii (2.2 m.)	Redevelop: 4-12+ m.*
Canada-France-Hawaii Telescope (3.6 m.)	Redevelop: 4-12+ m.*
United Kingdom Infrared Telescope (3.8 m.)	Redevelop: 4-12+ m.*
NASA Infrared Telescope Facility (3.0 m.)	Redevelop: 4-12+ m.*
Caltech Submillimeter Observatory (CSO) (10 m.)	Remain As-Is
James Clark Maxwell Telescope (JCMT) (15 m.)	Remain As-Is
Very Long Baseline Array (VLBA) (25 m.)	Remain As-Is
W. M. Keck Observatory (Keck I & II) (10 m.)	Add 4-6 1.8 m. Outrigger Telescopes
Gemini Telescope (8 m.)	Remain As-Is
Subaru Telescope (8 m.)	Remain As-Is
Submillimeter Array (SMA) (12 6-m. Antennas)	Add 12 Antennas
New: University of Hawaii – Hilo	New Site, 1 m. (Instructional)
New: Conventional Optical/IR	New Site, 4-12+ m.*
New: Next Generation Large Telescope (NGLT)	New Site, 25+ m.

Note: All new and redeveloped facilities require individual project review and approval. The NGLT will require the development of new technology.

* It is expected there will be a range of telescope sizes proposed in this group. Exterior dimensions of those on the ridge will be limited by Design Guidelines.

RECREATION PLAN COMPONENTS

The final integration of the Master Plan involves the recreational resource components in the Science Reserve. This plan provides direction for future recreational uses within the Science Reserve, including any potential facilities to support recreation on Mauna Kea. Recreation components, such as hiking, hunting, skiing, snow play and tourism, are addressed in an integrated approach overlaid upon the integrated plan of natural and cultural resources and education and research resources. The overall objectives for recreational resources are listed below.

Overall Objectives

1. Expand understanding of recreational uses and potentials of the Science Reserve.
2. Retain and enhance recreational opportunities within the Science Reserve, while protecting natural, cultural resources, and cultural practices.
3. Define areas, criteria and support facilities for recreational uses, sight seeing and commercial tours, as applicable, to allow for sustainable, integrated planning and management.

Recreational Resources Plan. The traditional uses for recreation on Mauna Kea, and the pattern of these uses, determines the form of the recreational plan component. Access to recreational resources will be enhanced and managed to ensure the protection of the natural, cultural, education and research resources. Hiking trails, ski areas and scenic viewpoints will be delineated within the Science Reserve to allow people to witness the unique resource areas while ensuring their protection. As part of the plan, the following facilities are planned:

- Recreational support facility in the summit region to support skiing, snow play, visitor tours and scenic resource enjoyment;
- A parking area that is primarily planned to serve cultural resource interests, located along the access road at the 13,000 ft. elevation; and
- Cabin camping by organized groups, using the planned conversion of the construction cabins built by the Subaru observatory at Hale Pōhaku.

Further details of the Recreational Plan elements are discussed in the following section.

Physical Plan: Expanded Understanding of Recreational Resource

While there are physical components to the recreational plan, most recreational issues are addressed in the management plan. There are modest facilities needs for recreational support, and support facilities to serve the cultural resource component overlap in certain cases.

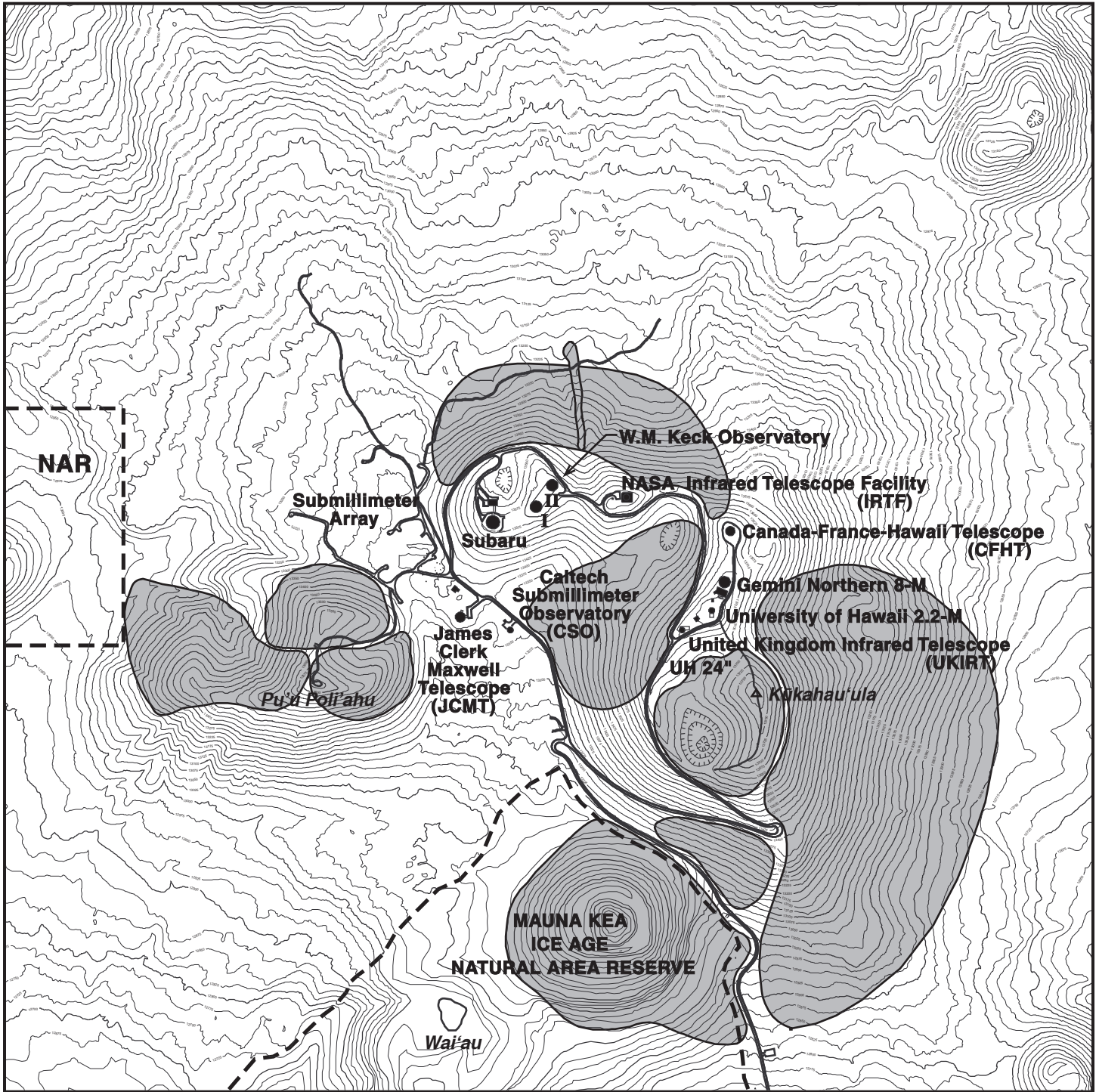
Skiing and Snow Play. Skiing and snow play activities are very popular recreational uses of Mauna Kea during periods of winter snowfall. Figure IX-25 shows the extent of popular ski runs and snow play areas in the summit area. It is also proposed that skiing and snow play use be restricted from the significant cultural landform of Pu‘u Poli‘ahu. Snow play activities are centered around the Poi Bowl area. Snow play will also be restricted to areas without archaeological sites and cultural preserve areas. Parking and bathroom facilities are existing needs to support skiing and snow play activities.

A recreational support facility is planned within the summit region to support skiing, snow play, visitor tours and scenic resource enjoyment. The support facility is planned to be located at the base of “Poi Bowl” along the summit access road in Millimeter Valley, at the center of skiing and snow play activity at the summit during winter months. The facility would include a shelter, rest rooms, emergency equipment storage, an emergency telephone, and possibly a small office space for the rangers. The design of the facility is envisioned as a building built into the surrounding landscape such that its presence will not detract from its natural setting. It is not to be a “ski lodge”.

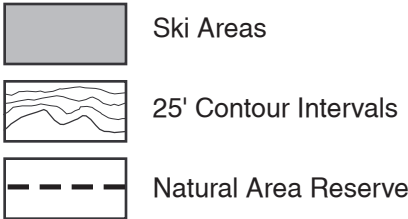
Individual Visitors and Tours/ Scenic Vista Out-Look Locations. The master plan defines areas for specific visitor stopping points in the Science Reserve and at the summit. Scenic lookout points will be organized at the summit at two locations where the observatories are willing to accommodate limited public access. Currently the Keck observatory sites allow such use, with the Keck Observatory providing a Visitor’s Gallery including restrooms. Very limited parking areas are present to serve the visitor areas, and visitors will generally be directed to use the restroom facilities planned for the Poi Bowl area.

Trails. In the rugged terrain in the upper slopes of Mauna Kea, trails to Wai‘au and the summit are evident on historic maps and on the ground today. Past ranching activities were responsible for creating the more defined trails. Interviews of informants with historical knowledge of Mauna Kea identified the routes of historical trails (Figure V-4).

The plan is to preserve the existing historical trails to Wai‘au and the summit. To protect the resources of the Science Reserve, formal public hiking routes within the Science Reserve will be mapped in the future, and trail improvements will be planned as needed for safety. A recreational support facility, including a parking lot and restrooms, is planned for the Millimeter Valley area and will be available to hikers and other users.

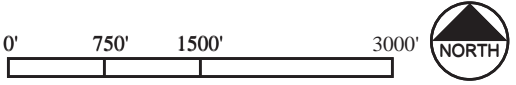


Source: 1983 Mauna Kea Science Reserve Complex Development Plan, Dr. Jerry Johnson, 1998



Existing Ski Areas

Mauna Kea Science Reserve Master Plan



Another support facility is a parking area that is primarily planned to serve cultural resource interests, located along the access road at the 13,000 ft. elevation. This location will provide access to existing trails leading to Wai'au and the adze quarry. These uses are directed to defined areas of the Science Reserve to protect the sensitive natural and cultural resource components. Development of this support facility will be subject to approval by the DLNR.

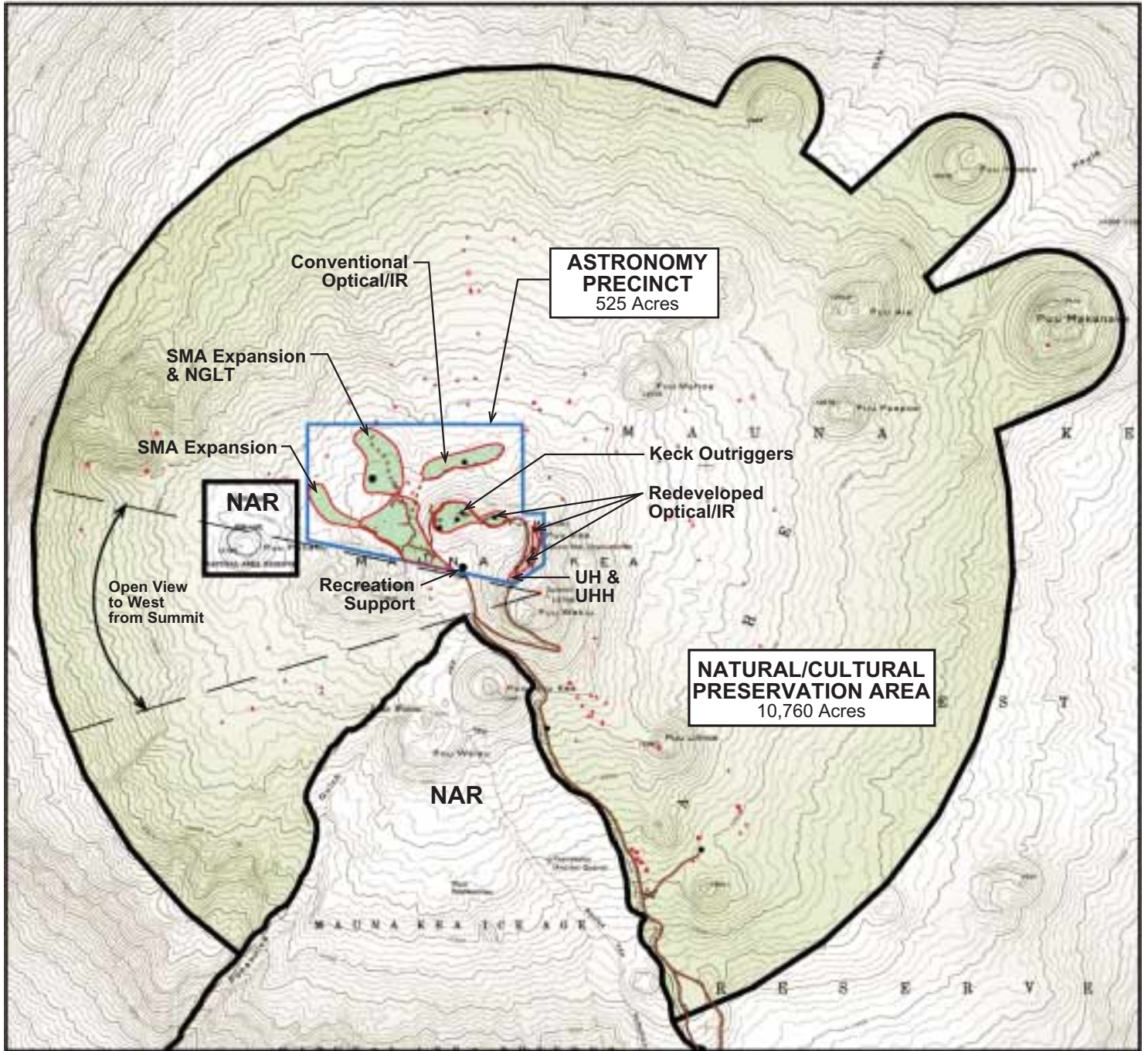
Camping. The public will also benefit from the planned conversion of the construction cabins built by the Subaru observatory at Hale Pōhaku. These will be turned over after construction operations cease (2001) and become available for public group stays.

Hunting. Hunting activity in the Science Reserve generally only occurs in the lower and mid-elevations of Mauna Kea. Hunting areas are shown in Figure VII-1. Access for hunters is available through Hale Pōhaku and Pu'u La'au. The Master Plan places no new restrictions on the future use of the Science Reserve for hunting.

Recreational Physical Plan. The recreational use elements of the Science Reserve are depicted as broad use areas for skiing, snow play, hiking and hunting. Specific landforms, such as Pu'u Poli'ahu have been designated as off-limits for future recreational use to respect the cultural significance of this *pu'u*. The plan includes informational signage for visitors such that a well-planned tour can be conducted without random stopping points that can result in adverse effects to important natural and cultural resources.

Overall Physical Planning Guide for Summit

An overall plan of the summit region is shown in Figure IX-26. The physical plan identifies all of the locations for existing and proposed astronomy facilities in the Astronomy Precinct. Also shown in the plan is the location of the recreational support building within the Precinct. This plan depicts a composite of all resource components into one integrated plan. Natural and cultural resources elements are preserved throughout the Science Reserve, with particular focus on the 10,760-acre Natural and Cultural Preservation Area surrounding the proposed Astronomy Precinct. Proposed facilities to support education/research and recreational elements are limited within the approximately 525-acre Astronomy Precinct.



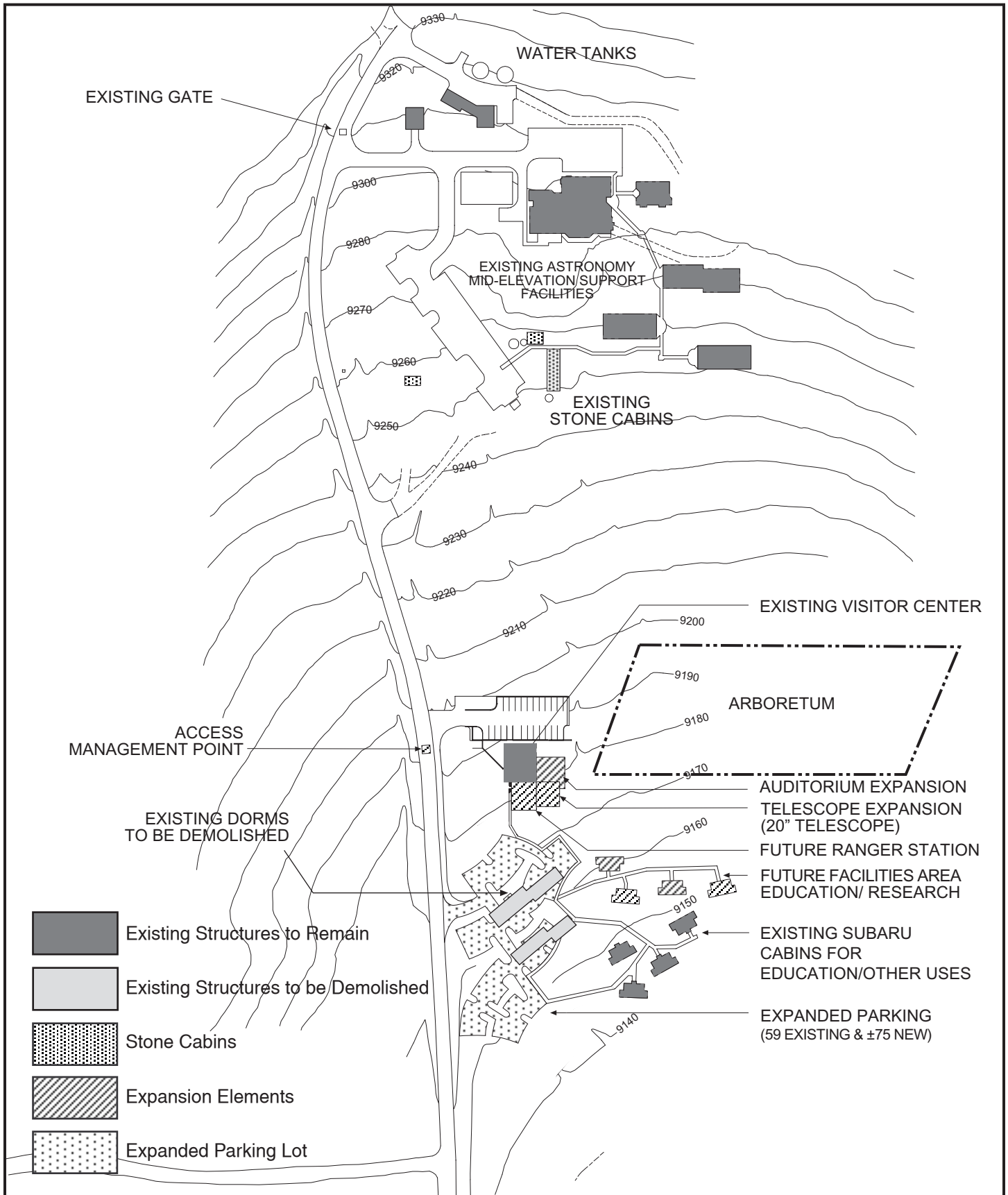
 40' Contour Intervals

PLAN FOR HALE PŌHAKU MID-ELEVATION FACILITIES

The mid-elevation facilities at Hale Pōhaku have typically been associated with support of astronomers, dating back to times when all facilities were operated by on-mountain astronomers and technicians. With today's technology and the fiber optic communications system, many of the studies occurring at these observatories can be operated remotely either from Hale Pōhaku, off-mountain Hawai'i locations (Waimea, Hilo), or via the Internet. Hale Pōhaku's role in providing public information and education about astronomy on Mauna Kea will be augmented by these base facilities and a planned planetarium in Hilo. Refer to the following section for additional detail regarding the off-mountain base facilities.

Even with the change in operating procedures, portions of the Hale Pōhaku facilities are being planned to accommodate increased non-astronomy use in the next 20 years. There are three components to the Hale Pōhaku facilities that are addressed in the plan, including: 1) Astronomy mid-elevation facilities, 2) Construction camp facilities, and 3) the Visitor Information Station facilities. Existing facilities at Hale Pōhaku, and uses planned at these locations, are described below and shown in Figure IX-27.

1. Astronomy Mid-Elevation Facilities. Due to the increased capability for off-mountain viewing, use of the existing astronomy mid-elevation facilities has been declining, and this trend is generally anticipated to continue or stabilize near current levels. As the total number of observatories on the summit will be increasing, overnight stays at the mid-elevation facility will generally decline on a per facility basis. This will result in a total number of overnight stays that is anticipated to be comparable to the present levels, therefore there will be no need for expansion.
2. Construction Camp Facilities. The older camp facilities are to be removed. The Subaru construction cabins will become fully available to the State in 2002. These cabins are proposed to be used for additional purposes including education, research and recreation, including:
 - Increased use by University of Hawai'i at Hilo, other college/university-level academic programs relating to geology, alpine and mountain forest ecology, astronomy and Hawaiian culture, as well as groups from schools and organizations.
 - Periodic temporary lodging for observatory construction crews for future projects.
3. Visitor Information Station Facilities. The visitor center facilities will require further expansion, which will complement the planned programs at UH-Hilo. A visitor information center will be included in the facility. Other possible uses could include natural and cultural resources interpretive center, and the ranger station offices and communications center. The new controlled access point on the summit road will occur at the Visitor Information Station, replacing the present (open) gate located at the astronomy mid-elevation facility. Current plans for the Visitor Information Station expansion include an auditorium addition and new observatory. The anticipated users of the Visitor Information Station are described below in several categories.



-
- Visitors attracted or directed by the planetarium program at UH-Hilo's University Park. People visiting the planetarium will learn about the Hale Pōhaku facilities, and some will visit the Mid-Elevation facilities for a first-hand experience of the mountain's cultural and educational resources.
 - Private tour groups and individual travelers are also expected to travel to Hale Pōhaku in greater numbers. With the improvement of the Visitor Information Station, its reputation will grow and people's interest in witnessing the facility and experiencing its programs about the mountain will expand. A 20-inch telescope will be installed at the VIS so the visitors and amateur astronomers can observe the sky in Mauna Kea's superior conditions. Other public astronomy facilities may also be developed in the future. All improvements at Hale Pōhaku are subject to design review.
 - Non-astronomy research groups (e.g. geology, botanical, faunal, cultural, etc.) will also increase over time. These types of groups will travel to the Visitor Information Station to experience exhibits and programs highlighting the unique natural and cultural resources of the mountain.
 - Recreational use by naturalists and cultural groups will expand. Individuals and organizations are anticipated to utilize the Visitor Information Station for their own recreational enjoyment or for organized functions.
 - Primary-level educators will utilize the Visitor Station for school field visits and educational programs (e.g. geology, botanical, faunal, cultural, etc.)

The anticipated increases in use will create the need for additional parking area at the Hale Pōhaku Visitor Information Station. The number of parking spaces is currently planned to increase by 75 spaces to a total of approximately 150 spaces. More parking may be needed at the Visitor Center in the future.

The number of travelers to Hale Pōhaku utilizing Saddle Road and the Mauna Kea Access Road is expected to increase in the future. Future improvements planned for Saddle Road by Hawai'i County will also allow for better access to Hale Pōhaku. Mauna Kea Access Road is not currently planned for improvements. However, future use levels at the Visitor Information Station may warrant additional work such as increased signage, new pavement and striping, and minor widening of pavement for paved shoulders.

OFF-MOUNTAIN BASE FACILITIES

It is difficult to conduct research investigations for prolonged periods at the high altitude locations of the Mauna Kea summit or Hale Pōhaku. In addition, it is difficult to access the observatories in harsh winter weather periods. Several observatories have found it more effective to conduct their studies from off-mountain base facilities. With the installation of fiber optic communications to the observatories on Mauna Kea, they now have the capability to be operated remotely. Off-mountain base facilities for these observatories have been established in Waimea (CFHT and Keck) and University Park in

Hilo (UKIRT, JCMT, CSO, Subaru, Gemini, and IfA). The trend toward providing off-mountain base facilities is expected to continue.

Some facilities, such as the Submillimeter Array (SMA), can be operated remotely via the Internet from its home base in Cambridge, Massachusetts. SMA also has offices in Hilo from which it conducts its current operations in Hawai'i. Future telescopes constructed at Mauna Kea will be encouraged to develop their base facilities in Hawai'i to the greatest extent practical.

Future observatory construction at Mauna Kea may require additional base facilities to be constructed in either Waimea or Hilo. The most recent base support facilities have been developed at University Park on the campus of UH-Hilo. In addition, UH-Hilo proposes to locate the Mauna Kea Astronomy Education Center, an educational and interpretive facility designed to broaden, public understanding of the Universe, at University Park, as noted in Appendix B.

INFRASTRUCTURE REQUIREMENTS

Infrastructure elements serving the Science Reserve will require periodic updating and expansion to serve the various users of the mountain in the next 20 years. Education and research facilities within the Astronomy Precinct will have facility requirements for updating and expansion of roadways, communications system, and electrical power supply. Infrastructure maintenance will be an ongoing requirement, which is addressed in the management plan.

Roadways. Roadway expansion will be minimized through the development siting criteria, which guides future facilities to be developed near the existing roadways. The existing unimproved roadways serving the expansion sites within the Astronomy Precinct will require additional improvement. Although there are narrow road alignments present, these roads will require modest widening and grading to make them passable for new facilities operations located beyond the existing astronomy areas at Millimeter Valley and the summit ridge. The Master Plan recommends paving of the remainder of the access road from Hale Pōhaku and the remainder of the summit spur road which runs from the SMA building past the Subaru Telescope to the W.M. Keck Observatory. Paving will reduce the amount of dust generated by vehicles, thus improving conditions for astronomy observations and for Wēkiu habitat.

Communications and Power Supply. The fiber optic communications system and the electrical power system will be expanded to serve new facilities sites to the north and northwest. The main power supply to the mountain is adequate to serve the additional facilities anticipated under this plan. To minimize the visual impact of new utility pull boxes to be located along the new underground conduit routes, colored concrete will be used to match the surrounding ground surface.

Water Supply. There is no water supply extending to the summit of Mauna Kea, and future water supply to the summit will continue to follow current procedures. Water will continue to be provided from two 40,000-gallon water tanks located at Hale Pōhaku. Currently, 25,000 gallons of water are trucked to the mid-level facility from Hilo each week. Each of the observatories will continue to be supplied with potable water that is transported to the summit by tanker trucks from Hilo. About 15,000 gallons of water is presently trucked to the summit each week, and each facility has its own water storage tank. The supply rate will increase to serve new facilities that are planned for the summit. Changes to technology allowing remote (off-mountain) viewing access could reduce the number of workers and scientist actually present at new facilities, and a corresponding lower water use rate as compared to existing facilities.

Wastewater Management. There is no plan for construction of a sewer collection system to serve the summit area. Wastewater generated at the observatories will continue to be managed by each facility through individual wastewater disposal systems (cesspools and septic tank/leaching field systems). Due to the small number of workers and visitors utilizing these facilities on a daily basis, the volume of water use and wastewater generation is small, approximating domestic rates. Changes to technology allowing remote (off-mountain) viewing access could reduce the number of workers and scientist actually present at new facilities, and a corresponding lower water use and wastewater generation rates.

Drainage. Erosion due to storm water runoff will be controlled on all new roadways, such that there will be no adverse affects to the surrounding landscape. There are six culverts within the 4.5 miles of roadway from Hale Pōhaku to the summit. Culverts will be installed as needed along the extension of the access roadway system to the north to minimize erosion

Summary of Physical Planning Guide for the Science Reserve and Hale Pōhaku

The overall physical planning guide for the Science Reserve depicts a composite of all resource components into one integrated plan. Natural and cultural resources elements are preserved throughout the Science Reserve, with particular focus on the 10,760-acre Natural and Cultural Preservation Area surrounding the proposed Astronomy Precinct. Proposed facilities to support education/research and recreational elements are limited within the approximately 525-acre Astronomy Precinct, except for improvements to facilities at the Hale Pōhaku Visitor Center.

This updated physical plan, in conjunction with the updated Management Plan (discussed in the following section), creates a living planning and management document that has been developed in collaboration with the University, Mauna Kea Advisory Committee, native Hawaiian interests, and other stakeholders and interested community members.

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

X. MANAGEMENT PLAN

MANAGEMENT PLAN

I. MANAGEMENT PLAN OBJECTIVES

The experience of the last three decades has shown the need for re-examination of the existing management procedures. The lessons from this experience are summarized in the following clusters of management objectives:

- A. To create a structure for sustainable, focused management of the resources and operations of the Mauna Kea Science Reserve in order to:
- **Protect historic/cultural resources: e.g. archaeology sites, traditional cultural practices.** While actual damage to known archaeological sites has been minimal, there has evolved a greater sensitivity to cultural values and the importance of geophysical forms in the cultural landscape. The proposed management plan incorporates these values and sets up a supportive framework for current, traditional Hawaiian cultural practices. It proposes a framework for assessing the impact of current practices on historic sites, natural resources and other uses on the mountain. If there are conflicts, the management plan would establish a procedure for resolving disputes. The plan also promotes education and further research in ethnography and related disciplines.
 - **Protect natural resources: e.g. Wēkiu habitat, alpine ecosystem.** The natural resources that should be protected begin with the mountain's geology and atmospheric qualities. These form the base for the unique ecosystems that make up the Science Reserve, Summit Road corridor and Hale Pōhaku. Tropical island alpine environments are extremely rare on the planet. The value of the mamane forest has been recognized in all plans. The passage of years has only reinforced the importance of this ecosystem. The impetus from the planning for astronomy and other activities has provided us with studies that have given us greater understanding of the uniqueness of the Wēkiu and other endemic species. This increased understanding has provided more information on potential protective and mitigative measures.
 - **Protect and enhance education and research: e.g. astronomy, Hawaiian language and culture, archaeology, ecology, geology.** The continued recognition of the importance of astronomy in the Mauna Kea Science Reserve remains critical. Its economic impact to the island is significant. Mauna Kea's global importance has grown over the last twenty years until it is now recognized as one of the premier viewing places in the world. The qualities that make Mauna Kea such a desirable site need to be preserved. Facility and infrastructure improvements must continue for the complex to retain its continued prominence in the field.

Knowledge about the potential for other research disciplines has grown. Mauna Kea has many qualities and resources that make it a great outdoor laboratory and classroom for Hawaiian language and culture, archaeology, ecology, biology, geology and a host of other disciplines. This is recognized in the plan by the encouragement of joint use of support facilities and the identification of these other disciplines as important overall goals. Education is a major function of the State of Hawai'i and the University. The value of the mountain for educational purposes with particular emphasis on K-12 and post-secondary programs for native Hawaiian students, is recognized and incorporated in the use concepts for the mountain. The proposed management plan recognizes this greater diversity of interests.

- **Protect and enhance recreational opportunities: e.g. hiking, snow play and skiing.** Recreational opportunities are an adjunct to the existence of the natural resources of the mountain. The proposed plan recognizes the importance of recreational values by identifying it as a separate resource cluster. Proposed management plans hope to address the anticipated growth in recreational uses while protecting the resources.
- **Promote public safety.** Improved access and growing numbers of visitors and vehicles raise concerns about public safety. This is already a problem with accidents and injuries; especially on the Summit Road. The plan proposes various measures to increase public safety.

B. To create a structure which meets the following objectives:

- **Promote community input.** The inadequacy of opportunities for public input has been a long standing issue. The proposed plan addresses the issue with the creation of a new management structure and review procedures for amendments and proposals that include public participation.
- **Establish local management.** The need and sentiment for local management has been clear. The plan addresses this question with the creation of a management body located on the Big Island.
- **Establish a focal point for management responsibility.** For the general public, multiple jurisdiction has created vagueness and confusion in responsibility, authority, communication and policy. The need for a focal point of management responsibility and contact has become clear. The plan addresses this goal by creating a single entity as a hub for activity and management on the mountain.
- **Establish clear lines of decision making and accountability.** Within responsible agencies, lines of authority and communication must be clear. The proposed management structure must increase the accountability of all parties on the mountain and make sure each agency is aware of its responsibilities.

-
- **Economic and structural feasibility.** Funding for management has been inadequate. The proposed plan focuses on changes that can be achieved without statutory changes to existing regulations and responsibilities. Management functions would become a part of a funded function of the University supported by the Board of Regents.
 - **Provides a base for future expansion of the scope of activities in the Science Reserve.** It is anticipated that activities supported in the Science Reserve will expand beyond astronomy to include a variety of other areas such as cultural practices, sports/recreation, education, other academic areas and environmental programs. The proposed plan provides a structure designed to manage these varied activities under a single management entity.

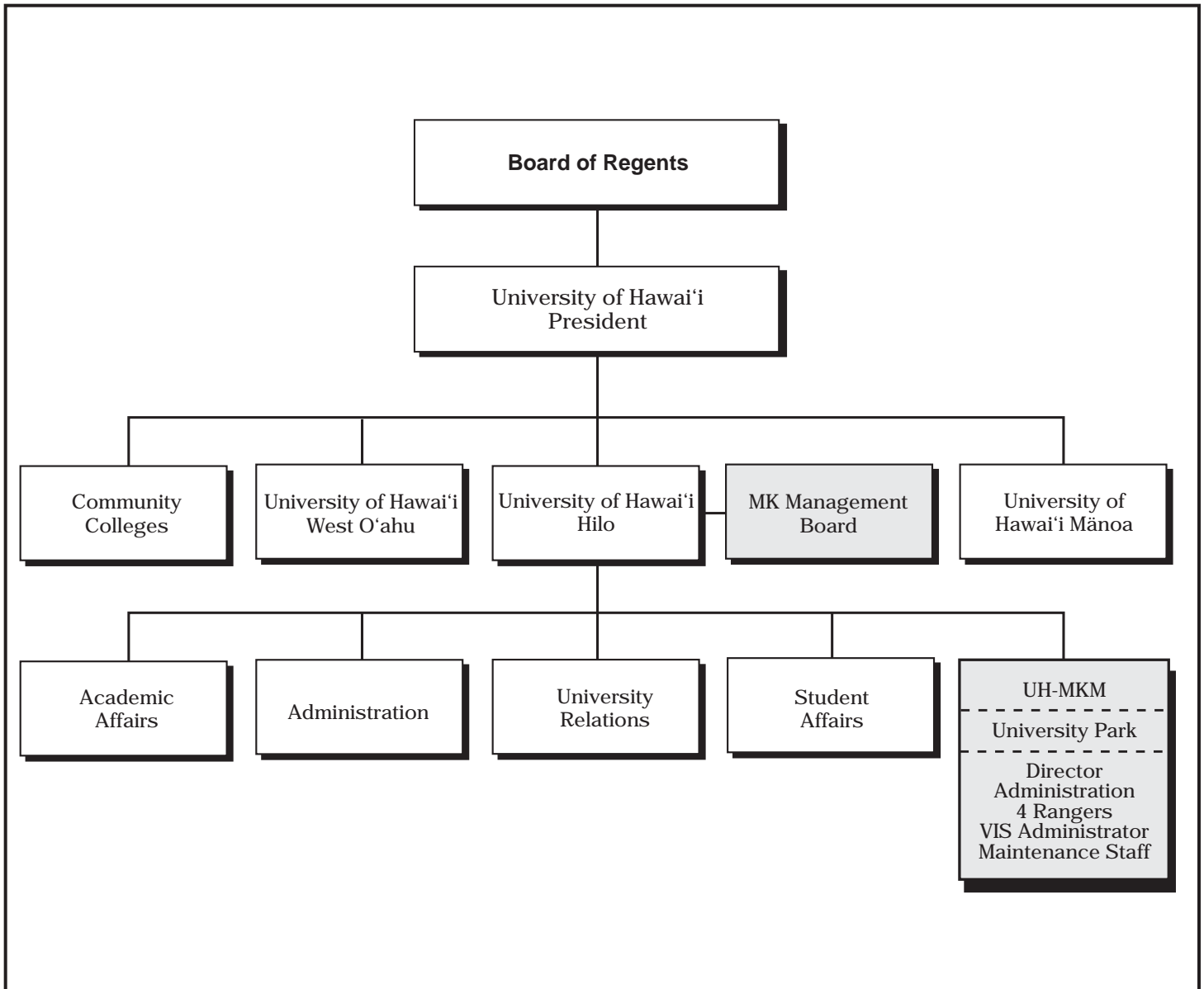
The management objectives and the proposed management plan evolved after many Mauna Kea Advisory Committee meetings and discussions with key individuals from the University of Hawai'i, Department of Land and Natural Resources and the community. Many alternative management structures were proposed, discussed, revised and/or discarded. The management plan delineated here addresses the issues mentioned in Chapter XIII and meets the objectives listed above. It can be implemented quickly with a minimum of consent or approval outside of the current University of Hawai'i system. The plan calls for the creation of a management organization capable of providing the necessary stewardship for the sustainable use of Mauna Kea. The structure can also evolve to take on more responsibility and authority as needed. The plan also considers the integrated nature of the resources and establishes clear relationships with the adjacent NAR and other DLNR lands.

II. MANAGEMENT ORGANIZATION AND PROCEDURES

Three levels or tiers of responsibility comprise the structure at Mauna Kea: land ownership, policy setting/regulatory compliance, and management. The following is proposed:

Management Organization Proposal: There is a need for a single entity to manage a comprehensive integrated plan for the Mauna Kea Science Reserve. This management organization should be based on the Big Island and recognized by the general public as the point of contact for the summit region. It could be housed within the University of Hawai'i system and funded as a separate, ongoing program unit out of the University of Hawai'i at Hilo (See Figure X-1). Housing it within a permanent unit of the UH system makes a clear statement that the University accepts the responsibility for this function, including its funding.

A suggested name for the organization is the University of Hawai'i Office of Mauna Kea Management (UH MKM or Office). It is also proposed that a Mauna Kea Management Board be recommended by the UH Hilo Chancellor and appointed by the Board of Regents to guide the operations of the UH MKM. This Board will be advisory

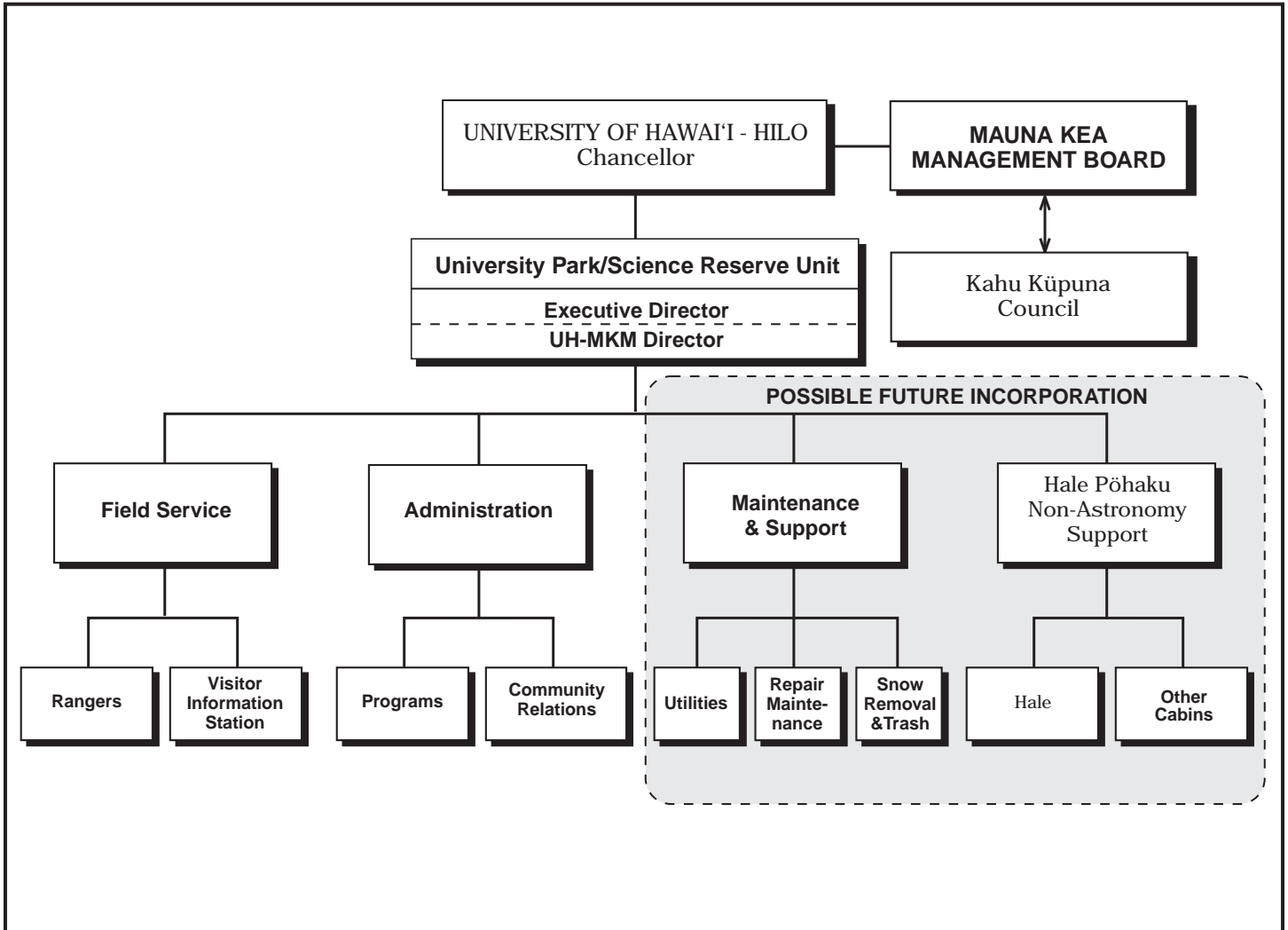


to the Chancellor. It is further proposed that the Office be housed within the unit for UH Hilo which is projected to manage the University Park. The Office should be responsible for the management of the Science Reserve, Summit Road and Hale Pōhaku. It would be responsible for establishing and enforcing management policies within the parameters of General Lease S-4191. The Office would be the focus of contact for the general public and would function as a referral and facilitative agency for issues that are outside its authority but related to the mountain.

It is projected that the UH MKM would have an initial staff which includes a director, administrative assistant, mountain rangers and general maintenance and support staff (Refer to Figure X-2). For general maintenance and support services, except for functions retained by IfA for existing leases and agreements, most of the current Mauna Kea Support Services could be transferred to the UH MKM. This transfer would be projected to occur over time after the updated master plan is adopted by the Board of Regents and the new structure is implemented.

Within the UH system, the director would have overall management responsibility for the Office. The director would be the key representative of the Office and the daily point of contact for the general public and tenant organizations on the mountain and at University Park. Any permitting and rental arrangements that may be established could be processed through UH MKM. Except for facilities managed by IfA at Hale Pōhaku for astronomy support, scheduling and requests for use of facilities or support services should be processed through the director. The Office would also address other requests, grievances and requests for information. Monitoring programs and databases would be coordinated through UH MKM to provide integrated management of the mountain.

Rangers, located at Hale Pōhaku, should be trained as cultural and natural resource specialists and it is recommended that some of the ranger staff be bilingual Hawaiian and English speakers. Their primary role would be education, coordination, monitoring and resource management. They would have a secondary enforcement role with possible assistance from DLNR DOCARE officers and County of Hawai'i police. It is envisioned that there would be a minimum of two rangers on the mountain at any time; one at Hale Pōhaku managing the entrance and one roaming in the Science Reserve. The ranger at Hale Pōhaku should register and orient visitors and coordinate programs that may be occurring at the Visitor Information Station (VIS) or other parts of the mid-elevation facilities. The ranger that is roaming would monitor people activity and make periodic field checks in resource areas. They would assist with safety and emergency procedures. Rangers would assist and educate visitors at all times. Rangers should monitor all field activities in the summit area from sports activities to volunteer rubbish sweeps and outdoor educational programs.



Organization Chart

General maintenance and research support services are currently provided by Mauna Kea Support Services (MKSS). At present these functions include:

- Food and lodging at Hale Pōhaku;
- Gas, diesel and water to existing astronomy facilities and their staff;
- Provision of utility support services, including trash removal;
- Safety and emergency services;
- Road maintenance and snow removal;
- Visitor Information Station services and manpower;
- Library and office services at Hale Pōhaku;
- Maintenance of the communications network;
- Servicing the construction camp.

After negotiations with IfA and current tenants, portions of MKSS functions, budget and personnel would be transferred to the MKM and become a permanent part of the new management organization. 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 holders.

Hale Pōhaku: The mid elevation facilities at Hale Pōhaku are projected to accommodate much of the anticipated growth in facilities and programs for astronomy education and non-astronomy purposes. As the facility expands with new equipment and spaces, program specialists in education, culture and natural resources may be added to the staff as funding increases. These specialists would assist in program development and coordination and may be accommodated at either Hilo or Hale Pōhaku. New programs in culture, Hawaiian language, geology, biology, ecology, habitat restoration and others are potential areas of growth. These programs may have field, classroom and distance learning components. Facility and infrastructure support may be provided in the Science Reserve, at Hale Pōhaku or elsewhere.

Community Involvement: Mauna Kea is a community resource. Community involvement in the management of the mountain begins with the membership of the Mauna Kea Management Board. The Board should be composed of members representing the major stakeholders of Mauna Kea.

The Board's primary role is to advise the Office of the Chancellor at UH Hilo on management of the Mauna Kea Science Reserve. The Board should be the main community voice for activities and development planned for the Science Reserve. The Board would be a public forum for future uses, activities and development on the mountain. Finally, the Board could act as a facilitator during grievance procedures and assist in the resolution of conflicts.

The Board is encouraged to establish special committees on culture, environment and education, as needed, to assist it in its functioning. For cultural issues the Burial Council

model is suggested. The Burial Council is a group of appointed citizens which provides guidance on the disposition of human remains. A special Kahu Kūpuna Council made up of representatives of native Hawaiian organizations as well as individuals recognized for their specialized knowledge could function like the Council. Other special advisory committees may be formed for environmental and education issues. These committees could focus on docent and other programs for Mauna Kea.

Docent programs are suggested to expand knowledge of the mountain and to encourage greater community participation. Docents could teach visitors about the rich and complex resources of the mountain. Volunteer organizations and alliances are also encouraged in order to broaden the pool of people who value and support the stewardship of the mountain. These groups could be called upon for various functions such as the periodic maintenance sweeps, special programs or fund raising events. Groups should be encouraged to “adopt the mountain”. The UH MKM should encourage and coordinate community participation.

Grievance Procedures: The MKM should establish grievance procedures to address issues as they arise. All grievances should be presented to the director of the Office who will make an assessment about the appropriate resolution of the issue. If the issues represent broad plan or policy questions beyond the management authority of the MKM, the director should refer the questions and/or questioner to specific contacts at the appropriate agencies; usually the DLNR or the UH Board of Regents. The Office should follow the progress of the grievance and assist where it is able. Where the grievance is about management issues or items within the jurisdiction of the Office, the director will receive and respond to the questions. If the issue requires management or rule changes by the Office, the director will research the question and bring it before the Management Board for review. All grievances should be handled in a sensitive and timely manner.

Coordination and Other Agencies: A major role for the Office of Mauna Kea Management will be its role in coordinating actions that are peripheral to its responsibilities but still important to the management of the mountain. This is because authority on the Mountain is distributed among many governmental entities. Besides the University of Hawaii, the Department of Land and Natural Resources retains a major role in management of the mountain. The Office will communicate issues and concerns that it receives to the appropriate agencies and follow through in their resolution.

It needs be re-emphasized that while the University of Hawaii has the master lease for the Science Reserve, the Board of Land and Natural Resources holds the title to the lands that make up the summit of Mauna Kea. In the master lease, DLNR specifically reserved its authority over activities that are not related to the educational and research mission of the University of Hawaii. Even in the Science Reserve, DLNR is still the primary agency responsible for protection of natural and cultural resources, managing recreational activities such as hunting and hiking, as well as controlling commercial uses. These responsibilities are written into the Hawaii Revised Statutes and cannot be delegated without legislative or constitutional action. Of special importance is the DLNR authority

and responsibilities related to historic sites and cultural practices. These responsibilities remain with DLNR and are not delegated through the master lease.

Other lands related to the management of the summit of Mauna Kea are under the jurisdiction of DLNR and DHHL. The two natural area reserve areas which are part of the summit region are not part of the Science Reserve. Also, the summit access road passes through land belonging to the Department of Hawaiian Home Lands and lands managed by the Forestry Division of the Department of Land and Natural Resources. Beyond the roadway reserve the responsibility for management remains with DLNR. Finally, except for the acreage specified in the lease, Hale Pōhaku is located in the forestry reserve managed by the Division of Forestry. Access and management of the lands around Hale Pōhaku are the responsibility of DLNR.

Finally, during medical emergencies and special events like forest fires or inclement weather other agencies such as the County fire and police departments as well as the military units at Pohakuloa may play lead or major roles in responding to these emergencies. The Office of Mauna Kea Management will assist and coordinate during these situations.

III. POLICIES AND STRATEGIES

The management plan proposes policies and strategies to integrate and balance the natural, cultural, educational/research and recreational values of Mauna Kea within a framework that provides responsible stewardship of the resources. It seeks to allocate resources and priorities toward sustainable use and enhancement of the Mauna Kea Science Reserve as a Hawaiian place with a unique and significant meaning, both locally and globally.

The management plan has several sub-components: A, General Policies, B, Natural Resources, C, Cultural Resources, D, Education/Research E, Recreation and F, Commercial Uses.

A. General Policies

Access Management: Vehicular access to the summit area should be managed but not curtailed. Hiking will remain unrestricted. Pack animal access should be managed. Detailed policies and guidelines for access should be adopted and implemented by the University of Hawai'i. Access through the summit region should be managed through a control point at Hale Pōhaku. The management plan seeks to integrate the developments at Hilo, Hale Pōhaku and the Summit Region. Access management will be consistent with the provisions of the DLNR Historic Preservation Plan (March 2000). The following are some guidelines:

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1. Registration, Orientation and Permits: Visitors may be required to register at the Visitor Information Station before they go beyond Hale Pōhaku. Specified visitors and pre-authorized groups may be allowed to proceed on their own schedule without the normal orientation. Acclimatization is recommended for all visitors. During registration, visitors should be given information about risks associated with the summit area, times of use, road conditions, inclement weather and cultural and environmental resources. Information about the adjacent NAR should be included in the orientation package.

The list of permitted uses is presented later in this plan. The Office may issue permits and assess fees where desired. Special permits should be processed through the director. No fees will be assessed for traditional cultural access.

2. Hours of Operation: Hours of operation will be established by the UH MKM and communicated visually and electronically. Special permission for public vehicular use of the road outside these hours would require permission from the Office. The Visitor Information Station is currently open 7 days a week and at night for stargazing programs and special events.
3. Control Point: A kiosk and/or entrance control protocol should be developed to manage the Summit Road. Primary access management would be by the ranger at the Visitor Information Station. Signage about hours of operation and access policies should be displayed prominently at the control point.
4. Shuttle: A shuttle service may be developed for summit access as traffic increases. Visitors would park at the Visitor Information Station parking lot and access the summit via shuttle. The shuttle schedule would be developed after completion of a more detailed assessment of demand and cost.
5. Helicopters: Helicopter landings will be permitted for emergencies and special purposes.
6. Private vehicles: standard sedans and 4 wheel drives: Standard sedans would normally be restricted from the Science Reserve. Private 4-wheel-drive vehicles would be allowed beyond the control point with appropriate registration. The policy for private 4-wheel-drive vehicles should be re-evaluated if a shuttle service is developed. Travel would be restricted to designated roadways. For cultural, research, education, special recreation and other approved special uses private 4-wheel-drive vehicles may be used in the Science Reserve, with passes, even if the shuttle is developed.
7. Other means: hiking, horses, motorcycles, bicycles, snow mobiles etc.: Hiking will remain unrestricted. Access by horseback or mule should be managed to minimize impacts on the fragile summit environment. Horses and mules should generally stay on established trails and roadways. Recreational activities

involving “off road” vehicles are not allowed. This restriction should apply to both the general public and commercial vendors and their clients. “Off-road” vehicles include motorcycles, dune buggies, snowmobiles and 4-wheel-drive passenger vehicles. This restriction does not apply to emergency rescue, medical or service purposes.

Facilities and Physical Maintenance: The UH MKM will be responsible for the physical maintenance of the Science Reserve, Summit Road and Hale Pōhaku.

1. Visitor Information Station (VIS): The Visitor Information Station is proposed to be managed by the Office. It should also be expanded into a facility where the Mauna Kea experience can be made satisfying at this elevation such that people may be less inclined to go to the summit. This should reduce the pressure on the summit region and also reduce the risk of potential health and safety problems. Safety concerns would otherwise increase as greater numbers of people head to the summit. The VIS should also be the headquarters for the mountain rangers.
2. Hale Pōhaku Mid-Elevation Support Facilities: Hale Pōhaku should remain the physical management Station for the mountain. The UH MKM should manage the services and facilities at Hale Pōhaku. Dormitories for researchers on the mountain would remain in this location. IfA may retain services and facilities that specifically support astronomy and/or are included in its sublease agreements. Other functions should be transferred to the UH MKM. New concessions, other subleases and subcontractors would be managed through the UH MKM.
3. Subaru Cabins/Construction Camp: The Subaru construction cabins will become fully available to the University in February 2002. At that time they should be managed and made available for educational/research/cultural uses. Faculty and student groups should be given preference. Secondly, they may be offered to recreational and commercial users. These cabins should be administered by the UH MKM. Cabins and the area around the dormitories would be managed to avoid potential conflicts between day users and night users of Hale Pōhaku. Astronomers tend to work at night and sleep during the day while other users are likely to be active during the day. Programs and activities should be limited to those which do not generate excessive noise.
4. Stone Cabins: The historic stone cabins at Hale Pōhaku may be renovated to accommodate other uses. The exterior facades should be preserved as is. Interior renovations may be made to allow appropriate adaptive re-use. Renovation plans should be reviewed by the State Historic Preservation Office early in the planning process. If the restroom facility is restored, new methods of wastewater disposal should be reviewed in concept by both the Department of Health and the SHPO before detailed designs are started. The renovated buildings may be used for cultural programs, education, other research, environmental restoration or similar

programs and purposes. If they are renovated as cabins they may be used in a manner similar to the construction cabins.

5. Roads and Parking Areas : Roads and parking areas from Hale Pōhaku to the summit will be maintained on a regular schedule. Over time, guardrails should be installed along all segments of the road identified as potentially hazardous. A schedule for guardrail installation should be developed after a road safety study is completed. As new facilities are planned or new recreational or service roads and trails are needed, the UH MKM should be responsible for construction and maintenance. Significant new roads should be identified in the physical plan before development.
6. Trails: It is proposed that the Office of Mauna Kea Management maintain trails in the Science Reserve. Historic trails should be identified. Other trails, if developed, should be designed and maintained in a safe and environmentally sensitive manner. The Office should consider enhancements such as signage or *ahu* markers for trail identification and interpretation. The SHPO would be consulted for activities or improvements that may impact known historic or pre-contact trails.
7. Utilities and Infrastructure: The UH MKM should manage utility and infrastructure support in the Science Reserve. Agreements in existing subleases will be managed as contracted unless revised by mutual consent. The Office would be responsible for development, implementation and management of all new infrastructure and utility systems. Utility services, gas, oil and water support, and repair and maintenance facilities should continue to be managed from the mid-elevation facilities.
8. Trash and Solid Waste: Solid waste and trash are generated from three sources: construction activity, visitors and ongoing observatory activities. Construction trash is expected to abate with the slowdown in construction. When new construction begins again, the development agreements with the facility developer should include strict guidelines for trash pick-up and removal. Agreements would also include provisions for securing supplies in a manner that prevents them from being blown by high winds and scattered over the summit region. Compliance monitoring for these conditions would be the responsibility of the UH MKM. Visitor generated trash should be managed in two ways: First, there should be routine service provided by UH MKM. Second, periodic clean-ups should be organized with various community groups to sweep the summit area of windblown trash. Broad sweeps are periodically needed because strong winds in the summit region spread trash over large areas. These sweeps should be conducted in an environmentally sound manner with sensitivity to environmental and cultural features, sites and practices. Volunteers involved in sweeps should be given instructions to avoid unintentional damage to the mountain's resources. Solid waste pick-up from existing astronomy operations could become the

responsibility of the UH MKM. Regular pick-ups should be organized to serve the Science Reserve and Hale Pōhaku.

All trash receptacles in the Science Reserve should be designed, and secured to withstand high winds which may blow over normal containers and spread the trash over wide areas. Containers should be sited to encourage usage by visitors.

Handouts, paper cups and other similar items that may be disposed should be minimized to limit the supply of potential sources of trash on the mountain. This precaution should be a part of the orientation presentation at the Visitor Information Station.

Safety, Security and Liability: The UH MKM should develop and maintain safety and security plans which include the following:

1. Weather: The summit region is subject to severe weather conditions that may be life threatening. The Office will restrict access when conditions dictate. Additionally, since weather changes can occur quickly on the summit region, rangers should monitor activity to warn people when weather becomes inclement. Rangers should be trained in emergency rescue procedures. Hale Pōhaku may serve as the weather station for the summit.
2. Altitude: High altitudes may affect people visiting or working on the summit. During registration, visitors should be oriented to the potential hazards of high altitude environments. Rangers will have access to oxygen and other first aid supplies at the summit region. Even frequent visitors will be invited to spend time acclimating at the Visitor Information Station.
3. Medical Emergencies: The existing medical emergency system involves IfA, the observatories, the military, County emergency services and hospitals. Helicopter landing areas could be identified in the emergency evacuation plan. The UH MKM should coordinate medical emergencies in the Science Reserve.
4. Security and Vandalism: While this is not a serious problem UH MKM should maintain security programs. Registration at the VIS and the control point at Hale Pōhaku will aid in monitoring activity. The mere presence of uniformed personnel will often act as a deterrent. Rangers would monitor activity as they roam the summit area. Enforcement will continue to be handled in coordination with DOCARE and County police officers.
5. Other Hazardous Site Conditions: Road and site conditions may occasionally require closure of the road or certain sections of the mountain. UH MKM may coordinate such emergencies. The UH MKM should also prepare an emergency evacuation plan should there be a need for such action.

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6. Fire Protection: The UH MKM fire plan would include education for visitors, a trained volunteer fire crew, emergency procedures (especially from the summit area) and a habitat fire plan for the Hale Pōhaku māmane-naio forest area.
 7. Alcohol and Drugs: Alcohol and drugs are prohibited from the Science Reserve.

Jurisdiction: The management plan applies to the Mauna Kea Science Reserve, the summit access road and Hale Pōhaku. It does not include other state lands in the upper mountain region managed by the DLNR or DHHL.

Compliance with Regulatory Requirements: The Office will oversee permitting and compliance activity for uses on the mountain in areas of the University's jurisdiction. MKM will work with DLNR in areas of DLNR's jurisdiction. MKM could prepare annual reports on the status of activities and include regulatory compliance as a part of this annual report. The Office will monitor sub-lease holders and permit holders to check on the status of CDUA conditions, EIS mitigation measures, historic sites treatment, endangered species monitoring and other similar conditions and requirements.

Language: As a general policy, Hawaiian and English languages should both be used for signs, pamphlets, videos and other material developed for the general public. Where practical, the Hawaiian language should be given the position of prominence in the communication format.

B. Natural and Environmental Resources.

Special plans to protect and enhance the natural and environmental resources of Mauna Kea for their perpetual enjoyment and use into the foreseeable future are suggested. Baseline studies of geology and biology have been completed and can be used to protect the resource. Some of these studies have data over time that may be used to discover trends. More detailed mitigation response plans may be developed as knowledge of the resource increases. The information is contained in a GIS database and it seems desirable for the office to maintain the database.

Recommendations for geological resource management (Lockwood, January 2000) and botanical resources management (Char, January 2000) will be implemented to avoid impacts to sensitive resource areas.

UH MKM policies to support educational and research programs in these areas may call for provision of support facilities for these programs. While information about potential programs and requests are limited at the current time the demand is expected to grow. Sharing existing and future facilities developed for astronomy requires coordination with IfA and the observatories. New support facilities would also require programming, permitting, construction funds, and operations and maintenance support. Overall

management is needed when the facilities at Hale Pōhaku and the summit area are made available to these programs. Uses may be as simple as a small storage area and desk space or it may include computer hook-ups, meeting rooms and libraries. At Hale Pōhaku the impact of sharing facilities should be considered before permission is granted. If compatibility is a problem, expansion at the mid-elevation facility may be considered to provide resting, storage and work spaces for other disciplines and programs.

The two adjacent NAR areas contain some of the best natural, cultural and environmental resources in the summit area and are accessed through the Science Reserve. It is suggested that protocols be developed at the Visitor Information Station and the road/trail interface between the Science Reserve and the NAR to inform people of the importance and proper treatment of these resources.

C. Historic and Cultural Resources

This plan protects archaeological sites and provides guidance for traditional Hawaiian cultural practices. Known archaeological sites within the Science Reserve are identified in the GIS database. These sites have been identified using GPS coordinates. Additional information should be added to the database as more information becomes available.

The State Historic Preservation Office (SHPO) has prepared a plan for the historic and cultural resources within the Science Reserve (Appendix F). SHPO's proposed plan describes policies and management guidelines for archaeological sites, cultural properties, and cultural practices. The physical plan was developed with a consideration for the cultural landscape. View planes, no-build areas and restoration plans are based on an understanding of the significance of geomorphological features such as the summit *pu'u* complex, Wai'au and locations of known archaeological sites. The following policies and activities are recommended:

1. Orientation: An educational program should be developed to inform all visitors of the cultural, spiritual, historic and archaeological values of Mauna Kea. This program should be a part of the registration process.
2. Archaeological and Historic Sites: Known sites on the summit area should be preserved. Preservation sites near potentially heavy traffic areas should be identified with signage. Some of the features are difficult for layman to notice and the danger from inadvertent destruction seems greater than from deliberate tampering. Periodic photographic monitoring of sites is suggested.
3. Geo-physical Features: These features are identified in the physical plan. Educational programs should be developed to heighten the sensitivity of visitors to the natural landscape and its role in Hawaiian culture. The concept of *wāhi pana* is of special importance here. Signage from key vantage points could describe their significance. Earlier or more authentic place names should be used where they are

known. Future studies may provide more information on this topic and adjustments should then be made accordingly.

4. Current Practices: Hawaiian cultural and religious practices should be generally unregulated. However, practices that have potential to significantly impact the physical landscape or traditional Hawaiian spiritual values of sites should be managed or coordinated. Examples of this would be a revival of adze making (requiring resource extraction), and building new religious or cultural activity areas with their affiliated structures: *ahu*, platforms, shelters, walls. The operative word is “significant” which needs to be defined more specifically after discussions with potential Hawaiian practitioner groups and knowledgeable individuals. Modern non-Hawaiian cultural and religious practices would be reviewed for sensitivity to Hawaiian cultural values. Where conflicts are unresolved, native Hawaiian practices and values should take priority.
5. Advisory Committee: A Kahu Kūpuna Council of individuals knowledgeable about native Hawaiian cultural practices should be formed to advise the Mauna Kea Management Board. This Committee should be:
 - Organized by the Board;
 - Review current cultural activities and programs and recommend programs and policies to support cultural programs on the mountain;
 - Advise the Board on questions about cultural practices;
 - If needed, be available to assist in dispute resolution.

Awareness and understanding of the cultural significance of Mauna Kea is growing. The following protocols and programs are suggested as possible activities to improve the management of the cultural values and resources of the mountain:

Protocols

- Before any facility siting or infrastructure alignment decision has been finalized, if warranted, an inventory level archaeological survey of the area should be conducted to ensure that no unrecorded sites are located in the area.
- In addition to the archaeological inventory survey, it is recommended that geophysical features, *wahi pana* and other aspects of potential cultural significance be evaluated.
- Where possible, avoid impact to cultural and historic sites.
- If unavoidable mitigate the impacts.
- The treatment of historic and cultural features will be governed by the Historic Preservation Plan for Mauna Kea. The Preservation Plan includes designation of the summit area as a historic district and various protocols for use and activities on the summit area. The Plan proposes inventory surveys, significance evaluations, potential impact on cultural properties, mitigation measures and the presence of a qualified archaeologist during excavation activities. The Plan also

expands on the treatment of potential and inadvertent burials that may be discovered as well as permanent long-term monitoring programs needed to protect the resources of the mountain.

Suggested Programs

- Support ongoing ethnographic and archaeological research programs.
- Create an education oriented docent program.
- Develop a signage plan to protect resources and educate the public.

D. Education and Research

1. Astronomy: A goal of the plan update is the maintenance of Mauna Kea as one of the premier astronomical observing locations in the world. Most of the factors necessary for its continued desirability as an astronomical site are addressed in the physical planning guide for the mountain (Chapter IX). IfA will remain the lead UH entity responsible for astronomy development in the Science Reserve. However, since development and upgrades occur in the context of the master plan the UH MKM would be responsible for other activities and overall property management. Issues that need to be addressed from a management standpoint include:

- Upgrades of equipment, facilities and support facilities are needed to retain its global position. In partnership with IfA, the UH MKM would be responsible for maintenance of support facilities and infrastructure.
- Dust and light conditions near the summit must be controlled to ensure a continued high quality environment for ground based astronomy. Vehicular headlights and other night activities need to continue to be managed to avoid negatively impacting astronomical activities. The gate at Hale Pōhaku may be closed for this reason. Where possible, activities that increase atmospheric dust or otherwise degrade air and environmental quality should be prohibited or minimized. IfA and the UH MKM would monitor and manage activities that may affect these conditions.
- No new fixed radio frequency transmitters will be allowed in the Science Reserve because of their potential to interfere with radio telescopes and other sensitive astronomical detectors. The only possible exception would be a low-powered repeater for emergency use only. The use of low-power handheld transmitters (walkie-talkies and cellular phones) is permitted if they do not interfere with telescope detector systems.
- Interference from other radio transmitters: Radio transmitters can negatively affect astronomy observations. The growth of private telecommunication companies creates pressure to develop these facilities in high elevation sites. The MKM should discourage these facilities from developing in locations where they would affect astronomy operations.

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2. Non-astronomy related academic and research areas: The sentiment supporting the growth of other research disciplines on the mountain is growing. Facility implications of such support are unclear. If new spaces are needed, these proposals would be evaluated for their conformity to the plan vision before they are sent to the Board of Regents or DLNR. The following needs further definition before this support can be realized:

- Define program areas and activity zones.
- Relate to academic plans and programs.
- Identify resource needs and manage support facilities requirements and standards.
- Assess potential impact to existing uses.
- Identify functional relationships and alternative sites and strategies.
- Train rangers and other personnel to manage these areas and policies.

When programs are defined, plan amendment proposals can be developed for facility and resource support and processed through the UH MKM.

3. Education: Mauna Kea is a great outdoor classroom. Policies should encourage the use of the mountain for educational purposes. Approvals and logistical support should be coordinated through the UH MKM. The following activities are suggested:

- Set up policies and procedures to accommodate and encourage educational use of the mountain.
- Identify areas and zones of the mountain appropriate for field activities and outdoor classrooms.

The interpretation and educational components of the DLNR Historic Preservation Plan include a “Public Interpretation Plan” which addresses four major tasks. The first is an interpretive plan which designates those historic properties which are suited for public access and proposed ways in which visitation will be informative and cause the least amount of disruption to the historic properties. Second, a brochure will be prepared for distribution at the Visitor’s Center at Hale Pohaku on the historic properties found within the summit region and in the area surrounding Hale Pohaku. The third task, according to the scope of work, was to prepare a display for the Visitors Center. Instead, the plan may only propose an appropriate display or display options because plans to renovate or expand the current center have been proposed. If this is the case, then it would be premature to produce a display that might not conform to the size of general lay-out of the rest of the Visitor’s Center. The fourth task is to provide background materials that would help staff prehistory and history of Mauna Kea and to answer many of the routine questions asked by the public.

E. Recreational Activities

The existence of natural resources draws recreational users to the mountain. Recreational uses need to be managed to avoid conflicts of use and degradation of resources. Education is the best tool for reducing the impact of man on natural resources. All visitors should be given a brochure and/or briefing on the proper treatment of resources; both natural and cultural. Signage should be developed in areas of sensitivity and high traffic. The presence of rangers will also enhance resource protection while accommodating recreational activities.

1. **Hiking:** Hiking will be unrestricted but hikers should be encouraged to stay on known trails for safety and minimization of impact to natural and cultural resources. Simple rules of sustainability such as walking gently in the wilderness and carrying out what one brings in should be emphasized. Signage is suggested at appropriate places on trails to provide information necessary for safety and sensitivity to area resources. The creation of formalized trails may be necessary if monitoring determines that multiple paths or tracks are being created because of repeated visitation to specific areas.
2. **Sightseeing and Tourism:** Most visitors will come by vehicle and stay on paved roads and stay near developed facilities.
3. **Snow Play, Skiing and Snow Boarding:** Private four-wheel-drive vehicles may be allowed for skiers and snow players. Brochures could be developed to educate recreational visitors about the cultural and environmental resources that may be impacted if they ski or snow play outside of designated areas.
4. **Hunting:** Hunting is unrestricted in the Science Reserve. Hunters should be cautioned about safety regarding the presence of other people on the mountain. Commercial hunting operations are prohibited in the Science Reserve.
5. **Extreme Sports:** This term refers to any number of recreational activities that seek dangerous or unusual thrills such as down hill biking or hang gliding. While these activities are not categorically prohibited they must be evaluated on a case by case basis and require a permit. A fee may be attached to such activities. Some activities may be prohibited if they may impact resources, appear too dangerous or require support services that are unavailable.

F. Commercial Activities

Limited commercial activities would be allowed in the Science Reserve. These activities and operations should be small and low impact in nature. Commercial operations should remain small to avoid negatively impacting the primary missions of protecting natural and cultural resources and the promoting educational and research activities. It is suggested that the UH MKM manage the permitting responsibilities for these functions.

The following commercial activities are allowed in the Science Reserve and Hale Pōhaku:

1. Commercial Sightseeing Tours: At present commercial tours are allowed in the Science Reserve. Tour operators apply for a permit and pay a fee for these activities to the DLNR. These tours would continue to be allowed. Tours should generally stop at Hale Pōhaku for registration, orientation and acclimatization.
2. Movies, Commercials and similar productions: These activities would be allowed with special permits. Logistical support could be provided from the construction cabins. These activities should be allowed with the condition that they will not negatively impact the natural and cultural resources of the mountain or the priority uses for education/research and culture.
3. Concessions: Concessions may be allowed on a limited basis at Hale Pōhaku; especially around the Visitor Information Station. These concessions would be an accessory to the major activities and provide support services and items. Special care must be taken to ensure that trash does not become a problem in the operation of concessions.
4. Special Events: Facilities at Hale Pōhaku may be rented for special events if they do not interfere with education/research activities or contractual obligations. Small conferences and cultural festivals are possible activities. Additionally, with special permits the Science Reserve may be used for events like snowboarding contests.
5. Eco-education Tours: Commercial eco-tours may be allowed. These tours should be conducted on established trails and designated areas and designed to avoid impact to natural and cultural resources. The facilities at Hale Pōhaku may be used to support these tours as long as they do not conflict with education/research use of the facilities.
6. Cabin/room rentals: The facilities at Hale Pōhaku may be rented to individuals and small groups as long as education/research uses take priority and are not compromised. Commercial rentals should generally consider the rental of the construction cabins to avoid conflicts with the research dormitories.

IV. FUNDING

As part of a permanent program unit within UH - Hilo funding is anticipated through normal University procedures. In addition to basic program funds from the University of Hawai'i, the following potential funding sources may be pursued to improve management and program implementation.

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1. Existing observatories. Existing facilities at Mauna Kea may be willing to provide additional contributions for the proposed management entity and new programs.
 2. New astronomy development could share in the broader management and maintenance responsibilities of the mountain. New license agreements could consider monetary contributions to support programs and personnel needed to protect and manage environmental and cultural resources.
 3. User fees and licenses: Commercial and quasi-commercial uses such as tours, and ski operations should be charged fees. If allowed, extractive uses like quarrying done for commercial purposes should be monitored closely and charged. Traditional Hawaiian cultural practices should not be charged. A general Science Reserve vehicle entrance fee may be considered. A charge should be considered for the proposed shuttle transport. Transfer of fees from existing DLNR permits to a Mauna Kea management account should also be considered.
 4. Hale Pōhaku: If compatible with astronomy activities, Hale Pōhaku could be made available to other parties. Small conferences and retreats may be held. Education/ research/ culture related gatherings should have preference but other uses could be accommodated with fees.
 5. Construction Cabins: When the Subaru cabins are turned over to the University of Hawai'i in 2002, they could be made available to other users. The construction cabins may also be renovated to serve as rental accommodations. Support services could be provided from the Hale Pōhaku kitchen and housekeeping staffs.
 6. Stone Cabins: These facilities may also be rented in a similar fashion as the construction cabins.
 7. Visitor Information Station: Fees could be charged for private or non-UH use of the Visitor Information Station and related facilities. Concessions may be permitted.
 8. Research and other grants: Funding could be sought from foundations and governmental agencies for research and management objectives.
 9. Private and non-profit donations: A tax exempt trust fund for the maintenance of Mauna Kea could be set up. This fund could be the repository for special funds that may be received. This would support, not replace, the normal O&M budget.
 10. The Department of Land and Natural Resources is responsible for many of the management responsibilities on the mountain. It may be possible to obtain additional DLNR resources to assist in some of the overall management responsibilities.

In summary, management functions must be funded. Funding would be from the UH system in cooperation with astronomy interests and supplemented by other sources.

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

XI. IMPLEMENTATION PLAN

IMPLEMENTATION PLAN

SCHEDULE

Implementation of the updated Mauna Kea Master Plan began with the adoption of the Plan by the University of Hawai‘i Board of Regents. The Regents adopted the Master Plan in June 2000. The major steps in implementation include:

- Establishment of organizational structure,
- Funding,
- Appointment of Management Board,
- Hiring staff and establishing offices and support facilities,
- Adoption of administrative rules,
- Development of programs.
- Development of facilities

The proposed overall implementation schedule is shown in Figure XI-1.

Program and facility development will follow their individual schedules as they receive funding.

ORGANIZATIONAL STRUCTURE

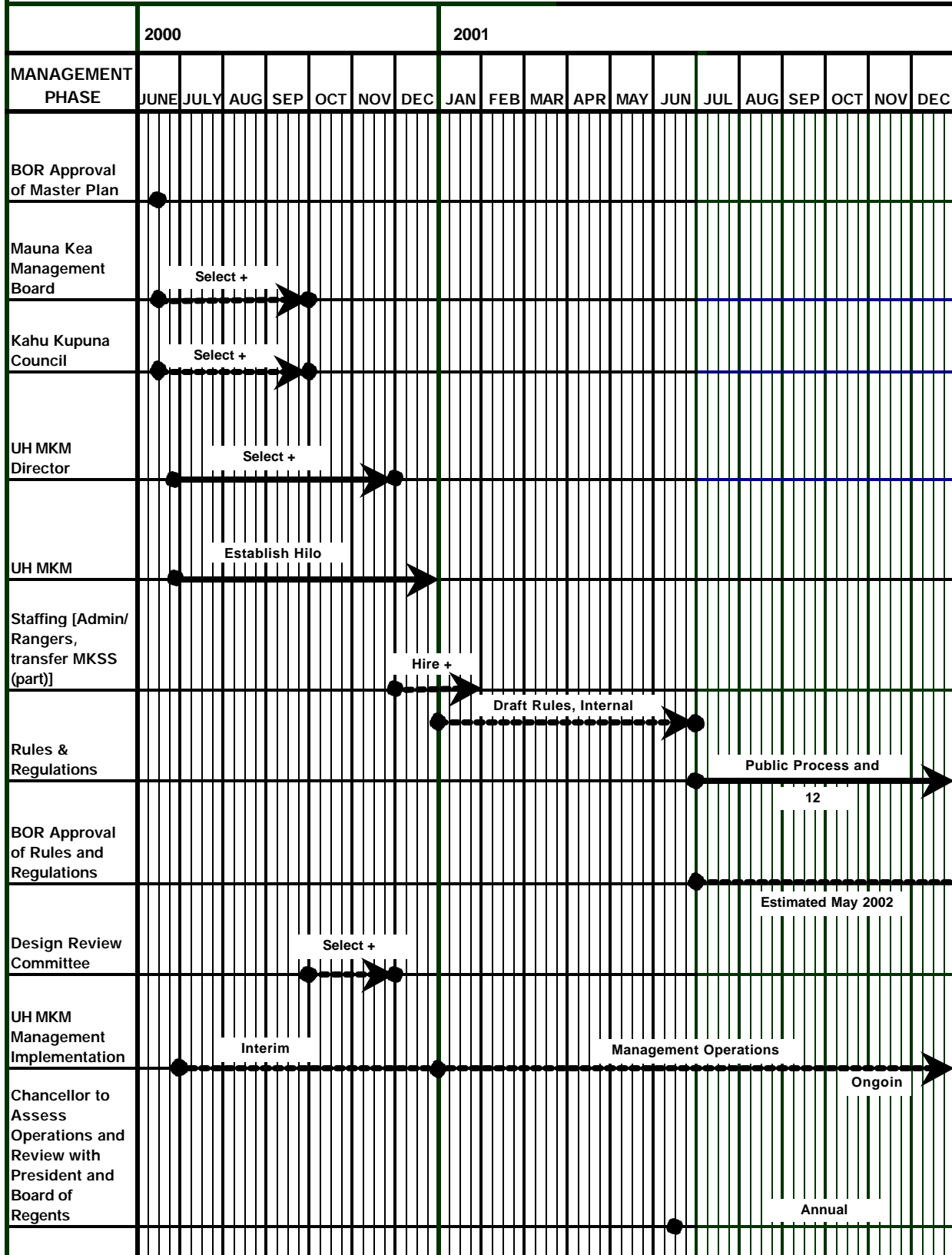
There are four new major components to the organizational structure surrounding the Mauna Kea Science Reserve. They are the University of Hawai‘i Office of Mauna Kea Management, the Mauna Kea Management Board, the Kahu Kūpuna Council and the Design Review Committee. These components should be formed within six months of the approval of the updated Master Plan.

Office of Mauna Kea Management (UH MKM)

Steps in the development of this office will include the following:

1. ***Finalize Organizational Structure:*** Establish position descriptions and pay scales. Clarify the relationship of the Office of Mauna Kea Management to the Office of the Chancellor at UH Hilo. This will be done concurrently with the finalization of the Master Plan.
2. ***Establish Funding:*** The President of the University of Hawai‘i has committed to providing \$400,000 funding per annum for this new office. Additional funds may be added as conditions dictate.

**Figure XI-1
Management Plan Implementation Milestones**



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3. **Select Director:** The director will be the key “face of the University” to the public and people who work on the mountain. This person needs to have the respect of and be able to communicate with scientists, the community and the UH Hilo community. Strong organizational and interpersonal skills are needed to cover the wide range of responsibilities and tasks involved in this position. Sensitivity and knowledge of Hawaiian cultural issues and natural resource management issues is required.
 4. **Hire and Train Staff:** The director should be involved in the hiring of the rest of the staff to have ownership of the office team. The staff should be knowledgeable about the resources of the mountain and sensitive to community needs. Some of the staff should be bi-lingual; especially in Hawaiian. A training program for the staff is needed to inform them of the values, resources and protocols on the mountain. The hiring and training of the staff should occur within two months after the director has been selected.
 5. **Develop Administrative Rules:** Rules should be adopted pursuant to Chapter 91. These rules would guide the daily operations of the UH MKM and the management of the Science Reserve. Draft rules should be prepared within approximately six months of the hiring of the director. Final rules should be adopted within approximately 18 months of the formation of the UH MKM. These rules should be based on the Master Plan policy guidelines.
 6. **Establish Hilo Office:** The main office of the MKM should be established at UH Hilo in the Research Park to keep it close to the community, UH Hilo and the Research Park tenants. The Office should be established as soon as the Master Plan is adopted.
 7. **Reorganize Hale Pōhaku Operations:** The Visitor Information Station should be renovated to headquarter the rangers and accommodate the expanded VIS operations. Renovations should be completed within approximately one year of operations under the UH MKM. Registration protocol and educational materials and programs should be established as soon as the positions are filled. A control point kiosk should be developed within the first year of operations. VIS expansion should be completed within three years.
 8. **Mauna Kea Support Services (MKSS) functions (partial) transfer:** Maintenance and management functions currently provided by MKSS would be reviewed and with the agreement of affected parties shifted to the UH MKM on a timely basis. Services that are related to existing agreements and efficiently managed by IfA will remain as is. Initial transfers of personnel and functions should occur within the first year of the establishment of the UH MKM.

Mauna Kea Management Board

- 1. *Appoint Management Board:*** Members will be recommended by the UH-Hilo Chancellor and appointed by the Board of Regents. Terms and responsibilities will be detailed in administrative rules. The Board should be appointed and organized concurrently with the establishment of the UH MKM.
- 2. *Establish Administrative Rules:*** The Board should adopt formal rules within one year of its formation. Procedures for public participation should be included in the adopted rules.
- 3. *Kahu Kūpuna Council:*** The Board should organize the Kahu Kūpuna Council to assist in deliberations of cultural and community values. This committee should be formed soon after the adoption of this Master Plan.

Design Review Committee

This Committee should be appointed with the adoption of the Master Plan. It should include design professionals such as architects, landscape architects and civil engineers.

DESIGN GUIDELINES

The purpose of the design guidelines is to direct development in a manner which integrates it into the summit environment. The design guidelines would apply to both renovations of existing facilities as well as new construction. General goals include the following:

Facility Siting: Siting decisions are the first steps in design and often determine the range of options that are available. Siting of various facilities are identified in the Physical Planning Guide. Candidate sites for recycling, expansion and new facilities are designated. New facilities are sited generally. Individual instrument locations are not specified. The NGLT and facilities on new site locations may require adjustments after viewing tests and archaeological inventory level surveys are conducted. The following siting criteria should be considered early in project development:

- Site facilities to avoid negative visual or functional impacts to existing facilities.
- Where known archaeological, cultural and natural resources exist the following sequence of evaluation is to be followed: 1) avoid disturbance of the resource, 2) minimize impact if unavoidable and 3) mitigate impact as needed. Natural resources include biological populations and geo-morphological features and geo-chemical resources.
- Set sufficient buffer distances between the facility and the cultural or natural resource. Buffer distances should be assessed individually based on the feature and the proposed facility.

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- Site facilities to minimize visual impact from both the summit areas and off-mountain locations such as Hilo, Hāmākua and Waimea.
 - Cluster facilities for proximity to roadway and utility lines. This should reduce site development costs and minimize visual impacts and unnecessary disturbances of the natural environment.
 - If possible, avoid steeper areas and drainage paths.

Scale: Facilities should be scaled to minimize their impact on the natural landscape of the summit area. As much as practical, telescope enclosures should be designed to minimally accommodate the instrument. Where the size of the enclosure is necessarily large, strategies should be considered to blend it into the surrounding landscape. The following are some strategies for reducing apparent scale:

- Bury portions of the structure as practicable.
- Place berms against the building to reduce visible areas.
- Shape superstructures using natural and curved forms which blend into the environment rather than orthogonal geometries.
- Color surfaces to blend into the landscape.
- Design exterior articulations and changes in color and texture to break up large continuous surfaces.
- Use materials that blend into the natural landscape.

Heights & Widths: Heights and widths of ridge facility designs should seek to minimize visible heights above existing ground as much as practicable. The following are maximum dimensions established to guide the design of facilities and to regulate the impact of new development.

- Facilities developed on ridge sites may be developed to a maximum height of approximately 130 feet measured from finished grade, and a maximum width of 130 feet.
- Support facilities in the astronomy precinct should be designed to reduce the height of vertical planes on exterior walls.
- Facilities that can be built underground are encouraged to do so to reduce the part that must remain above grade.
- Mounding cinders around telescope bases could be considered to reduce visible heights.
- Where practical, build into existing slopes to reduce the visible height.
- Facilities at Hale Pōhaku should be a maximum of two stories and designed to look like one story structures by techniques such as building into attic spaces as per the existing buildings.

Colors: Color plays an important part in visibility and thermal impacts. Color choices should seek to minimize the visual impact of the facility from surrounding areas. While it is understood that the mitigation of thermal impacts on observatory functions is an

important consideration, domes should be colored to aid in masking and blending facilities into the natural landscape. The following strategies are to be employed:

- For ridge facility domes, a combination of detailed geometrical design, surface treatment (i.e. reflecting vs. non-reflecting) and color (blues and grays) to minimize visibility against the daytime sky.
- For base sections, use browns and other earth colors to blend facilities with the natural cinder cone surroundings.
- For off-ridge facility enclosures use colors and patterns such as the mottled brown tones of the surrounding lava landscape.
- Color concrete utility pull boxes installed along underground utility routes, antennae pads and miscellaneous structures with mottled brown tones to blend with the surrounding lava landscape. No raw, uncolored concrete surfaces are to be allowed.

Surfaces, Textures and Material: Surfaces, textures and material used for construction in the Science Reserve should seek to blend the facility into the landscape. Selection criteria are as follows:

- As much as possible, surfaces should be non-reflective in the visible spectrum to minimize glare and visibility from distant areas.
- Wood and other native plant materials may be used, as appropriate, at lower elevations near Hale Pōhaku or for support facilities that relate to natural and cultural programs. Natural materials are suggested for walls and surfaces as much as possible.

Parking: Parking areas should be designed with sensitivity to existing topographic contours and fitted into the existing landscape. Parking layouts should be designed to retain natural landforms and vegetation as much as possible.

Roadway and Utility Development; Minimize roadway development in the Science Reserve to what is needed to support functions approved in the master plan. Follow existing road and utility corridors and alignments as much as possible. Utility lines should be buried. Accessory utility structures will be screened or designed to blend into the natural terrain. Road designs should minimize slope cutting.

Roofs: Roof design and material and color selections in conventional structures should merge the facility into the natural landscape. Reflective materials are to be avoided. At Hale Pōhaku, roof designs, colors and materials should be compatible with those of the existing mid-elevation facilities.

Fences, Walls, and Barriers: Fences, walls and barriers will generally be designed to fit into the landscape. Where possible, alignments should follow natural contours. Grading cuts and fills should be minimized. The use of locally available construction material is encouraged.

Signage: Signs should generally be small and unobtrusive. A possible exception may be the entry sign at the control point at Hale Pōhaku. This sign should be clearly visible during the day and night. Print colors should be black, blue or dark earth tones. It is suggested that interpretive signage be located in natural entry points and lookout areas and designed to blend into the natural landscape. The potential impact of snowfall should be considered in the design of signs. Signage should be placed to orient and educate visitors about safety issues and the protection of natural and cultural resources. It is recommended that there be a consistency of signage styles and symbols for the Science Reserve and Hale Pōhaku.

Language for signage should generally be in both Hawaiian and English. An exception to this policy would be traffic signs which would remain in English for safety reasons.

PROJECT REVIEW AND DESIGN GUIDELINES

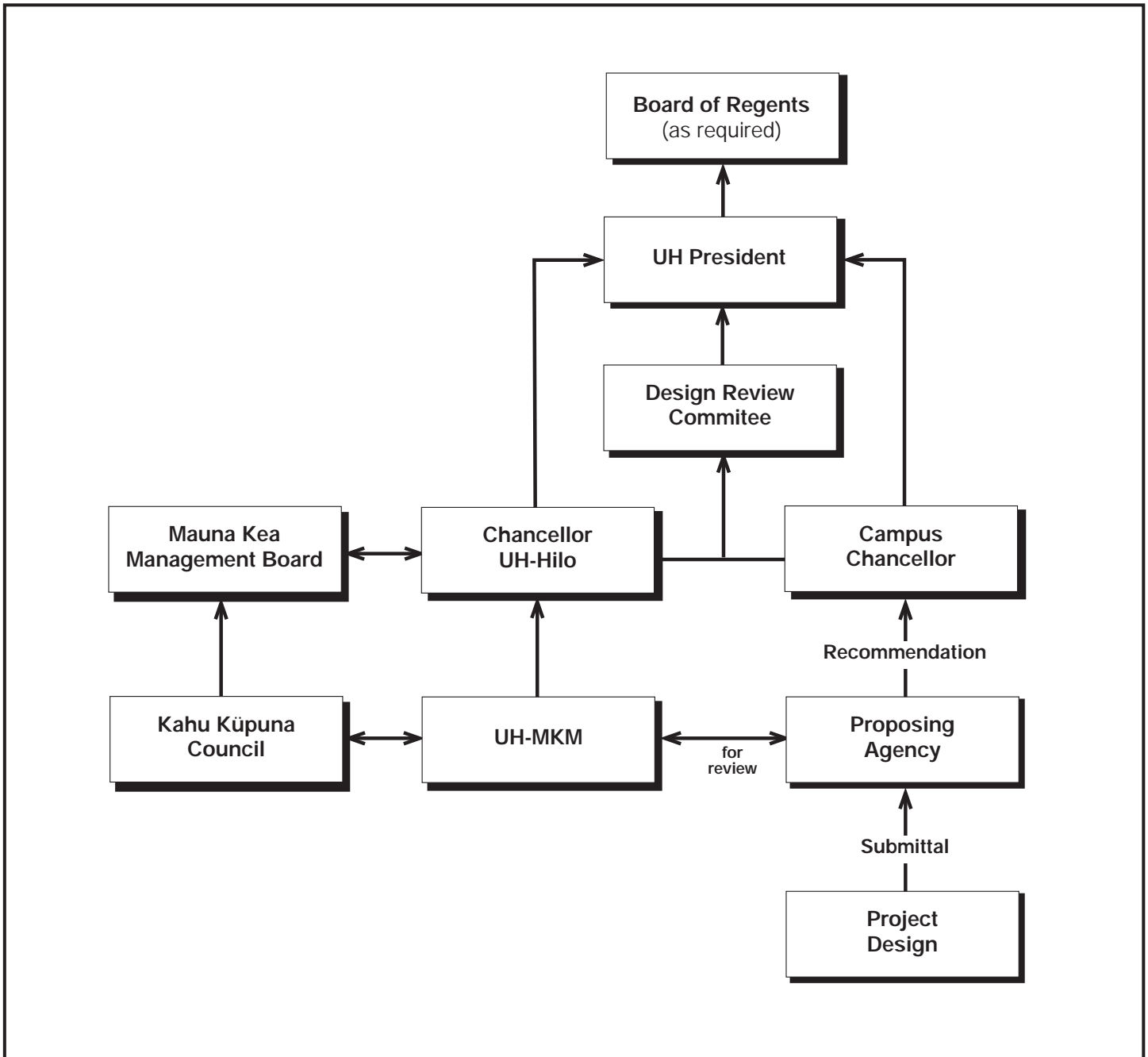
Purpose: A project approval and design review process is to be established to ensure that projects conform to and implement the concepts, themes, and development standards and guidelines set forth in this plan. Plans should support the Master Plan goals and objectives and contribute to the mountain's overall character and environmental quality.

Applicability: Any construction, installation or alteration upon any site, roadway, utility line, building, or other type of structure; any excavation, filling or change to surface topography; and any planting or removal of vegetation at a site may be undertaken in conformance with these procedures.

Participants: The University of Hawai'i Board of Regents and the President of the University of Hawai'i retain project approval and design review authority over all developments in the areas covered under General Lease S-4191. In order to assist the President and the Board of Regents in interpreting the design guidelines and intent of the Master Plan, the establishment of a Design Review Committee (DRC) comprised but not limited to professionals in the fields of architecture, landscape architecture, and engineering is recommended. UH MKM and the Mauna Kea Management Board will also review projects for overall conformance to the Master Plan while the DRC conducts design reviews (Figure XI-2).

General Review Standards: In reviewing plans and specifications the DRC, Mauna Kea Management Board and UH will be concerned with both the overall design concept, design details and overall impact. General concerns will include whether the proposed project:

- Conforms to the goals and objectives of the Mauna Kea Master Plan;
- Is consistent with the Design Guidelines in the plan;



Note: This process is applicable for projects proposed in the Master Plan.

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- Will not negatively impact adjacent facilities or uses;
 - Promotes resource conservation and sustainability;
 - Relates harmoniously to the surrounding landscape.
 - Does not add significantly to negative cumulative impacts.

Plans found to be inconsistent with the Master Plan concepts and objectives shall be rejected. Major variations from development standards shall also be rejected. Determinations of consistency shall be at the sole discretion of the University of Hawai‘i.

Minor and Major Projects: Separate processes are established for the review of “Minor Projects” and “Major Projects.” Minor project review would end with the Office of the President. Major projects would be given final approval by the Board of Regents. Examples of minor projects are providing small structures or changing a building’s color. The determination of which process is applied rests with the Office of the President. The decision is open to appeal to the President of the University of Hawai‘i.

Design approval for projects that are described in the Master Plan will follow two review paths. The first path would be through UH MKM, the Mauna Kea Management Board and the Chancellor of UH Hilo. The second path would flow through the chancellor of the campus from which the proposal is initiated. For example, IfA proposals would be processed through the Chancellor at UH-Mānoa. Proposals generated out of UH Hilo or the Community Colleges would be processed through the Chancellor of UH Hilo or the Chancellor of Community Colleges. Regardless of the source of the proposal, the one constant would be that all proposals would include reviews and comments by the UH MKM, the Mauna Kea Management Board and the Chancellor at UH Hilo.

Review Procedures – Minor Projects: Upon notice of a proposed action, UH MKM will make an initial determination of the major/minor review process for the President who will make the final determination. The project would be reviewed at various phases. Phases of the review will generally be as follows:

1. ***Schematic Submittal:*** At the initiation of the project, a verbal and graphic submission should be made which outlines the action, describes its major characteristics, and briefly assesses its impacts on any existing or approved facility or use.
2. ***Design Development Submittal:*** After approval of the schematic phase, drawings addressing schematic design comments should be submitted for design development review. Emphasis should be given to relationships (setbacks, colors, materials, etc.) to adjacent properties and existing buildings.
3. ***Final Submittal:*** Should approval be given at the design development phase, final drawings and other documents should be submitted for final approval.

The Offices of the Chancellor will complete all phases of the review within 30 days of the submission of the review documents.

Review Procedures – Major Projects: UH MKM will make an initial determination on major projects for the President who will again make the final determination. This determination is for processing category; not project approval. Actions determined to be major by the President would go through the following process:

1. **Pre-design Meeting:** This meeting may include the following participants: the applicant, the project architect/engineer, a representative of the University, a representative of IfA, and a representative of the DRC.

The purpose of this meeting is to introduce the applicant and the project architect to the design and environmental goals of the Mauna Kea Science Reserve, and to provide a context for further work and reviews. The applicability to the project of the overall design framework and the specific development standards and guidelines established in this Master Plan will be discussed. In particular, information regarding infrastructure and elements such as roadways and landscaping will be clarified. Information regarding the character of the Mauna Kea Science Reserve and Hale Pōhaku will also be provided.

2. **Schematic Design:** This meeting is to include the following participants: the applicant, the project architect and other appropriate consultants, representatives of the University of Hawai‘i and the DRC.

At least seven days prior to the meeting the applicant is to submit seven half-sized schematic plans to the University for distribution. The schematic plans should include sufficient information to show how the proposed design satisfies the parameters established at the pre-design meeting and the design guidelines of this Master Plan.

The review will include the following:

- a. Site plan considerations including vehicular and pedestrian circulation, parking, service areas etc. The site plan should show relationships to adjacent facilities and resources.
- b. Overall building massing considering view planes, heights, setbacks, etc. All major sections and elevations should be indicated.
- c. Building characteristics including architectural style, volumetric forms, building materials, colors, etc. and perspective drawings and/or models are encouraged. Models may be physical or 3D computer files.
- d. Landscape plans showing general concepts, plant, rock and ground features.

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- e. Basic environmental effects (i.e. sunlight and shade, wind surface topography and drainage), especially on adjacent properties and resources.
 - f. Energy and other resource conservation methods.
 - g. Provisions for recycling and use of recycled materials.

Whenever possible, recommendations arising from the review will be forwarded to the applicant within thirty (30) days of the meeting. Other meetings in the schematic stage may be necessary if the design is not initially approved. The review period may be extended for up to thirty (30) additional days to review plans for large projects or projects which require more study. Schematic design submittals will also be reviewed by the Mauna Kea Management Board.

3. ***Design Development:*** This meeting is to include the following participants: the applicant, the project architect, representatives of the University of Hawai'i and the DRC.

At least seven days prior to the meeting the applicant is to submit seven half-sized design development plans and outline specifications to the University for distribution.

The information to be provided on the design development plans include the following:

- a. Site plan drawings shall at a minimum include the following information: all building locations and sizes, number of stories, setbacks, locations of roads and walks, location and size of parking areas and service bays. Ground elevations with existing and finished grades, drainage, earthwork, utility lines, etc. should be indicated. Special attention should be given to relationships to adjacent facilities and nearby natural or cultural resources. Energy and resource conservation methods should be identified.
- b. Review of conceptual floor plan drawings at a scale of at least 1/8" = 1.0' for all building types.
- c. Review of elevation drawings. Inclusion of perspective drawings and a physical or computer 3D model is encouraged. Special attention will be given to dome and roof colors, forms and materials. Building colors and materials will also be evaluated.
- d. Review of sections of buildings and site. Attention will be given to any major changes in ground elevations in regard to drainage, views and adjacent facilities and natural and cultural resources.

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- e. Review of landscape drawings. These drawings should show the location, type, size, and quantity of all plant materials, walks, landscape lighting, signs, paved areas, rock and ground surface materials, etc.

The design development review will be completed within thirty (30) days, and a report forwarded to the applicant containing the recommendations and requirements arising from the review and meeting. The review period may be extended for up to 30 additional days to review plans for large projects or projects which are deemed to require more study. Design development documents would also be reviewed by UH MKM and the Mauna Kea Management Board.

Approval will depend on the extent to which the proposed design satisfies the objectives, standards and criteria established in previous reviews, as well as those identified in this Master Plan. Other meetings in the design development stage may be held if the design is not initially approved. In no case should the applicant proceed with construction documents prior to design development approval.

4. ***Construction Documents Review:*** Construction documents will be checked for compliance to design review comments. Two half-sized construction drawings and specifications should be submitted to the University. Approval of the documents or a report listing modifications will be forwarded to the applicant within thirty (30) days of their receipt. The review period may be extended for up to 30 additional days to review plans for large projects or projects which are deemed to require more study. Drawings should, if possible, be accompanied by a computer disk containing the overall site plan and landscape plan.

Approval of construction documents by the Design Review Committee and the University of Hawai'i does not constitute authorization to proceed with the project. Compliance with applicable codes, laws, ordinances, and governmental agency conditions of approval is the responsibility of the applicant.

Construction Review and Approval:

1. ***Duration of Final Approval:*** Any approval provided shall be effective for a period of 12 months and shall be deemed revoked if the approved construction, reconstruction, refinishing, alteration, or other work approved thereby has not begun within the 12 month period. The University may authorize an additional 12 month extension on the approval.

If approval lapses hereunder, the owner or lessee may be required to resubmit the final plans and specifications for approval. The DRC and the University of Hawai'i shall not be bound by any previous decision in reviewing such plans and specifications, but shall either approve or disapprove the same in writing within thirty (30) days after such resubmission.

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2. **As-built Plans:** Upon completion of construction, a complete set of as-built plans and specifications for infrastructure improvements will be provided to UH MKM.

Temporary Facilities: Temporary facilities are facilities that, when constructed, are planned for removal within five years of completion of construction. These facilities include test optics, facilities for short term experiments, constructions support structures, temporary cultural, educational or recreational activity shelters and structures and small test facilities.

1. **Approval Process:** Temporary facilities will go through the same project review and assessment procedures identified in this section for permanent facilities. As with the permanent facilities there will be a distinction made between Class A and Class B facilities paralleling the Class A and B amendment criteria identified in this chapter. Those that may have potentially significant impacts will be processed through the major projects review channels. Facilities deemed to have minor impact will be processed through the minor projects review track. It is anticipated that most temporary projects may be processed through the minor projects review process. Appeals may be processed through the Director's to the Office of the President of the University of Hawai'i. Temporary facilities need not go through the formal amendment process which would then require a subsequent amendment to remove the facility from the Master Plan when the facility or activity is terminated.
2. **Pre-application review:** When proposals for temporary facilities are received, in addition to the normal project review criteria they will be evaluated according to the following additional criteria:
 1. Duration of existence;
 2. Likelihood of extension requests.
3. **Extensions – Single or Multiple:** Requests for the extension of a temporary use will be sent to the Director of the Mauna Kea Management Office. Appeals for the granting or denial of extensions would be sent to the Office of the President of the University of Hawai'i. Reasons for the approval of extensions may include the following:
 1. Unusual hardships or delays due to budgets and financing,
 2. Inadvertent delays in the start or conduct of the,
 3. Discoveries that suggest additional areas of investigation,
 4. Mitigation requirements that required additional time.

The Director may approve extensions from one year to two years as appropriate. A maximum of two extensions may be allowed for a total extension not exceeding three years. Uses extending beyond this would require a formal amendment to the plan.

4. **Removal After Term:** All temporary facilities will be demolished and/or removed after completion of the use term unless otherwise exempted by the President of the

University of Hawai'i. The site will be restored to the pre-existing natural site as much as practicable. The Office of Mauna Kea Management will monitor compliance with this condition. The President will receive a report and recommendation from the MKM and the Mauna Kea Management Board before making final decisions on any exemptions to this requirement.

Variances:

Variance requests will be approved or rejected by the President of the University of Hawai'i. Requests for variances from development standards and guidelines may be approved if they are minor in nature and otherwise consistent with the overall goals and objectives of the Master Plan. Variance requests found to be substantially inconsistent with the provisions of this document will not be approved. Variances will be approved after receiving input from the DRC, the Mauna Kea Management Board and UH MKM.

AMENDMENT PROCEDURES

Plan Amendments

The Mauna Kea Master Plan is adopted by the University of Hawai'i Board of Regents and will guide the use and development of the Science Reserve. It is anticipated that there would not be many amendments to the plan during its life. Amendments would be required for large new facilities and major renovations only if they are not anticipated in the Master Plan. Projects identified in the Master Plan would not require plan amendments unless there are significant changes in design or location that have major impacts on the plan itself or the environment. It is proposed that plan amendments be separated into two categories: Class A and Class B amendments.

Class A amendments would be major amendments for proposals that require approval by the Board of Regents. Examples of these include:

- New projects not identified in the Master Plan with site coverage over 2,000 square feet or a building envelop over 24,000 cubic feet (40' x 50' x 12');
- Major expansions of existing facility sites not anticipated in the Master Plan (more than 50% of existing floor area or 2,000 square feet, whichever is greater);
- Improvements identified in the Master Plan which require significant changes in size or location;
- New utility alignments and corridors.

Class B amendments would be administrative. Final approval for Class B amendments would rest with the President of the University of Hawai'i. Class B amendment requirements also apply only to projects that are not anticipated on the Mauna Kea Master Plan. The following are examples of Class B amendments:

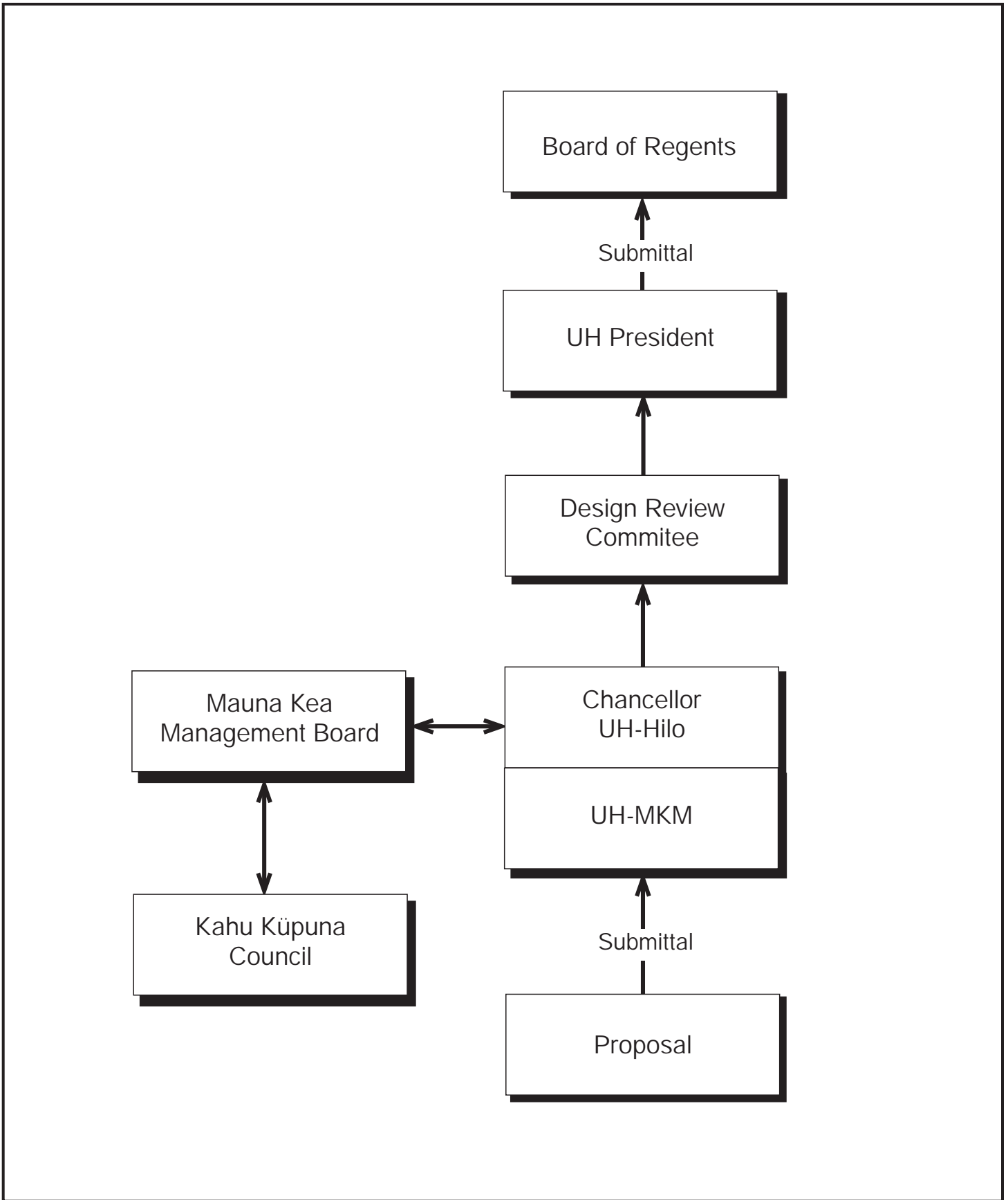
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- Significant land altering proposals unanticipated in the Master Plan with a ground coverage of less than 2,000 square feet and a volume of less than 24,000 cubic feet;
 - Unanticipated additions (less than 50% of existing floor area or 2,000 square feet, whichever is greater);
 - Accessory support facilities;
 - Comfort stations;
 - Temporary structures;
 - Roadway and utility improvements within existing alignments and corridors;
 - Other unanticipated proposals such as significant equipment platforms, parking areas or cultural facilities such as *heiau* over 2,000 square feet.

Exempt Activities: Many improvements would not require plan amendments even though not explicitly anticipated in the plan. Exempt actions would be reviewed by the UH MKM, Office of the Chancellor. Questions of qualification for exemption would be decided by the President of the University of Hawai‘i. Exempt activities include but are not limited to the following examples:

- Small *ahu* and shrines used for traditional cultural practices;
- Renovations within existing structures;
- Repairs to existing facilities;
- Exterior renovations which do not significantly change the scale or character of the structure;
- Utility repairs and upgrades within existing lines, conduits and utility corridors;
- Routine and emergency roadway repairs, guardrails or vehicle ramps;
- Minor drainage improvements;
- Addition or deletion of signage;
- Installation or removal of walls and fences;
- Minor landscaping;
- Other minor activities such as the placement of instructional and safety signs and movement and placement of rock boulder lines.

Rules for amending the Master Plan are guided by the rules of policies of the Board of Regents. Board of Regents procedures for plan amendments are specified in their rules entitled “The Facilities Planning Process for Implementation and Management of Long-Range Development Plans, University of Hawai‘i”. Board of Regents information requests include program justification, functional relationships, square footages, design requirements, alternative sites analyses and special studies, as needed.

All amendments would be processed through the UH MKM and the Chancellor of UH Hilo (See Figure XI-3). All amendment proposals would be reviewed for general conformance with the Mauna Kea Master Plan goals and objectives.



General Master Plan Amendment Procedures for Science Reserve

For Class A amendments, the office would receive and process all applications. UH MKM would review the application, suggest changes or additions and send the proposal with its review and recommendations to the Office of the Chancellor at UH Hilo. The Office of the Chancellor would transmit proposal material to the Mauna Kea Management Board for their comment. The Board would submit its comments and recommendations to the Office of the Chancellor. If the proposal is a building or a project that may have an impact on the physical or aesthetic qualities of the mountain the Office of the Chancellor may request additional review by a design review committee attached to the Office of the President. The design committee would review the proposal and submit its comments and recommendations to the Chancellor. The Office of the Chancellor at UH Hilo would prepare a report and forward the Management Board's comments, design review comments and its own recommendations to the President of the University of Hawai'i for consideration by the Board of Regents.

Class B amendments would follow the same procedure as Class A amendments except that final decisions would rest with the President of the University of Hawai'i.

Classification of a proposal as either Class A, Class B or Exempt does not obviate the need for any other pertinent federal, state or county requirements set by statutes or ordinances. Many plan amendments are likely to require Chapter 343 Environmental Assessment or Environmental Impact Statement documentation. If the UH MKM is not the proposing agency, it should begin its review of these documents at the pre-consultation stage. Other frequently needed reviews are historic sites review and Section 7 endangered species consultation. Proposals that may impact significant historic sites or traditional cultural properties would require DLNR review and approval even in the Science Reserve. Consultation with SHPO is recommended at an early stage in project development.

ADMINISTRATIVE RULES

Administrative Rules should be adopted within one year of the formation of the UH MKM and the appointment of the Mauna Kea Management Board. Rules should be adopted for both the MKM and the Management Board.

AUDITOR'S REPORT RESPONSES

As noted in Section 8 the Legislative Auditor's Report concluded with a number of comments and recommendations. The following section responds to the Auditor's Report. The bold sentences and phrases are the auditor's comments and recommendations.

Management:

- ***Develop rules and regulations for development and public access in the summit area and Hale Pōhaku.***
Rules for the Science Reserve and Hale Pōhaku are to be developed and processed by the UH MKM. Rules and regulations will be adopted pursuant to Chapter 91. Tentative schedule for rules adoption is June 2002. Public access will not be restricted but it will be managed.
- ***Hire ranger/guides at Hale Pōhaku who will be there on a daily basis.***
Rangers will be an integral part of the UH MKM. There will be a minimum of two rangers on the mountain every day. They will operate out of Hale Pōhaku. These rangers will be trained in cultural and natural resource management.
- ***Require registration of visitors for education and safety reasons.***
This is the primary reason for managed access. Visitor registration procedures will be part of the proposed rules being developed. It is anticipated that registration will occur at the VIS at Hale Pōhaku and managed by the ranger. Registration will include orientation on safety, environmental and cultural aspects of Mauna Kea.
- ***Develop milestones, specific timeframes & other controls to ensure implementation.***
The implementation schedule presented in this chapter identifies milestones and time frames. Other controls and assurances of implementation are identified in Section 10 under Management Plan. Incorporating the UH MKM as an integral part of UH Hilo makes the management of Mauna Kea a clear responsibility accepted by the University of Hawai‘i. It also establishes a sustainable funding platform for the office.
- ***Develop a forum for continuous community input.***
The appointment of the proposed Mauna Kea Management Board provides a forum for continuous community input. Additionally, the creation of a Kahu Kūpuna Council creates an added dimension and authority to the community’s voice. Finally, as programs are developed it is anticipated that decent programs on many subject areas will be created providing ongoing partnership with volunteer organizations and community members. Volunteer groups will be encouraged to assist in the stewardship of the mountain during events such as clean-up days or possible future programs such as silversword re-vegetation or habitat restoration in the māmane-naio forest around Hale Pōhaku.
- ***New method for measuring impact.***
Telescope counting was criticized in the Auditor’s report as an inadequate method for measuring impact which did not take into account changes in technology. Interferometers were specifically identified as needing special treatment. The updated Master Plan measures impact more specifically by observatory type, external impact as measured by design guidelines and improvements evaluated by site location

and type. Maximum sizes and color are included in the evaluation criteria. Proposed projects are grouped into recycled sites, expansions of existing facilities and new locations. Adoption of this Master Plan and its project review process provides a new and specific methodology for assessing the Master Plan impact of each facility. The Plan also requires that projects which deviate from the Master Plan's descriptions or are not described in the Master Plan must under go full environmental review (EIS) as major amendments to the Plan.

- ***Measure impacts individually and cumulatively.***

Individual and cumulative impacts are addressed in the Master Plan EIS process. State and Federal EIS laws both require analysis of individual and cumulative impacts. This is addressed by the formation of UH MKM and the Mauna Kea Management Board. These two entities will now be a part of every EIS review process and ensure broad and comprehensive reviews which will include individual and cumulative impacts. In addition, all individual projects must be individually and cumulatively addressed in project specific Environmental Assessments and/or Environmental Impact Statements.

- ***State specific carrying capacity.***

- The issue of carrying capacity was discussed with the Office of the Legislative Auditor. It was clarified that the comment was generic and not a specific reference to a methodology or specific study product. It is understood that the technical carrying capacity of the Science Reserve is huge; limited only by available sites, infrastructure, critical habitat, historic sites and the interference of one facility by another. The Science Reserve is large and capable of housing many more instruments or observatories. The concept of social carrying capacity used in recreation and wilderness planning does not result in clear limits to capacity because of differences in opinion and tolerance. The concern implied behind the comment was addressed by limiting physical development to an Astronomy Precinct of approximately 525 acres and re-designating the rest of the Science Reserve as a Natural Cultural Preservation Area. Several factors relating to carrying capacity were instrumental in the defining the boundaries of the precinct. First, all undeveloped summit pu'u were removed as future development sites. Additional Wēkiu bug habitat was avoided. Specifically, the precinct was defined on the west by eastern edge of the Pu'u Pōhaku NAR boundary. To the north, consideration of the concentrations of archaeological sites at the outer edge of the summit plateau defined the limit. On the eastern side, view protection and the retention of the pristine character of the eastern flank limited development to the developed areas of the summit ridge. The southern boundary was based on the protection of a westward view corridor from the true summit (Kūkahau'ula), and an analysis of views and relationships between Pu'u Poli'ahu, Wai'au, Kūkahau'ula, Lilinoe and the adze quarry (Keanakāko'i). Attempts were made to minimize future disturbance of the southern edge with the idea of protecting a relatively intact cultural landscape. These factors relate to the concept of carrying capacity implied by the Auditor's report and the companion recommendation to identify no-build areas.

- ***Require management plans that have time frames.***

The management plans described in this Plan include the time frames identified in this chapter. While some deviations may occur due to unforeseen circumstances, the inclusion of major stakeholders and the community as partners with the University of Hawai'i in the decision process ensures its timely implementation.

- ***Ensure internal deadlines prior to release of land or sub-leases.***

The Auditor's report states that sub-leases and other land management issues are not completed in a timely manner. This criticism was largely aimed at the Department of Land and Natural Resources. In its report to the Legislature, the DLNR mentioned the following:

1. It will work with the UH Institute for Astronomy to ensure the completion of sub-leases prior to the start of construction.
2. Land Division has begun a computerization plan to track and administer permits and sub-lease issuance in a timely manner.
3. Ongoing discussions with the University regarding lines of authority and management responsibilities on the mountain.

Development of UH MKM will facilitate the performance of these responsibilities.

- ***Make sure all responsibilities are assigned; either UH or DLNR.***

It is noted that all responsibilities are currently assigned by legal requirements. The problem in the past has not been in the assignment of responsibilities but in the resources and personnel needed to address them adequately. Additionally, overlapping responsibilities, the complexity and generality of rules and policies has led to a public perception of mismanagement, unfulfilled responsibilities and ignored promises. The creation of the UH MKM at UH Hilo addresses this issue by creating a lead agency based on the Big Island that can receive concerns and make sure they are addressed or brought to the attention of the responsible agency. UH MKM will function as the public point of contact with the University and its responsibilities. For other responsibilities UH MKM will act as liaison and bridge to the appropriate agency and assist in the follow through of community concerns.

Historic/Cultural Resources:

The Auditor's report was critical of the neglect of cultural issues and resources. The criticism is one of not valuing and protecting both cultural sites as well as traditional cultural practices. Specifically, the report calls the University to do the following:

- ***Address cultural and historic issues.***

Cultural and historic issues have been addressed in a number of ways. First, the planning process has resulted in new knowledge about the cultural and historical resources of Mauna Kea. In the development of the updated plan a detailed

archaeological study was conducted by Dr. Patrick McCoy of the State Historic Preservation Office. His final report is currently being completed. Additionally, ethnographic studies have been conducted by Kepā Maly which include archival searches into Hawaiian language documents dating back to the 19th century and oral history interviews with cultural practitioners, kūpuna and kama‘aina. The information gathered in the ethnographic studies have been assessed by PHRI, Inc. Input was also received through the Mauna Kea Advisory Committee appointed by the President of the University of Hawai‘i. Committee members solicited additional input from other community sources. Holly McEldowney is working on a historic preservation plan for the Science Reserve and the SHPO is considering the designation of the summit area as a historic cultural landscape.

The information from the archaeological survey, ethnographic study and the President’s Mauna Kea Advisory Committee were incorporated in a GIS database. The components and configuration of the Physical Plan within the Master Plan incorporates both physical, spiritual and symbolic cultural issues in a balanced way. The importance of the cultural values in the Science Reserve are emphasized and formalized by the designation of 10,763 acres as a Natural/Cultural Preservation Area. Astronomy development areas were reduced to a 525-acre precinct.

The Cultural Resource Management Plan, siting criteria and design guidelines all consider potential impacts to cultural and archaeological site and resources. Site specific inventory level surveys are requirements prior to facility siting. Cultural sensitivity to view impacts are considered and minimized where practical. All undeveloped summit pu‘u are removed from future development.

A permanent Kahu Kūpuna Council is recommended to help guide the University’s management of Mauna Kea’s cultural resources and cultural practices. The committee would also assist in the resolution of questions and potential conflicts.

New protocols during visitor registration will improve sensitivity to cultural resources and values. Signage plans and the cultural resources management plan are geared to the protection of these resources by directing visitors to less sensitive areas and educating them about the value of these resources. Rangers will be especially trained in this area to educate the public and protect resources.

New protocols for construction are also proposed to protect cultural resources. The details of the protocols will be delineated in the Preservation Plan being prepared by the State Historic Preservation Office. Some features of this plan will include monitoring programs and the presence of qualified archaeologists during excavations and related construction activities that may have the potential to impact cultural properties.

- ***Complete the Historic Preservation Plan.***

A memorandum of agreement was signed between the University of Hawai'i and the DLNR for the State Historic Preservation Office to prepare the Historic Preservation Plan at the University's expense. A detailed outline has been developed to date. As noted earlier, a proposal in the Historic Preservation Plan to designate the summit region as a historic, cultural property is being considered. A full draft of the Plan was completed in March 2000 by the State Historic Preservation Office with adoption following public review.

Maintenance:

- ***Periodic inspection and documentation of trash control.***

This is occurring. In the future, this responsibility will be handled through the UH MKM.

- ***Remove remnants of old equipment.***

The two instances that led to this comment have been removed. New sublease agreements will include this requirement as a routine condition and UH MKM will monitor compliance.

Physical Planning Guidance:

- ***Identify areas suitable for astronomical development.***

Areas suitable for astronomy development have contained in an "Astronomy Precinct" of approximately 525 acres.

- ***Identify critical habitats for plants, invertebrates and other endangered species.***

There is no officially designated endangered species in the Mauna Kea Science Reserve. The Wēkiu bug (*Nysius wēkiuicola*) is being considered for endangered status but this has not yet occurred. The notion of critical habitat is an unclear parameter in the absence of knowledge about the life cycle of the species, critical population size or area distribution. However, new biological studies identified habitat areas for ferns, lichen, moths, spiders, and Wēkiu. These areas were identified, placed in a GIS database, and mapped. Areas considered sensitive habitat were avoided as much as possible. The importance of the māmane-naio forest as a critical habitat of the palila has always been considered a given. Development at Hale Pōhaku recognizes the importance of this habitat and follows guidelines which avoid or minimize disturbance to this ecosystem.

- ***Identify no build zones.***

The area outside the Astronomy Precinct is a "no build" area. Theoretically, without such a restriction, development could occur anywhere in the 11,288 acre Science Reserve. The VLBA is a case in point.

- ***Include facilities besides telescopes.***

A recreation support pavilion is identified in the summit area. Other non-telescope facilities were not included because there were no specific requests from other users. It was decided that facilities would not be proposed unless there were users groups requesting them since it was not the intent of the Master Plan to encourage unsupported development in the summit area.

At Hale Pōhaku the Plan proposes sharing some facilities and encouraging the use of former construction cabins for other non-astronomy purposes. The Subaru Cabins are specifically targeted for this function. The VIS is also planned for expansion to accommodate other uses. The stone cabins at Hale Pōhaku might also be renovated for other uses.

Statutory Recommendations/Sublease Agreements:

- ***Incorporate EIS mitigation measures as CDUA conditions.***

This is a recommendation to the Board of Land and Natural Resources since the BLNR issues conservation district permits. The Department of Land and Natural Resources has stated in its December 1998 response to the State Legislature that it agrees with the purpose of this recommendation and will pursue its implementation more diligently in the future.

- ***Relate permit conditions to sub-leases.***

DLNR and the University of Hawai'i will review this recommendation and where applicable include permit conditions in the subleases to any future tenants. This will also be considered in the renewal of existing subleases.

- ***Adopt rules for Chapter 6E, Historic Preservation Program.***

Draft rules for Chapter 6E were published and circulated for review in May 1999 and Fall 2000. After a period of public review and revision, it is anticipated that these rules will be adopted in late 2000 or early 2001.

All items in the Legislative Auditor's report have been addressed (see Table XI-1). Several items have already been completed and the remainder is projected for implementation with the adoption and commencement of this Master Plan Update.

**Table XI-1
Response to Auditor's Recommendations**

	Addressed in MP	Implementation Milestone
Management		
Development rules and regulations for summit area and Hale Pōhaku	✓	Draft 6/2001 Final 6/2002
Hire ranger/guides at Hale Pōhaku who will be there on a daily basis	✓	7/2000
Require registration of visitors for education and safety reasons	✓	
Develop milestones, specific timeframes & other controls to ensure implementation	✓	6/2000
Develop a forum for continuous community input	✓	6/2000
New method for measuring impact	✓	11/1999
Measure impacts individually and cumulatively	✓	8/1999
State specific carrying capacity	✓	
Require management plans that have time frames	✓	6/2000
Make sure all responsibilities are assigned; UH or DLNR	✓	6/2000
Historic/Cultural Resources		
Address cultural and historic issues	✓	11/1999
Compile the Historic Preservation Plan	DLNR	6/2000
Adopt rules for Chapter 6E, Historic Preservation Program	DLNR	Draft 9/2000 Final 4/2001
Maintenance		
Periodic inspection and documentation of trash control	✓	4/1999
Remove remnants of old equipment	✓	Completed
Physical Planning Guidelines		
Identify areas suitable for astronomical development	✓	6/2000
Identify critical habitats for plants, invertebrates and other endangered species	✓	6/2000
Identify no build zones	✓	6/2000
Include facilities besides telescopes	✓	6/2000
Statutory Recommendations/Lease Agreements		
Incorporate EIS mitigation measures as CDUA conditions	<u>DLNR</u>	Completed
Relate permit conditions to lease	DLNR	Ongoing
Ensure internal deadlines prior to release of land or leases	DLNR	2000

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

**XII. COMMUNITY INPUT:
PROCESS, COMMENTS AND RESPONSES**

COMMUNITY INPUT: PROCESS, COMMENTS AND RESPONSES

The community-input process was multi-tiered and very involved. It began with the formation of a Mauna Kea Advisory Committee established by President Mortimer. Twenty-four members were appointed. Nine of these members were part Hawaiian. This committee met for 15 months (often twice a month), participated in field trips and heard expert testimony from IfA, advisory committee members and a panel of cultural experts.

The advisory committee held two series of public meetings. The first set of meetings were a preliminary set of informational hearings in September of 1998. These meetings were held in Hilo, Waimea and Kona. The committee held another series of public meetings at the same communities after a draft 2 of the Plan was developed in May of 1999. Input was received at both sets of public meetings.

Input from the committee played a major role in shaping the Master Plan. The committee approved draft 2 for circulation and review in the community. The committee later recommended the proposed new management structure but voted to withhold recommending the draft 3A version of the Plan until the management plan was in place and native Hawaiian cultural issues were addressed further.

A committee recommendation was drafted on June 2, 1999 and reiterated in a final letter to the Board of Regents in August 25, 1999. The final recommendation stated,

“Our committee was charged in June of 1998 to provide needed input to the University of Hawai‘i regarding the conditions under which future development should occur on Mauna Kea on the Island of Hawai‘i. Our committee has collected important input regarding Mauna Kea. A considerable portion of this information has been incorporated into Draft #3 of the Mauna Kea Science Reserve Master Plan developed by Group 70.

It is our recommendation that any future development on Mauna Kea be coordinated closely with the community. This coordination of community input should be via the Mauna Kea Advisory Board and the Kahu/Kupuna Advisory Committee in a formal and permanent manner. Along these lines, we reiterate our recommendation of June 2, 1999 that there be no further construction until a plan is approved, the Mauna Kea Management Authority is funded and the Mauna Kea Advisory Board is established. The Mauna Kea Science Reserve Master Plan might be approved by the Board of Regents upon further attention to Native Hawaiian concerns.”

Throughout the planning period the project team met with other organizations and gave individual presentations as requested. Groups that were contacted included the Hawaiian Civic Clubs, DHHL homestead associations in Keaukaha, Waimea and Kona, Hawai‘i County Mayor’s office, State and local units of the ILWU and Big Island Labor Coalition, Hawai‘i Environmental Coalition and business organizations such as the Hawai‘i Economic Development Board and the Kona Kohala Chamber of Commerce. The team also spoke to many individuals.

As part of the master planning process an ethnographic study was commissioned and an 800 ± page oral history report compiled representing 25 interviewees.

Additionally, the EIS process provided another avenue of input for public comments. The EIS was completed prior to the finalization of the Master Plan.

Recognizing the complexity and depth of the Master Plan, the need for a vehicle for broad public dissemination of the Plan was expressed in a summary circular (Appendix O). This 8-page, newsprint, graphic format document highlights the educational, management and physical elements of the Master Plan, and it incorporates community voices expressed during the evolution of the Final Plan.

Mauna Kea inspires all who work and live on the mountain, feel its shadow and view it from afar. This is true of those who favor development or oppose it.

While a detailed listing of the issues, questions, concerns and comments would be too voluminous, the following is a summary of major comments and how they were addressed in the planning process.

Cultural Sensitivity: Issues of cultural sensitivity were raised repeatedly. The sensitivity of the plan to Hawaiian cultural values was mentioned and questions were raised as to whether community voices would be heard. Also, the initial plans were criticized for showing the location of burial sites identified from studies conducted by the State Historic Preservation Division. Part of this criticism was based on the perception that native Hawaiian voices were not part of the advisory or decision making agencies. At the same time some native Hawaiians mentioned that the voices that were loudest did not necessarily represent the majority of the community.

The Master Plan responds to these concerns in many ways. First, responding to comments about the cultural and spiritual importance of the mountain, the Plan reduced the potential area for astronomy development from the full Science Reserve of 11,288 acres to an astronomy precinct of 525 acres. Further, specific siting areas for telescopes were designated comprising 150 acres of land within the Astronomy Precinct. This is a reduction of 10 acres from the areas specified in the 1983 Long Range Development Plan for telescope siting.

The remaining area is proposed as a natural cultural preserve where astronomy facilities would not be developed. The auditor's report had suggested a "no build" line but the initial view was that this would be excessively restrictive to astronomy. Upon further review and responding to the input on the cultural importance of the summit area, the idea of the precinct was developed. The precinct is essentially the boundaries of a no build line for astronomy to contain its impact on the cultural landscape of the summit. The shape of the precinct was specifically tailored to avoid historic sites, preserve view corridors related to possible cultural lines of sight and maintain the integrity of the cultural landscape as much as practicable. The southern boundary was moved northward

to create greater distance from Lake Wai‘au, which is clearly one of the most significant sites in the summit region. The northern boundary was pulled back to avoid the ring of shrines at the 13,000 foot elevation. The line was adjusted to leave Pu‘u Poli‘ahu out of the precinct. The eastern boundary was pulled back to reduce the potential visual impact from the Hilo side of the mountain.

Second, the Master Plan gives greater sensitivity to historic sites, cultural values and Native Hawaiian issues. The designation of the vast majority of the Science Reserve as a natural cultural preserve is a recognition of the cultural resource value of the mountain. All designations of burials were removed from the Plan. Where known, earlier indigenous place names are used instead of English names or Hawaiian names of later derivation. An example of this is the use of the name Kūkahau‘ula for the summit cone. Historic trails are identified and marked for preservation. Larger Shrine complexes are identified for better protection and management. An ethnographic study and archaeological study were specifically commissioned for the master planning process. Both studies were the most extensive studies of their kind on the mountain to date.

Third, the Plan protects all undeveloped summit pu‘u. As mentioned previously, Poli‘ahu was deleted out of the astronomy precinct even though it is recognized as an excellent observatory site and a roadway and test telescopes were previously placed on the cone. The Plan specifically identifies undeveloped pu‘u as features that need special consideration. The recognition that these pu‘u were seen as the kino, physical manifestation, of akua played a role in this special consideration. The potentially negative visual impact on the cultural landscape of development on the ridges and pu‘u was also a consideration in this decision.

Finally, to maintain sensitivity to these issues, the master plan proposes a Mauna Kea Management Board as an integral part of the management of the mountain. These community voices will play an important role in keeping a broad management perspective. Beyond the Board, the Master Plan recommends that a Kahu Kūpuna Council be established to assist the Office of Mauna Kea Management in addressing these issues. This is a recognition that Native Hawaiian concerns are of special value and require special knowledge and wisdom to address appropriately. This committee will be composed of experts in Hawaiian culture and practice and will advise the Office in developing appropriate protocols and programs for the mountain and its management. Docent programs and training sessions will be developed to improve the cultural management skills of staff and broaden the sensitivity of workers and visitors.

Land Ownership: The question of land ownership was brought up many times in different forms. The summit of Mauna Kea is State land controlled by the Department of Land and Natural Resources and leased to the University of Hawaii. Sometimes the comments would focus on the ceded lands issue and how this meant that OHA or some other representative organization of kanaka maoli should receive rent for the land and have decision making authority over the land. Comments were made that Mauna Kea is not “your” land, it is Hawaiian land, and that ceded land is just a legal euphemism for stolen colonized lands.

The Master Plan does not respond to comments on sovereignty, ceded land revenues and the public trust because these issues are larger than the Mauna Kea Science Reserve Plan or the University of Hawai'i. They are beyond the scope of the Plan. The Plan is based on the 1968 lease from the Department of Land and Natural Resources (Lease No. S-4191) to the University of Hawaii and the provisions contained in that lease.

Regarding ceded land, current negotiations between OHA and the State of Hawai'i will set the tone for the manner and type of compensation. Also, the University, as an educational institution, is a beneficiary of the trust and is exempt from the payment of the 20% revenues to Native Hawaiians. As a co-beneficiary, the University is also a recipient of public trust revenues. Additionally, the position that the land belongs to native Hawaiians and not the broader public, as represented by the State of Hawai'i, is not addressed in the study because that issue is also beyond the scope of this plan.

Sacredness of the Mountain/Summit: Along with reverence for the beauty and grandeur of Mauna Kea there is a broad sentiment about the sacredness of Mauna Kea as the piko (highest point) in the Hawaiian Islands and the Pacific Basin. Also, the mountain's association with Wākea the sky father and the snow goddess Poli'ahu and her kin add to this belief. The shrines on the summit area enhance the sense of sacredness, as do the one known and three suspected burial sites on the upper slopes. There has also been oral testimony about burials of important ancestors in the summit area. Others have said that the region is wao akua, the realm or wilderness of the gods. Some have stated that construction on the summit should stop because it is a desecration of the sacred mountain. Some have claimed that development has disturbed the iwi of ancestors. As a comparison it has been questioned whether astronomers would build on the sacred sites of other people.

These sentiments have been some of the most difficult to resolve. Distinctions between the sacred and the profane are not the same in Hawaiian culture as they are in western societies. Wao aku is not heaven as the literal translation would imply. It did not mean people did not do things or build things in the sacred place. If this were so, the existence of Keanakāko'i in the summit region would not make sense. Keanakāko'i is the largest known paleolithic adze quarry in the world. The adze quarry is literally a manufacturing place for stone implements with shelters, work stations and shrines. What seems important is the protocol, the attitude of respect and appreciation for nature and gods. Worship and daily life were one in the ancient culture. One asked permission of the gods and the aina before one took or used the resource and then thanked the gods for their forbearance and generosity.

Process is as important as substance in this situation. Each situation must be viewed individually with the appropriate sensitivity. The Master Plan responds to these concerns by creating a new management office and Kahu Kūpuna Council. The Office of Mauna Kea Management should develop new protocols that express this attitude. These protocols should be developed with the advice of the Kahu Kūpuna Council and include broad representation from the Native Hawaiian community. These protocols are

appropriately a part of the management rules and regulations that will be adopted pursuant to Chapter 91. The rule making process is separate from the Master Plan process and takes anywhere from one and a half to two years to complete. We already know that the values of aloha ‘āina, lōkahi and malama pono need to be respected. Ahupua‘a management principles should also be used as guides where they are appropriate. The incorporation of these values into the rules and management structure of the mountain will be the responsibility of the Office of Mauna Kea Management.

Traditional Cultural Practices: Concerns have been expressed in public testimonies that traditional cultural practices will be restricted and sites desecrated. Some of this fear and anger stems from an unfortunate incident that occurred because of misdirected policy on the part of a member of the University of Hawai‘i maintenance staff. A current cultural practitioner had created new ahu type shrines with special stones, pōhaku, in the summit region. Maintenance staff removed the rocks. Apologies have been made and the staff instructed to leave such features alone in the future, but suspicion and hurt feelings remain. Other comments stem from the implications of the State Supreme Court’s PASH decision and what this means for cultural resources in the Science Reserve. A specific example that has been raised is the modern day removal of adze material from Keanakāko‘i to make adzes and other stone tools. Another example is the alternation of shrine sites in renovation and repair efforts as modern practitioners re-use these sites in revivals of earlier worship activities.

In early discussions there were suggestions that modern cultural practitioners be given designated areas to engage in cultural practices. This suggestion was rejected because it was felt that there was no reason to place such restrictions on cultural practitioners.

The Master Plan does not restrict traditional cultural practices anywhere in the Science Reserve. The single exception is to activities that may impact known historic sites. The responsibility for protection of historic sites rests with the State Historic Preservation Office and they are statutorily required to protect these sites. These procedures will be incorporated into rules and regulations that will be guided by Dr. Holly McEldowney’s Historic Preservation Plan which was commissioned for the Master Plan. DLNR does not have enforcement personnel on the mountain and will rely on the management staff of the University of Hawai‘i to assist in this mission. Additionally, staff training programs and docent programs will raise the awareness level of all people who would be involved in some aspect of the management of Mauna Kea. Finally, while the common perception is a fear of restrictions on traditional practices, in reality the Plan represents a restriction on astronomy development.

Historic Sites: Charges have been made that historic sites have been damaged and bones have been desecrated. Others have stated that only a portion of the summit area has been surveyed and a complete inventory is needed. The concept of viewing the summit region as a cultural landscape rather than scattered distributions of individual sites has taken on greater value. Comments have often noted that landforms are often significant features and that the relationships between forms is as important as the features themselves; including areas that are devoid of features.

One incident of the disturbance of a lithic scatter site near Hale Pōhaku has been documented. The State of Hawaii has not been able to verify charges relating to the desecration of bones because the people making the statement have not disclosed the locations where the incidents took place. Also, no reports about bones being exposed were filed during construction of the observatories to verify the charge. Finally, the archaeological survey conducted by DLNR for the master plan did not identify any burial sites impacted by construction. Without information it has been impossible to verify or deny the charge. However, these comments have been persistent. The veracity of this criticism is difficult to assess since cultural protocols often prohibit knowledgeable people from disclosing this information.

The Master Plan response was to commission DLNR to conduct an archaeological survey, evaluate the cultural significance of the summit area and develop a management plan for the cultural resources. These studies were commissioned a year and a half ago. The completed inventory is the most extensive study of its kind done to date. The management plan is still in a preliminary draft stage. While a more comprehensive inventory would be good to have, due to limitations of time and funding the study focussed on the areas that have greater potential of being impacted. The university will institute a monitoring program for historic sites and encourage future studies in this area.

Based on the study commissioned for the Master Plan, DLNR is considering designating the summit region as a traditional cultural property, with appropriate regulatory criteria, which have not yet been developed. The Office of Mauna Kea Management will need to consider these criteria in developing their rules and regulations. The Master Plan recognized the concept of natural landforms being the kino or physical embodiment of gods and spirits and the plan protects all undeveloped pu‘u. The concept of the cultural landscape is recognized in the designation of the vast majority of the Science Reserve as a natural cultural preserve. The Astronomy Precinct was deliberately framed to maximize the visual panorama of the cultural landscape.

Environmental: Testimony on environmental mismanagement has covered a broad range of issues but centered mostly on three areas: the decline of the wēkiu bug population and the destruction of its habitat, the lack of adequate information and monitoring programs and the lack of carrying capacity studies of the summit. The decline of the wēkiu population has been noted in many comments. Some comments express concern about the Palila habitat at the Hale Pōhaku elevation.

Much of the known information about environmental resources is a result of studies commissioned for master planning efforts in the early 1980s and the current effort. Recent studies commissioned for the Master Plan show a significant decline in the population of the wēkiu bug. While the reason for the decline in population is not known (several theories have been postulated from lack of snowfall, loss of habitat to new alien predators) future monitoring programs are expected to provide more information that will address the question and suggest solutions. The habitat of the endemic wēkiu bug is the cinder cones in the summit plateau region. Destruction of

some prime wēkiu habitat was expected to occur during the development of the ridge sites for observatories.

The Master Plan responds to the issue by minimizing the potential destruction of additional sites by protecting undeveloped summit cones (the primary wēkiu bug habitat) from future development. Additionally, within the existing developed summit ridge, construction will be limited to recycling of existing sites, which are already impacted to minimize areas of disturbance. It should be noted that in the most recent study, more wēkiu were found near disturbed sites close to the observatories than in relatively undisturbed sites along the summit cone.

Carrying capacity is a broad, vaguely defined concept that refers to the capacity of a place to receive or “carry” an activity or population. This capacity is often defined in terms of density related to the supporting infrastructure or resource base. The term originates from biological population studies of animal and plant species, which proliferate beyond the ability of the resource base to support them and the population crashes. It is closely related to the notion of sustainable yield. Others have suggested measures such as social carrying capacity but these concepts are vague, culture bound and highly subjective. There is no clear consensus about what social or cultural carrying capacity should measure and how they should be measured. Without identified criteria or methodology it was decided that defining social or cultural carrying capacity would not be a fruitful exercise to pursue further. Therefore, a carrying capacity study was not conducted because it was clear that regarding physical carrying capacity, the mountain is huge, existing infrastructure has available capacity and the site’s physical capacity far exceeded what was proposed for the mountain. The Plan responds to the concern behind the question by severely limiting telescope development well below physical limitations and regulating development of facilities.

Visual Impact: Many comments were made about the visual impact of the observatories. Some said they were ugly like pimples on the mountain. A few thought they were beautiful and inspiring. Others said the scale was inappropriate to the mountain and they alter the natural pristine quality of the landscape with an industrial look. Some suggested burying sections of the observatories to reduce visual impact.

The Master Plan responds to these issues by recommending color changes, directing material selections, recommending design solutions and other methods to reduce impact. Top scientists and technicians have been contacted and they have indicated a willingness to address the challenge of reducing the visual impact of observatory facilities. In addition, the master plan has set up design criteria and a design review process that will ensure designs that minimize visual impact. The criteria and guidelines that have been recommended are the most challenging in the world for astronomy facilities.

Commercial Activity: Some have expressed concern about commercialization of the mountain. People seem generally opposed to commercial uses of the Science Reserve. Some have stated that astronomy is a commercial activity. Others have said 20% of revenues from commercial uses should be given to OHA.

Other than minor concession operations and the possible periodic rental of cabins at Hale Pōhaku no commercial operations are proposed in the Master Plan. The University of Hawai'i views astronomy as an educational and research activity, not a commercial activity. Under current DLNR licensing procedures, purely commercial uses will pay 20% to OHA.

The Master Plan establishes the Office of Mauna Kea Management to address commercial activities and their coordination with the Department of Land and Natural Resources.

Hunting: The Master Plan places no restrictions on hunting. It should be noted that DLNR continues to retain all jurisdiction over hunting from the forest reserve to the summit in the lease of the Science Reserve to the University. At an early stage in discussion there were suggestions of placing a fence around the summit at a certain elevation to reduce the impact of feral ungulates. However, this suggestion was not accepted as part of the Master Plan.

Positions on Development: Many voices in the public hearings and the oral history interviews expressed the sentiment that there should be no more expansion of facilities. A smaller number have supported expansion of quality facilities and the needs of astronomy. Some have called for the dismantling of what is there. Others have said it is a clean industry providing good jobs. Others have said that while astronomy is good development has been unbalanced toward astronomy and other disciplines not supported.

The goal of the Master Plan has been to balance the various interests and uses on the mountain. A no-build option would have a severe negative impact on astronomy. Like any high technology enterprise, astronomy must continually upgrade and innovate in order to remain competitive. On the other hand, the possibility of development occurring anywhere in Science Reserve (VLBA is an example) was also changed because that position unbalances the scale too much in astronomy's favor to the potential detriment of other interests such as cultural and environmental resources. The Master Plan response was to designate the remainder of the area outside the Astronomy Precinct as a natural and cultural preserve. During discussions in the Advisory Committee some people felt recreational snow play and skiing were inappropriate in a sacred area. However, the Plan accommodates recreational uses with a support facility near the "poi bowl" area of the summit. The Plan hopes to achieve a balance that protects resources and promotes valuable uses.

Management: Many concerns about management were raised in the various meetings. Issues ranged from poor trash removal to hours of operation of the visitor center; non-management of cultural and environmental resources was raised. Most of the complaints were about what was not done and the lack of resources provided to achieve the management responsibilities. A related issue was a perception of confusing and overlapping jurisdictions resulting in certain functions being neglected. Inadequate safety measures and lack of enforcement of CDUA conditions and lack of oversight over

construction practices and a number of similar issues were raised. Lack of local decision making authority was frequently cited in the early discussions. Some concern was raised about the mountain being controlled by foreign, national and international agencies. Criticism was raised that IfA only took care of the interests of the astronomy community to the detriment of other interests.

The master planning process responded to the suggestion of alternative management schemes very early in the process. Due to multi-agency responsibilities a third party alternative that supercedes UH and DLNR was suggested. The independent third party commission modeled after the Kaho'olawe Commission was seriously considered and ultimately dropped as infeasible by the Advisory Committee because it would take legislation to authorize, create a whole new bureaucratic organization and require the agreement of the Board of Regents and the Land Board to implement. Also, preliminary discussions with the Board of Regents and the Board of Land and Natural Resources indicated that neither Board was willing or able to delegate the authority necessary to create a new agency with the suggested authority. Other management options that were discussed included DLNR taking complete responsibility for management but this idea was dropped when it was pointed out that DLNR's Statewide responsibility made it unlikely that sufficient resources would be available and dedicated to Mauna Kea. The idea of the University of Hawai'i taking full responsibility was also suggested but objections related to off island decision-making and lack of accountability to the local community resulted in this option being dropped. There were suggestions of the UH hiring the equivalent of a third party land manager, like a property manager, to manage the land. RCUH and the Nature Conservancy were mentioned as possible management entities. Questions of accountability were raised and some of the agencies suggested were not eager to take on the responsibility. A final option mentioned was to treat the mountain like a park. Some even considered moving the mountain into the National Park Service jurisdiction and letting the Service manage the mountain like Volcanoes National Park. Committee members cooled to the idea when they considered the loss of local control and the change in the mission of the managing entity.

The Master Plan proposes the creation of the Office of Mauna Kea Management out of the Office of the Chancellor of UH Hilo. By placing the Office under the Office of the Chancellor it becomes a visible and integral part of the University system and represents a more permanent and direct commitment. The lack of funding commitment to management was addressed by President Mortimer in a letter to the advisory committee wherein the administration stated that \$400,000 dollars would be committed toward the establishment of the Office of Mauna Kea Management upon adoption of the Plan. The importance of managing the broad resources of Mauna Kea is now well understood. This was not the case earlier as management was conducted with a more narrow focus. This broadened focus also creates the potential for other revenue sources. The creation of the Mauna Kea Management Board also maintains a community voice that will insist on maintaining the proper funding priorities and commitments and retaining a broad view of the mountain's resources.

The issue of local authority is addressed by placing the management office in the Office of the Chancellor of UH Hilo. While policy authority remains with the Board of Regents, management authority is now delegated to Hilo. Issues and concerns can now be addressed locally. Community input will have a clear and singular doorway through which its concerns can be addressed rather than the amorphous and remote structure that is currently in place. The suspicions about foreign control of the mountain will be addressed when the public realizes that the Office has real authority on the mountain and the observatories develop more outreach programs into the community.

Lack of Trust: Lack of trust is a special problem closely related to management but different and associated with specific past experiences and history of relationship between the University of Hawai'i, DLNR and the public. Many comments expressed skepticism about the commitment of the responsible agencies to the task of managing the resources of Mauna Kea. Both the University of Hawai'i and the Department of Land and Natural Resources were faulted. Lack of funding commitment for management purposes raised skepticism about the current promises. The issue of local control is also connected with the issue of trust. Reasons cited for this lack of trust included the following:

- Prior advisory committee was never convened.
- Previously promised monitoring was not conducted.
- Prior ranger positions never funded and the positions were cut during budget cutbacks.
- Trash control measures were not enforced and clean-up efforts were inadequate.

The Master Plan response is the creation of the Mauna Kea Management Board and the establishment of the Office of Mauna Kea Management on the Big Island. This should go a long way towards restoring trust as there will now be a face and physical presence with authority to address community concerns. The new agency exists outside IFA and has a broader mandate. The Management Board will be staffed and the Office will have rangers on the mountain to educate users and manage resources. The visitor center director will coordinate community programs on the mountain while the Hilo office will interface with the broader community. Additionally, trash clean-up has been greatly improved and the old equipment have been removed.

Access: The question of access has been raised many times: in committee, in public meetings and in individual presentations to special groups. Concerns included fears of restrictions for traditional practices, hunting and recreation.

In a rare unanimous vote the Advisory Committee recommended managed access as opposed to completely unrestricted access or restricted access. Unrestricted access was rejected because committee members clearly understood the safety issues involved when uniformed people travel into the high altitude environment. They also understood the potential damage to cultural and natural resources, especially through the use of all terrain vehicles and recreational activities that take people off the summit road.

Restricted access was not supported because members viewed the mountain as a resource for all the people of Hawai‘i and there was strong belief that it should remain open to the many interests that exist.

The Plan repeatedly states that access will be managed, not restricted. Managed access means that visitors will need to register at the visitor center, receive an orientation about safety issues and the value of the resources on the mountain, receive information about any applicable rules and then be sent on their way. The purpose of the managed access is to protect resources and enhance public safety. Rules are suggested to prohibit the use of off-road vehicles. Weather conditions, repairs and emergencies will also dictate some level of management. Suggestions for nighttime vehicular movement also indicate additional guidelines.

Hazards: The following concerns about hazards have been expressed:

- High altitude can make people sick; they should be informed.
- The summit road is steep and unsafe for normal cars; brake failure is common.
- Weather changes quickly and can kill.
- Hypothermia and snow blindness are real dangers.
- Fires around Hale Pōhaku can be hazards to people and natural resources.
- Construction at high altitudes has special hazards such as pulmonary edema and lack of concentration due to low oxygen.

The Master Plan responds to hazards with the registration/orientation program and an emergency response system implemented by rangers. Management of access will also help address these concerns. A single point of management authority will also allow for oversight into construction and operational safety practices in the Science Reserve.

Process: The master planning process was criticized as exclusive, confusing and insincere. Keeping the Advisory Committee meetings closed generated suspicion and resentment. The multiple drafts have been confusing and there have not been enough copies for review. Some have stated that the approval process should stop while the community discussions are taking place; otherwise the effort is not genuine. The credibility of the consultants has been questioned. Others have said the results were foregone conclusions.

The closed meetings of the Advisory Committee was a decision made by the Committee early in its proceedings but the purpose was for manageability not exclusivity. The composition of the group is proof that it was not meant to be exclusive. The accessibility of documents was a problem and draft 3A was placed on the UH web page to increase its accessibility. The multiple drafts were the result of trying to keep the public informed of an evolving document. Normally, these would have been internal drafts not available for public review. Although some have viewed the process with suspicion, the efforts to create an open process added to the confusion.

Benefits to the Public: The benefits of the development on the mountain was the subject of a number of testimonies. People recognize the general economic, scientific and research benefits of astronomy. Local residents, including part Hawaiians, increasingly fill these jobs as the workforce receives training. However, many Native Hawaiian speakers questioned the value of the development to Native Hawaiians. Some questioned the quality of jobs given to local people.

The Master Plan creates a physical plan and management structure that seeks to preserve a balance that allows astronomy to continue its evolution as a premier ground based viewing location and its associated economic benefits. At the same time, the Plan protects cultural, environmental and recreational interests. It provides resource protection and improves safety on the mountain for all users by the placement of rangers on the mountain and opening Hale Pōhaku to more users.

Regarding direct benefits to the Native Hawaiian community, the Master Plan does not specifically address the issue as a separate topic. It is an area of ongoing discussion. The master planning process has heightened awareness about the need for more proactive programs in this area. Several are now being reviewed and considered. A positive note from the public testimony is the number of local people working in good jobs in the astronomy industry. Many young, part Hawaiian residents are part of this growing workforce. The October 1999 edition of National Geographic highlighted the role of local resident Gary Puniwai and his important role as operator (equivalent to ship's captain) of the Keck telescopes.

More work beyond the Master Plan needs to be done. This should be one of the major focus areas for the Office of Mauna Kea Management, UH Hilo, UH, astronomers and the Hawaiian community.

**MAUNA KEA SCIENCE RESERVE
MASTER PLAN**

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