

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
OFFICE OF CONSERVATION AND COASTAL LANDS
Honolulu, Hawaii

December 13, 2019

**Board of Land and
Natural Resources
State of Hawaii
Honolulu, Hawaii**

REGARDING: 2019 Annual Report on the status of the implementation of the Mauna Kea Comprehensive Management Plan (CMP) (non-action item)

PERMITTEE: University of Hawaii at Hilo

REPRESENTATIVE: Stephanie Nagata, Director, Office of Mauna Kea Management, 200 W. Kawili Street, Hilo, HI 96720

LANDOWNER: State of Hawaii; leased to the University of Hawaii under General Lease S-4191

LOCATION: Mauna Kea Science Reserve, Ka'ohē Mauka, Hāmākua District, Hawaii

TAX MAP KEYS: (3) 4-4-015:009 (Maunakea Science Reserve)
(3) 4-4-015:012 (Halepōhaku)

ARE OF PARCEL: approximately 11,288 acres (Mauna Kea Science Reserve)
19.3 acres (Halepōhaku)

SUBZONE: Resource

ATTACHMENTS: Exhibit 1: Map of University Management Areas on Maunakea
Exhibit 2: Maunakea Background Information
Exhibit 3: Google Earth Map of Observatories
Exhibit 4: 2019 Annual Report to the Board of Land and Natural Resources
Exhibit 5: Schemata of Maunakea Ecosystems

BACKGROUND

On April 9, 2009, the Board of Land and Natural Resources approved the Maunakea Comprehensive Management Plan (CMP) for the Maunakea Science Reserve, including Halepōhaku and the Summit Access Road, Ka'ohē, Hāmākua District, Hawaii.

On March 25, 2010, the Board approved four associated resource subplans which elaborated on the management actions contained in the CMP. The four plans were the Natural Resource Plan, Cultural Resources Management Plan, Public Access Plan, and Decommissioning Plan.

A condition of the approval is that the University Board of Regents, or its authorized designee, submit annual reports to the Board of Land and Natural Resources, in writing and in person, with information regarding the status of the development of each sub plan, and the status of the development of each management action.

This current report reflects the ongoing management actions and activities in the Science Reserve. The full report is attached as Exhibit 4.

This and previous years' reports are available on OCCL's website at dlnr.hawaii.gov/occl/maunakea-management.

OCCL notes that CMP is in the process of being updated. OMKM is currently preparing a report on the status of the cultural and natural resources for Maunakea. This will form the basis for any proposed revisions to the CMP. At the end of the process the revised CMP will be presented to the BLNR for consideration.

AUDITOR'S REPORT

In November 2019 the Office of the Auditor released their *Report on the Implementation of State Auditor's Recommendations 2014-2017*, Report No. 19-15.

Of the eight recommendations that the Auditor made in Report No. 14-07, four have been implemented, two are no longer applicable, and two are in the process of being implemented. The ones that are in process are **Recommendation 1.a:** *The University of Hawai'i should adopt administrative rules governing public and commercial activities as soon as possible, but no later than 2017;* and **Recommendation 2.a:** *The Department of Land and Natural Resources should continue working with UH to renew the general leases for the UH-managed lands on Mauna Kea and ensure the leases are substantially in the form DLNR's Land Division recommended for approval by the land board.*

Regarding Recommendation 1.a: University of Hawai'i Board of Regents approved administrative rules for University of Hawai'i managed lands at a special meeting held at UH Hilo on November 6, 2019.

Regarding Recommendation 2.a: The general lease for UH-managed lands expires in 2033. The University has notified DLNR that they are preparing a draft Environmental Impact Statement that will explore a renewed land authorization on Mauna Kea.

OCCL notes that there are no remaining pending recommendations from the State Auditor's from their Audit of the Management of Mauna Kea and the Mauna Kea Science Reserve.

RECOMMENDATION

OCCL is presenting the attached annual report as a “non-action” item on the Board’s Agenda. We have invited a representative from the Office of Maunakea Management to give a brief presentation to the Board.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Michael Cain".

Michael Cain, Staff Planner
Office of Conservation and Coastal Lands

Approved for submittal,

A handwritten signature in blue ink, appearing to read "Suzanne D. Case".

Suzanne D. Case, Chairperson
Board of Land and Natural Resources

UH Management Areas

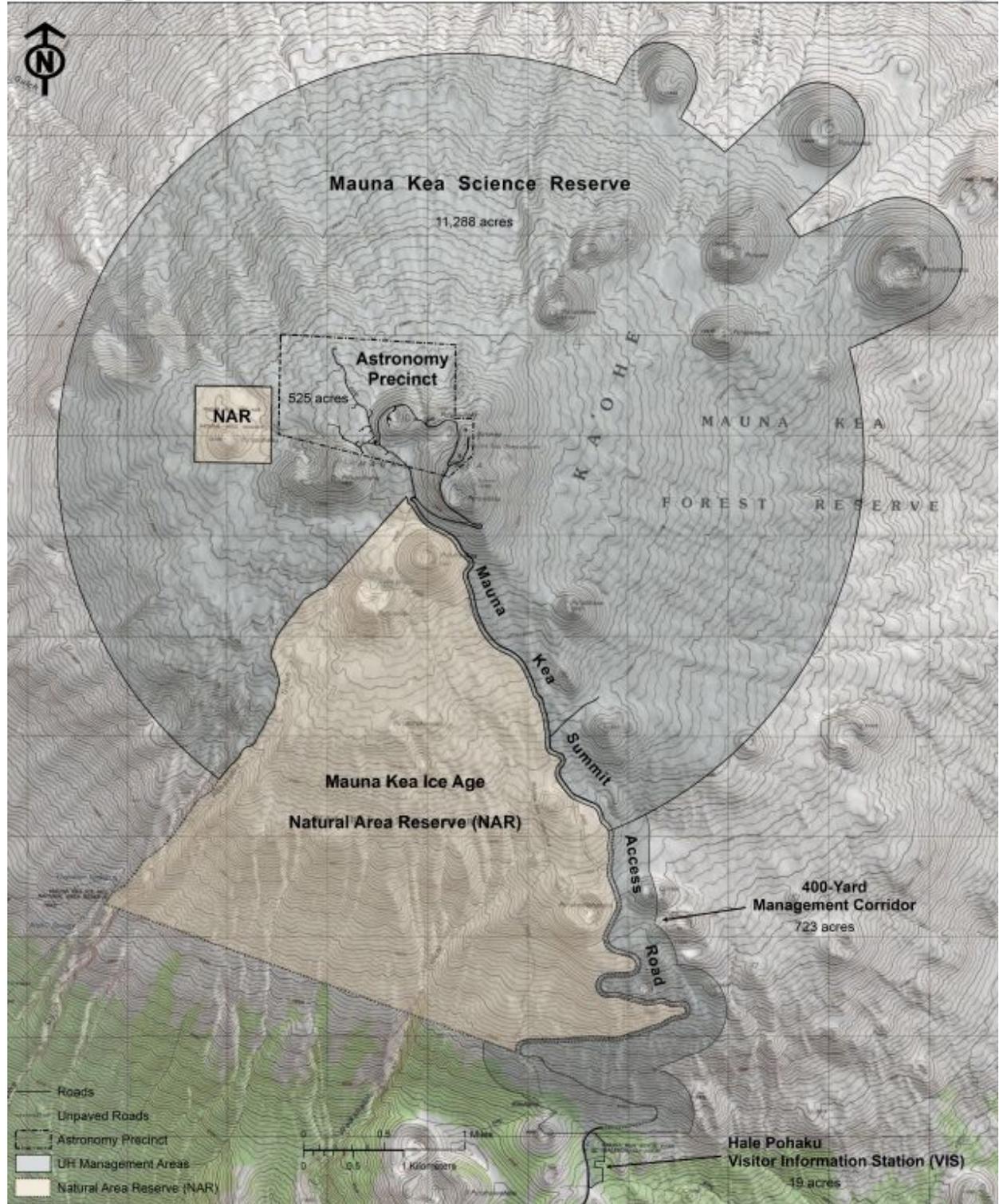


Exhibit 1: Map of University Management Areas on Maunakea

THE MAUNAKEA SUMMIT¹

For the sake of clarity, OCCL will use the following terms for the summit region in this report:

The **summit plateau** is the alpine desert ecosystem 3900 meters above mean sea level. The slope shifts abruptly here, from approximately 27% downslope to less than 10% on the plateau. Geological evidence indicates that this broad, circular region was formed by remnant lava flows in the former caldera, and subsequently sculpted by glaciers. The plateau itself varies only approximately 100 meters in elevation, but it is dotted with scattered cinder cones that rise 30 to 180 meters above the surface of the plateau. Other significant geological features are the outcrops of hawaiite, an olivine basalt formed via the interaction of glacial ice and hot lava, and prized for adze making; the alpine Lake Waiau; and remnant glacial from previous episodes of glaciation in the summit region. The highest point is 4205 meters.

Pu'u o Kūkahau'ula is the traditional name for the cluster of cones and ridgelines that are above 4080 meters. The names of the individual cones, Pu'uwēkiu, Pu'ukea, and Pu'uhau'oki, are believed to be more recent cartographic designations.

The State Historic Preservation Division identifies Kūkahau'ula, as well as Lake Waiau and Pu'u Līlinoe on the summit plateau, as *traditional cultural properties*. This area has a strong association with Hawaiian folklore and mythology.

The **north plateau** is the portion of the summit plateau to the north of Kūkahau'ula, identified as the Great Rocky Table Summit in an 1891 government survey.

The **lower summit region** is the alpine shrub and grassland ecosystem above the tree line at 2900 meters. OCCL notes that the record indicates that the tree line has shifted down-slope since the introduction of cattle.

Maunakea's **lower slopes**, from approximately 2000 meters to the tree line, is composed of a māmane-naio forest.

COMPREHENSIVE MANAGEMENT PLAN

The Board of Land and Natural Resources approved a Comprehensive Management Plan (CMP) for University-managed lands on Maunakea on April 9, 2009. The CMP included management actions of previous management documents, including the 1995 Management Plan for UH Management Areas and the 2000 Mauna Kea Master Plan.

A CMP, as opposed to the standard Management Plan referred to in Hawai'i Administrative Rules, is needed for larger parcels with multiple significant land uses. The CMP provides a framework and management guidelines ranging from the preservation of cultural and natural resource, to the management of the built environment, construction activities, and access to outreach and education.

The Maunakea CMP contained 103 management actions and associated reporting requirements that would govern the future of Maunakea. A condition of BLNR approval was that the University develop a *Project Development and Management Framework* and four resource sub-plans *Natural Resources Management Plan*; *Cultural Resource Management Plan*; *Public Access Plan*; and *Decommissioning Plan*. The Resource subplans were approved by BLNR on March 25, 2010.

The University of Hawaii Board of Regents (BOR) is the entity ultimately responsible for the implementation of the Management Plan.

The Office of Maunakea Management submits annual reports to the BLNR discussing status of the implementation of each management section.

¹ A note on spelling: The UH School of Hawaiian Language recommends spelling Maunakea and Halepōhaku as one word. The Office of Maunakea Management adopted the one-word spelling in 2013. This report will follow this format unless the two-word spelling (Mauna Kea) is part of a proper name or direct quote

MAUNAKEA ADMINISTRATIVE UNITS

The Department of Land and Natural Resources (DLNR) managed areas in the summit region and upper slopes of Maunakea are the Mauna Kea Natural Area Reserve and the Mauna Kea Forest Reserve. The University of Hawai'i managed areas are the Maunakea Science Reserve, the Halepōhaku Midlevel Facilities, and the Maunakea Access Road between Halepōhaku and the summit.

The lower slopes of Maunakea also contain lands managed by or under the jurisdiction of the Department of Hawaiian Homelands, the U.S. Army (Pōhakuloa Training Area), and the U.S. Fish and Wildlife Service (Hakalau Forest National Wildlife Refuge). The County of Hawai'i maintains the Access Road below Halepōhaku.

Mauna Kea Forest Reserve: The Forest Reserve encompasses 52,500 acres, and is under the jurisdiction of DLNR's Division of Forestry and Wildlife (DOFAW). The māmane forest here is critical habitat for the federally listed palila.

Mauna Kea Ice Age Natural Area Reserve: The 2033-acre reserve was created in 1981. It is managed by DOFAW's Natural Area Reserve System. Among its unique geological and cultural features are the Keanakakoi adze quarry, Lake Waiau, and Pu'u Pōhaku. The Mauna Kea NAR is bounded by the Science Reserve and the Mauna Kea Forest Reserve.

The Maunakea Science Reserve is an 11.288-acre State-owned leased by the University of Hawai'i under General Lease S-4191, with day-to-day management delegated by the Board of Regents to the Office of Maunakea Management (OMKM). It contains most land within a 2.5-mile radius of the site of the UH 2.2-m telescope – in effect, all land above 3700 meters in elevation except for a pie-shaped wedge set aside as the Mauna Kea Ice Age Natural Reserve. The Science Reserve also includes a section in the lower summit region where the Very Long Baseline Array is located.

Halepōhaku is a 19.3-acre State-owned parcel below the summit region leased to the University of Hawai'i through 2041 under General Lease No. S-5529, which describes the character of use as “premises leased to be used solely for permanent mid-level facilities, a construction camp, an information station as well as existing facilities purposes.” It is the site of the Onizuka Center for International Astronomy (Halepōhaku Mid-Level Facilities).

The portions of the **Summit Access Road** that extend from Halepōhaku to the boundary of the Science Reserve is also under UH management. This includes a 400-yard corridor on either side of the road, excluding those areas within the adjacent Mauna Kea Ice Age Natural Area Reserve.

The University's 2000 Master Plan proposed the creation of an astronomy precinct encompassing approximately 525 acres of the overall Science Reserve. Although the Master Plan was never formally adopted, the term 'astronomy precinct' continues to be used informally in planning documents.

DLNR MANAGEMENT RESPONSIBILITIES

The **Division of Forestry and Wildlife** (DOFAW) manages the Mauna Kea Forest Reserve, as well as outdoor recreation programs, trail and access systems, and the hunting program.

Land Division is charged with the management and enforcement of leases, permits, executive orders, and other encumbrances.

The **Office of Conservation and Coastal Lands** (OCCL) is responsible for the permitting and regulating of land uses in the Conservation District. Conservation District Use Applications are processed by OCCL, although the Board of Land and Natural Resources has the final authority to modify, grant, or deny permits. OCCL is also responsible for investigating potential land use violations and permit violations.

The **State Historic Preservation Division** (SHPD) is charged with preserving and protecting historically and culturally significant properties as outlined in the National Historic Preservation Act, the Statewide Historic Preservation Plan, and Chapter 6E of the Hawai'i Revised Statutes. SHPD-managed programs include: Statewide

Inventory of Historic Properties, Burial Sites Program, Certified Local Government Program, National Main Street Program, Historic Preserves Program, Information and Education Program, Interagency Archaeological Services, and maintenance of the Hawai'i and National Register of Historic Places. SHPD also reviews proposed development projects to ensure minimal effects of change on historic and cultural assets.

The **Hawai'i Island Burial Council** (HBC) falls under the jurisdiction of SHPD, and is responsible for the management of all human remains over fifty years old. Burial protection plans and burial treatment plans on Maunakea are required to be done in consultation with the HBC.

The **Division of Conservation and Resource Enforcement** (DCOARE) is responsible for enforcing all laws and rules that apply to lands that are managed by DLNR. Pursuant to Act 226 Session Laws of Hawai'i 1981, DCOARE's enforcement officers have full police powers to execute all state laws and rules within all state lands.

UNIVERSITY MANAGEMENT RESPONSIBILITIES

The BLNR approved a Project Development Implementation Framework on February 18, 2010 that established a new management structure for the Science Reserve. The framework was based on the 2000 Mauna Kea Science Reserve Master Plan. The management structure now consists of:

- **The Office of Maunakea Management (OMKM):** The office is charged with the day-to-day management of the Maunakea Science Reserve as prescribed in the Master Plan, and reports directly to the UHH Chancellor.
- **Maunakea Management Board:** An advisory body comprised of seven members of the community who are nominated by the UH Hilo Chancellor and approved by the UH Board of Regents.
- **Kahu Kū Mauna Council:** A nine-member Native Hawaiian council appointed by the Board, and that advises the Board and Chancellor on cultural matters and issues

In addition, OMKM coordinates several advisory committees, including an Environment Committee and a Wēkiu Bug Scientific Committee.

The University's **Institute for Astronomy** (IfA) is responsible for conducting and coordinating astronomical research in the Science Reserve.

The **Maunakea Observatories Oversight Committee** is funded by the observatories, and contains representatives from each observatory as well as IfA. The funds are used to fund road maintenance, snow removal, facilities maintenance, management at the midlevel facilities, the Visitor Information Center, weather forecasting, and other common activities affecting the observatories.

The **Maunakea Observatories Support Services (MKSS)** oversees the Visitor Information Station, provides administrative support for the weather center and communication system, and operates the food and lodging at Halepōhaku. MKSS provides administrative support to OMKM for the Maunakea Ranger program.

The **Maunakea Ranger Program** was established in 2001 to provide daily oversight on University-managed lands. The rangers help educate the public about the natural and cultural resources of Maunakea, advise visitors of the hazards of high-elevation travel, safe driving information, and participate in search and rescue operations. In addition, they report potential violations of DLNR rules in the surrounding Forest Reserve and Mauna Kea Ice Age Natural Area Reserve. Other duties include conducting trail maintenance, invasive species removal, coordinating litter removal, and assisting with research on the summit. Rangers conduct daily patrols of Kūkahau'ula, and assist DLNR with monthly patrols and trash pick-up at Lake Wai'au, and periodic patrols to the Keanakakoi adze quarry, both part of the NARS.

MAUNAKEA OBSERVATORIES

There are currently thirteen observatories in the Maunakea Science Reserve: nine optical/infrared observatories² and three radio observatories³ on Kūkahau'ula, and one radio observatory⁴ in the lower summit region. A permit has been issued for one optical / infrared observatory⁵ for the northern plateau in the Maunakea Science Reserve.

Two these telescopes are non-operational. The Caltech Submillimeter Observatory (CSO) was no longer scientifically competitive once the Atacama Large Millimeter/Submillimeter Array came online in Chile in 2011. Caltech has filed a Notice of Intent to Decommission, and has begun pre-assessment consultation and scoping for the decommissioning of the observatory. The UHH 0.9-m telescope, Hōkū Ke'a, is also non-operational. The University has filed a Notice of Intent to Decommission this telescope. The remaining observatories remain scientifically competitive.

University of Hawai'i 2.2-meter Telescope (UH2.2)



The University of Hawai'i 2.2-meter telescope (UH2.2) was built in 1968 and became operational in 1970, making it the first large telescope built on the summit of Maunakea. It is currently owned and operated by the University of Hawai'i.

UH2.2 is the primary telescope used by UH professors, postdocs, and graduate students. In 1991 scientists discovered the first Kuiper Belt object, and in 1992 a team discovered forty-five of the known moons of Jupiter and additional moons on the outer planets. Current science includes an integral field spectrograph devoted to the observation of supernovae.

BLNR approved CDUP HA-954, an 'after-the-fact' permit, for the telescope in September 1977.

UH Hilo Hōkū Ke'a Educational Observatory

The original 0.6-meter telescope on this site was built by Air Force Cambridge Research Laboratories in 1968. Ownership was ceded to the UH Institute for Astronomy in June 1970, and transferred to the UH Hilo Department of Physics in 2003.

The original telescope was decommissioned in 2008, and a 0.9-meter telescope named Hōkū Ke'a was installed in its place. This telescope never achieved first light. A 0.7-meter replacement for Hōkū Ke'a was purchased in 2015, but before it was installed the University of Hawai'i at Hilo decided to decommission the site to comply with Governor David Ige's Ten Point plan for the Maunakea summit. The University is currently seeking an alternative location for a teaching telescope.

BLNR approved CDUP HA-954, an 'after-the-fact' permit, for the telescope in September 1977. The University filed a Notice of Intent to decommission the site in February 2016.

² UHH 0.9m Telescope (Hōkū Ke'a), UH 2.2-m Telescope, NASA Infrared Telescope Facility (IRTF), Canada-France-Hawai'i Telescope (CFHT), United Kingdom Infrared Telescope (UKIRT), W.M. Keck Observatory (Keck I and II), Subaru Telescope, and Gemini North Telescope.

³ Caltech Submillimeter Observatory (CSO), James Clerk Maxwell Telescope (JCMT), and the Submillimeter Array (SMA)

⁴ Very Long Baseline Array (VLBA)

⁵ Thirty Meter Telescope (TMT)

Canada-France-Hawai'i Telescope (CFHT)



The CFHT is 3.6-meter optical telescope developed jointly by the University of Hawai'i, the Centre National de la Recherche Scientifique (France), and the National Research Council of Canada. The University of Hawai'i provides ten percent of the operating costs and one full-time staff person for CFHT as part of the telescope's tri-partite agreement.

Current science includes studies of the winds of Venus, detection of exoplanets, observations of interstellar dust, and the tracking of the interstellar asteroid 'Oumuamua.

Approximately 15% of the observing time is dedicated to the University of Hawai'i.

BLNR approved CDUP HA-527 for the telescope in 1974, and it began operations in 1979.

NASA InfraRed Telescope Facility (IRTF)



The IRTF is a 3-meter telescope that was initially built to support the Voyager missions to Jupiter, Saturn, Uranus, and Neptune. It is currently operated by the University of Hawai'i under a contract with NASA.

Current science includes research on the aurora on Saturn, observations of ozone on Mars, spectral monitoring, and observations of the moons of the outer solar system planets. The facility continues to provide support for NASA missions.

Approximately 15% of the observing time is dedicated to the University of Hawai'i.

BLNR approved CDUP HA-653 for the facility in 1975. It became operational in 1979.

United Kingdom Infrared Telescope (UKIRT)



The 3.8-meter UKIRT is the second largest dedicated infrared telescope in the world. UKIRT was originally owned by the United Kingdom. Ownership was transferred to the University of Hawai'i in 2014. It was then funded by NASA until June 2017, and operated under a cooperation agreement among Lockheed Martin Advanced Technology Center, the University of Arizona, and the University of Hawai'i. In June 2017 the UH Institute for Astronomy took over the operation of UKIRT.

The majority of UKIRT's current science is dedicated to the Infrared Deep Sky Survey, though it has also been used to study orbital debris and for research by planetary scientists at the University of Hawai'i.

Viewing time by the University of Hawai'i on UKIRT fluctuates between 15% and 50%, depending on funding and its partnership agreements.

BLNR approved CDUP HA-653 for the facility in 1975. It became operational in 1979.

Very Long Baseline Array (VLBA)



The Mauna Kea Very Long Baseline Array (VLBA) is one unit in an integrated system of ten identical radio telescopes stretching from the U.S. Virgin Islands to Hawai'i, which are operated remotely from Socorro, New Mexico. Each VLBA station consists of a 25m antenna and an adjacent control building. The ten stations work together as one single instrument. It is in the lower summit region at approximately 3700 meters elevation.

The VLBA has been operated by the Long Baseline Observatory (LBO) since October 2016, when it separated from the National Radio Astronomy Observatory. The LBO is a facility of the National Science Foundation operated under a cooperative agreement by Associated Universities, Inc.

Current science includes a long-term project to map the complete 3D structure of the Milky Way; coordinated effort with NASA Fermi Gamma-ray Space Telescope to observe gamma-ray sources; long-term study of active galactic nuclei; tracking near-earth asteroids; and monitoring movements of the earth's crust by tracking the distance between the telescopes. Such measurements are an integral part of the earth-based control segment in the development and maintenance of the U.S. government's Global Positioning System (GPS).

BLNR approved the CDUP HA-2174 for the facility in 1989. The facility has been operational since 1992.

Caltech Submillimeter Observatory (CSO)

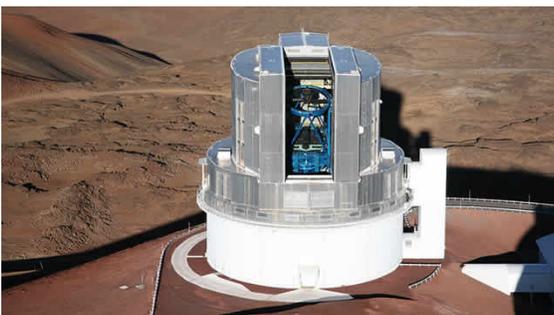


CSO is a 10.4 meter-diameter telescope located alongside the James Clark Maxwell telescope which is owned by the California Institute of Technology.

BLNR approved CDUP HA-1492 in December 1982. The facility was operational from 1986 through September 2015, with 15% of the viewing time dedicated to UH.

Caltech filed a Notice of Intent to Decommission with OCCL in February 2016. The public scoping period on the draft Environmental Assessment was completed on January 15, 2018.

Subaru Telescope



Subaru Telescope is an 8.2-meter optical-infrared telescope operated by the National Astronomical Observatory of Japan (NAOJ), National Institutes of Natural Sciences.

Current science includes the recent identification of 11 dwarf galaxies and two star-containing halos, tracking the source of gravitational waves, and mapping the hydrogen gas in the early universe.

Fifty-two nights per year, approximately 15% of the observing time, are dedicated to the University of Hawai'i.

The BLNR approved CDUP HA-3462 for Subaru in 1992. It achieved first light in 1999.

Submillimeter Array (SMA)



SMA consists of eight 6-meter radio telescopes that operate as one unit. The telescopes can be arranged in varying configurations using 24 concrete pads. SMA is located at the base of Pu'u Poli'ahu in an area informally known as "Submillimeter Valley."

Current science includes the study of newly-formed planetary systems, asteroids, comets, both dying and newborn stars, and red-shifted radiation from the oldest objects in the universe.

The SMA is jointly operated by the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy and Astrophysics (Taiwan).

Between 12.5% and 15% of the observing time is dedicated to the University of Hawai'i.

BLNR approved CDUP HA-2728 for the array in 1994. The system became fully operational in 2003.

James Clark Maxwell Telescope (JCMT)



The 15-meter JCMT is the largest submillimeter telescope in the world, and contains the second largest mirror on Maunakea

JCMT was originally funded by a partnership between the United Kingdom and Canada, and the Netherlands, and operated by the Joint Astronomy Centre. In March 2015 the operation of the JCMT was taken over by the East Asian Observatory.

Current science includes the study of the solar system, interstellar and circumstellar dust and gas. JCMT is also part of the Event Horizon Telescope, an array of global telescopes that coordinate observations and research on the Milky

Way's supermassive black hole Sagittarius A.

Between 12.5% and 15% of the observing time is dedicated to the University of Hawai'i.

BLNR approved CDUP HA-1515 for the telescope in 1983, and it began operations in 1987.

W. M. Keck Observatory (Keck I and Keck II)



The twin Keck Observatory telescopes primary mirrors are 10-meters, each composed of 36 hexagonal segments that work in concert as a single piece of reflective glass.

The W. M. Keck Foundation funded both the original Keck I telescope and Keck II. Today Keck Observatory is a 501(c)3 governed by the California Association for Research in Astronomy (CARA), whose Board of Directors includes representatives from the California Institute of Technology and the University of California, with liaisons from NASA and the Keck Foundation.

Keck currently produces over 150 papers per telescope per year, making it the most productive of any of the world's ground-based observatories. Current science includes the discovery of dozens of exoplanets, new studies on the rings and atmosphere of Uranus, high-resolution imaging of comets, and the study of protoplanetary accretion disks around fifteen young stars.

Approximately 10% of the observing time on Keck I and 15% on Keck II is dedicated to the University of Hawai'i.

BLNR approved CDUP HA-1646 for Keck I in 1984, and it saw first light in 1990. BLNR approved CDUP HA-2509 for Keck II in 1992, and it saw first light in 1993.

Gemini North Observatory



The Gemini Observatory consists of paired 8.1 meter optical/infrared telescopes, one in Chile and one in Hawai'i. It replaced the NASA-Lowell Observatory 24" telescope.

Gemini is operated by a partnership between the National Optical Astronomy Observatory (USA), National Research Council Canada, Comisión Nacional de Investigación Científica y Tecnológica de Chile, Institute for Astronomy University of Hawaii, Instituto de Astrofísica La Plata (Argentina), and the Laboratório Nacional de Astrofísica (Brazil).

The pairing of the telescope allows near complete coverage of both the northern and southern skies. Current research includes the imaging and analysis of exoplanets, star formation and evolution, quasars, and the large-scale structure of the universe.

Approximately 10% of the observing time is dedicated to the University of Hawai'i.

The BLNR approved CDUP HA-2691 for Gemini in 1994. The telescope saw first light in 2000.

Thirty Meter Telescope (TMT)



The core of the project is a 30-meter in diameter aperture telescope composed of 492 individual mirror segments, secondary and tertiary mirrors directing the gathered light, and a network of interchangeable sensors and instruments that will collect and process the light. TMT will be located on the north plateau, approximately ½ mile from the Kūkahau'ula Summit, at an approximate elevation between 4008 meters and 4015 meters.

The telescope will be operated by TMT International Observatory, LLC, an international partnership between the California Institute of Technology, the University of California, the National Institutes of Natural Sciences of Japan, the National Astronomical Observatories of the Chinese Academy of Sciences, the Department of Science and Technology of India, and the National Research Council (Canada).

Approximately 7.5% of the observing time will be dedicated to the University of Hawai'i.

The BLNR approved CDUP HA-3568 for TMT in a Decision and Order in October 2017. The permit was upheld the Supreme Court of Hawai'i on October 20, 2018. The Department issued TMT a Notice to Proceed on June 19, 2019. It is estimated that construction will take seven years.

DECOMMISSIONING PROCESS

The Maunakea Decommissioning Plan, a subplan of the Maunakea Comprehensive Management Plan, describes the process for decommissioning observatories on Maunakea. The plan defines decommissioning as a process that results in the partial or total removal of all structures associated with an observatory facility and the restoration of the site.

Provisions for financial planning for decommissioning are included to ensure that adequate funds are available to pay for the costs of deconstruction and site restoration at the end of the life of the observatory.

The Decommissioning Plan describes two options for removing the infrastructure:

- Complete infrastructure removal. This involves the removal of the entire facility, including underground utilities, pilings, and foundation to the extent practicable under normal engineering deconstruction practices;
- Infrastructure capping. Capping involves removal of above ground facilities with or without utilities and leaves all part of the underground portion of the facility in place.

The Plan describes three levels to which a site may be restored:

- Minimal restoration, meaning removing all man-made structures and grading the site;
- Moderate restoration, meaning removing all man-made structures, grading the site, and enhancing any native species habitat;
- Full restoration, meaning returning the site to its original topography and restoring any native-species habitat.

The decommissioning of an astronomy facility in the Science Reserve is a multi-step process involving

- Submitting a Notice of Intent.
- Completing an environmental due diligence review,
- Approval of the facility decommissioning plan by the University Board of Regents. Submitting a Conservation District Use Application which covers site deconstruction, observatory removal, and site restoration, and if necessary, a remedial action plan;
- Securing a Conservation District Use Permit (CDUP) from the Department of Land and Natural Resources.

MIDLEVEL FACILITIES AT HALEPŌHAKU (Onizuka Center for International Astronomy)

The 19.3-acre Halepōhaku parcel (TMK (3) 4-4-015:012) is situated at an elevation of about 9,200 feet on the south slope of Maunakea. The parcel is leased to the University of Hawai'i through 2041 by the State Board of Land and Natural Resources (BLNR) under General Lease No. S-5529, which describes the character of use as "premises leased to be used solely for permanent mid-level facilities, a construction camp, an information station as well as existing facilities purposes."

The first cabins were built at Halepōhaku by the Civilian Conservation Corps in the 1930s to provide shelter for hunters and hikers. In 1982 the Board approved CDUP HA-1430 for the construction of a 12,913-square foot support services and common area building, three dormitories totaling 13,938-square feet with a 59-bed capacity, a 2500-square foot maintenance building, an 800-square foot generator building, and an 1181-square foot Visitor Information Station (VIS).

In June 2018 BLNR approved CDUP HA-3812 for parking and infrastructure improvements at the VIS. Work was initiated in October 2018.

The lower portion of Halepōhaku contains two unimproved gravel parking areas, one of which is used for overflow parking for the VIS and the other as a staging area for construction activities. The overflow parking is often used by commercial tour groups if the paved parking area adjacent to the VIS is full.

The section of the Maunakea Access Road above Halepōhaku is also under University management.

LAND AUTHORIZATIONS ON MAUNAKEA

A. General Leases

The Maunakea Science Reserve encompasses 11,288 acres of State land leased to the University of Hawai'i under General Lease S-4191. The lease commenced on January 1, 1968, and is set to expire on December 31, 2033.

The character of use for GL S-4191 reads: *For a scientific complex and as a scientific reserve being more specifically a buffer zone to prevent the intrusion of activities inimical to said scientific complex. Activities inimical to said scientific complex shall include light and dust interference to observatory operation and certain types of electric or electronic installation on the demised lands, but shall not necessarily be limited to the foregoing.*

The Halepōhaku parcel encompasses 19.261 acres of State land leased to the University under General Lease S-5529. The lease commenced on February 28, 1986, and is set to expire on February 28, 2041.

The character of use for GL S-5529 reads: *The lessee shall use or allow the premises leased to be used solely for permanent mid-level facilities, a construction camp, an information station as well as existing facilities purposes.*

Grant of Easement No. S-4697 covering the Maunakea Access Road was issued to the University as of September 8, 1981. The easement is coterminous with GL No. S-4191, ending on December 31, 2033.

B. Subleases

The University currently has subleases with seven organizations for the purposes of operating astronomical observatories. Institutions were to build and operate observatories at their own cost and risk, in exchange for providing UH with time on the telescopes. Each sublessee pays the University a nominal fee of \$1.00 per annum in addition to giving the University a percentage of observing time on their respective telescope. UH used its dedicated time on the telescopes to build its astronomy program.

The subleases are:

- 1974: National Aeronautics and Space Administration, 70,650 square feet (NASA IRTF)
- 1975: Canada-France-Hawai'i Telescope Corporation, 2 acres (Canada-France-Hawai'i Telescope)
- 1983: California Institute of Technology, 0.75 acres (Caltech Submillimeter Observatory)
- 1985: California Institute of Technology, 2 acres (Keck I and Keck II)
- 1997: National Astronomy Observatory of Japan, 5.4 acres (Subaru)
- 1997: Smithsonian Institution, 3 acres (Smithsonian Submillimeter Array)
- 1997: Associated Universities Inc., 87,500 square feet (Very Long Baseline Array)
- 1997: National Science Foundation, 2 acres (Gemini North)

All subleases are co-terminus with the University's General Lease.

In June 2014, the Board consented to a sublease between the University and TMT International Observatory.

UH has notified the observatories that they will be paying rent under any new sublease.

Mauna Kea Observatories

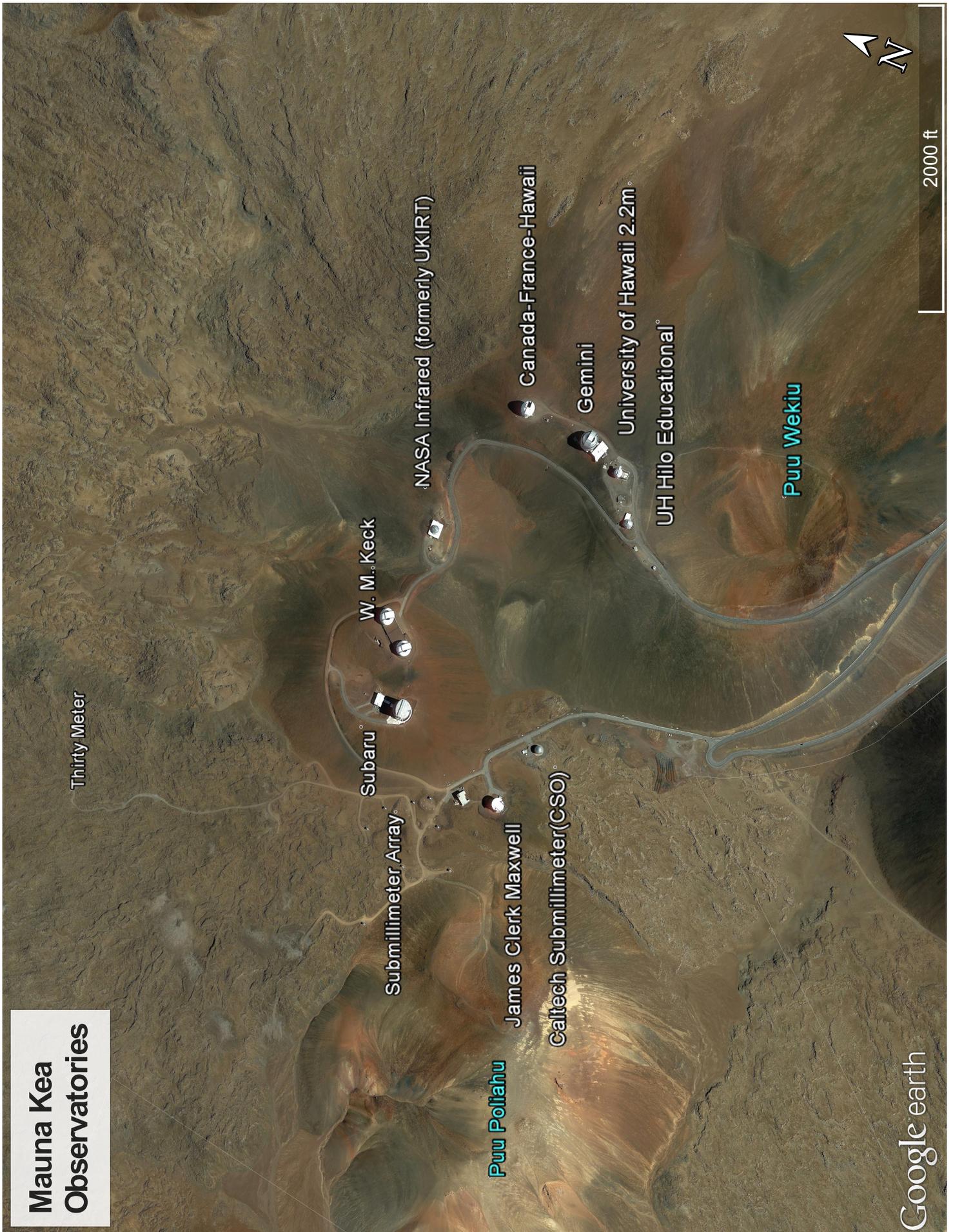


Exhibit 3: Google Earth Map of Observatories

2019 Annual Report to the Board of Land and Natural Resources

Status of the Implementation of the Mauna Kea Comprehensive Management Plan

Purpose

As identified in the 2009 Mauna Kea Comprehensive Management Plan, management action MEU-1 states: OMKM shall produce an annual progress report on the management goals, objectives, and actions for the year and what progress was made towards meeting them. "This Progress Report is not intended to be a status report on the resources in the UH Management Areas; rather, it is meant to inform management and stakeholders of the progress of the program and direction it is to take in the future."

Overview of CMP Management Actions

The CMP contains 103 management actions categorized into four component plans which are further subdivided into sub-components (Table 1).

Table 1. CMP component plans.

CMP Section	Component Plan
7.1	Understanding and Protecting Mauna Kea's Resources
7.1.1	Native Hawaiian Cultural Resources
7.1.2	Natural Resources
7.1.3	Education and Outreach
7.1.4	Astronomy Resources
7.2	Managing Access and Use
7.2.1	Activities and Uses
7.2.2	Permitting and Enforcement
7.3	Managing the Built Environment
7.3.1	Infrastructure and Maintenance
7.3.2	Construction Guidelines
7.3.3	Site Recycling, Decommissioning, Demolition and Restoration
7.3.4	Considering Future Land Use
7.4	Managing Operations
7.4.1	Operations and Implementation
7.4.2	Monitoring, Evaluation, and Updates

Assigning Categories and Priorities

Each management actions was assigned into one of four categories. These categories represent time periods during which it was estimated the actions would be implemented.

Immediate	1 - 3 years
Short term	4 - 6 years
Mid-term	7 - 9 years
Long-term	10 + years

Reporting Definitions

2010 and 2011. Each management action was initially assigned one of four progress status designations: **As Needed**,

Short to Long Term, Ongoing, or Completed.

2012. In 2012 the **Ongoing** category was further divided into two groups, **Ongoing** and **In Progress**, to distinguish management actions that are part of OMKM's regular responsibilities (ongoing) and those that require specialized implementation (in progress).

2014. Based on feedback from the Office of the Auditor, State of Hawaii, beginning with 2014, the definitions for Ongoing and In Progress were further refined. **Ongoing** refers to activities that have established processes in place and are performed as part of OMKM's daily responsibilities. For example, processes for reporting disturbances to historic properties are established while actual reporting is **Ongoing** as necessary. **In Progress** refers to actions that require specialized implementation such as the development of policies or hiring consultants and researchers, and while efforts are **In Progress** the action or process is not yet complete.

Evolution of the Definition of the Terms Ongoing and In-Progress (years 2010 through 2014)

2010 – 2011	2012 - 2013		2014
Ongoing are actions that are being implemented	Ongoing was divided into two groups		Auditor's recommendation
	Ongoing are activities that are performed as part of OMKM's daily responsibilities	In-Progress are actions that require specialized implementation, e.g., development of policies or hiring of consultants	Ongoing was further defined as activities that have established processes in place and are performed as part of OMKM's daily responsibilities. In-Progress are actions that requires specialized implementation and while efforts are in-progress, the action or process is not yet complete.

Short to Long Term In Progress	Management action still to be implemented during its scheduled time period. Management action that requires specialized implementation has been initiated, process is not yet complete.
Ongoing	Management action is implemented and processes are in place to fulfill this requirement, actions will continue indefinitely because they are part of OMKM's continuing management responsibilities.
Completed	Management action is completed.

Annual Reports are Cumulative

Each successive report builds upon the previous year's report, thereby the annual reports beginning with 2011 are cumulative. As an annual report, this submission provides additional detail on activities occurring in calendar year 2018.

2019 Summary of Implementation Status

Most management actions have either been implemented or are in progress. Many actions are considered 'ongoing' as they are long term, continuous land management responsibilities. Appendix A details the implementation status with explanations for individual CMP management actions. Appendix B details the cumulative annual progression of implementation status from 2010 to present.

CMP Implementation Activities

As reported in earlier reports OMKM identified five priority categories. Efforts have been initiated in all of the categories and are described below.

Priority Categories:

- Research
- Monitoring
- Resources Management Programs

- Education, Training and Outreach
- Printed Materials & Public Forums

A summary of implementation activities are described below.

Research (Table 1)

Data derived from research provides the basis for the development of resource protection programs. OMKM continues its efforts to conduct research including establishing baseline data of the various resources. In the case of the wēkiu bug, studies also focused on the bug's life history, habitat and genetics. OMKM utilizes resources available within the UH system including faculty, graduate and undergraduate students, in its efforts to fulfill CMP mandates.

Biological Research

Biodiversity of Arthropods

Field work for the 2011 study of the biodiversity of arthropods in the summit region in the Halepōhaku area is complete. Specimen curation and report writing are anticipated to be complete in early 2020. Two species of native moth were described in the scientific literature;

<https://biotaxa.org/Zootaxa/article/viewFile/zootaxa.4545.2.7/38727>.

Wekiu Bug

A study of the characterization and mapping of wēkiu bug habitat was completed in 2016. A study on the restoration of wēkiu bug habitat that was initiated in 2015 culminated in the publication of a thesis in early 2018.

Ongoing Research

Research initiated in 2017 included: 1) a project to investigate diets and parasitoid loads for important native and invasive arthropods, 2), research on wēkiu bug diet, and 3) field work for a multi-year survey of sea and forest birds, and bats. Both bats and seabirds have been detected at the upper elevations of the Mauna Kea Forest Reserve, using radar and acoustic monitors. Efforts to document habitat use, if any, by these species in the Mauna Kea Science Reserve is ongoing.

Invasive Species

Measures Prevent Introduction of Invasive Species

In 2015, OMKM initiated a study to evaluate measures to prevent the introduction of invasive species, in particular the inspections of vehicles and equipment. This included an analysis of the feasibility of a vehicle washing facility as a means of helping to prevent the introduction of invasive species. This study concluded in early 2018 and provides management-specific recommendations as part of a MS thesis.

Invasive Species Protocols - Update

Invasive species prevention protocols were updated in 2018 addressing relevant recommendations from the 2018 MS thesis research (above).

Geology and Erosion

Study of Erosion Processes

A multi-year study of surface erosion processes on cinder cones that was initiated in 2014 is still ongoing. A second iteration of terrestrial LiDAR mapping (detailed digital elevation mapping) was completed in 2017. In 2018 field work included data collection in the Halepōhaku area while in 2019 the Maunakea Summit Access Road corridor will be added to the study area. This study will help to better understand natural erosion as well as help characterize arthropod habitat.

Permafrost

OMKM funded a study to assess the presence of permafrost and whether conditions for the formation of permafrost still exist—this project is transitioning to a monitoring phase to document the long-term status of permafrost on Maunakea. The publication “The Coldest Places in Hawaii: The Ice-Preserving Microclimates of High-Altitude Craters and Caves on Tropical Island Volcanoes” characterized unique climate phenomena found on Maunakea; <https://doi.org/10.1175/BAMS-D-17-0238.1>.

Groundwater Hydrology

A groundwater hydrology study was begun, looking at sources of groundwater in west Hawai'i, including sensors at the summit and at Halepōhaku.

Observatories Assist with Volcano Threat Assessment

The U.S. Geological Survey national volcanic threat assessment was updated, addressing the ongoing Kīlauea eruption as well as Maunakea and other Hawaiian volcanoes. Low-light cameras developed by the astronomical observatories, installed at the summit with a view towards the eruption and lava flow areas, proved extremely popular.

Weather and Climate – Climate Change

Climate Change Model

A multi-year study developing climate change models to determine impacts to the summit ecosystem 50-years in the future is available in a public data archive (<http://thredds.soest.hawaii.edu:8080/thredds/catalog/downscaling/catalog.html>).

Long-Term Temperature Records

A separate study integrating long-term temperature records and other types of climate data for earlier years when temperature was not recorded was completed and a journal manuscript is in review. Research into climate processes for this plan was published as “Temperature Trends in Hawai‘i: A Century of Change, 1917–2016”; <https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.6053>.

The article “Snow cover in Hawai‘i (1893–1953) and its effect on ground temperature” was published as a result of coordination across several research projects, with a Farrington High School graduate (now a college undergraduate) as the lead author; <https://doi.org/10.1080/15230430.2019.1600963>.

Vog Monitoring

Sulfur dioxide sensors were installed at Halepōhaku to help assess vog distribution and allow visitors to better manage public health concerns; <https://tatacenter-airquality.mit.edu/hawaii-vog>.

Weather Monitoring

The above studies in conjunction with development of a plan to improve weather monitoring on the summit as part of a sea level to summit network of weather stations will help to track changes in weather and climate over the long term and will provide data to evaluate altitudinal changes and impacts on ecosystems from sea level to the summit.

Other Studies

Visitor and Commercial Tour Capacity Study

In collaboration with UH Mānoa’s School of Travel Industry Management, OMKM initiated a study to assess the capacity for commercial tour operations and public visitation on UH’s managed lands.

Collecting Information on Traditional and Customary Practices

In consultation with Kahu Kū Mauna, OMKM’s process for collecting information on traditional and customary practices is through published documents from studies, oral histories, or through other formal methods of information gathering, such as environmental assessments and impact statements. Examples of published works include the 1999 “Oral History and Consultation Study for the Mauna Kea Science Reserve and Hale Pōhaku Complex Development Plan Update”, 2005 archival project and oral history “Mauna Kea-Ka Piko Kaulana o Ka ‘Āina”, 2009 “Cultural Resource Management Plan”, and various cultural assessments completed as part of HRS Chapter 343 mandates. Similar third party materials, such as the USGS Open File Report 2017-1043 “Conversing with Pelehonuamea: A workshop combining 1,000+ years of traditional Hawaiian knowledge with 200 years of scientific thought on Kīlauea volcanism” also incorporate information on Maunakea’s traditional and customary practices. Additional partnerships within the UH-system and other State-agency partners, continue to be pursued.

Monitoring (Table 2)

Following surveys to determine the baseline inventory of a resource, the next step is monitoring to assess the status of the resource over time.

Historic Properties

Following the completion of an archaeological inventory survey of the Maunakea Science Reserve and summit access road, an annual assessment of the archaeological sites (historic properties) began in 2012. In compliance with the Long Term Historic Property Monitoring Plan, approved by SHPD in 2014, assessment of

historic properties in the Astronomy Precinct and alongside the summit access road is conducted annually while the more remote sites are assessed on a three and five year rotational basis. Annual reports for these efforts are submitted to SHPD after consultation with the Kahu Kū Mauna Council on management action recommendations.

Photo Documentation of Lake Waiau

While not part of UH's managed lands, in a cooperative effort with DLNR's Natural Area Reserve, OMKM rangers photo document monthly the level of Lake Waiau in the Mauna Kea Ice Age Natural Area Reserve, and periodically hike to the adze quarry to assess conditions.

Wēkiu Bug and Alien Species

Wekiu Bug

Monitoring surveys of the wēkiu bug, which began in 2002, and alien arthropods, in 2007, continues to be conducted annually.

Invasive Species

Monitoring of invasive species has been ongoing since 2007. Beginning in 2013 monthly surveys are made in and around the surrounding areas of the facilities at the 9,200 foot elevation. In addition, quarterly surveys are conducted at facilities at the summit.

Botanical Resources

Monitoring of botanical resources is completed in conjunction with the yearly historic property assessment. A more detailed monitoring plan for botanical resources will be developed in collaboration with recommendations for arthropod monitoring.

Resource Management Programs (Table 3)

Resource management programs may be policies, plans, or long-term action programs which purpose is to preserve or protect the resources, or to help ensure the health and safety of those visiting and working on the mountain.

Cultural Resources

OMKM, together with Kahu Kū Mauna, developed policies for the construction of new cultural features, including the stacking of rocks, the scattering of human remains, placement of offerings, buffers around historic properties and visitation and use of ancient shrines. The Maunakea Management Board (MKMB) approved these policies in early 2018 after extensive community consultation held over a period of several years by Kahu Kū Mauna.

Invasive Species

As mentioned in previous reports, data from surveys and studies provide valuable information for developing management programs to protect the resources such as the endemic wēkiu bug. Invasive flora and fauna are a concern because of their potential impact not only on the wēkiu bug, but also on other native species, and on the "health" of Maunakea's unique ecosystem. OMKM's invasive species prevention, response and control plan is actively being implemented, especially regarding observatory related activities. Preventing the introduction of predatory ants remains a high priority. The adaptive-management invasive species plan is periodically reviewed and updated, with annual reports prepared and made publicly available.

Removal of Invasive Weeds

OMKM continues its efforts to remove fireweed (*Senecio madagascarensis*). While on patrol, rangers remove fireweed found along the road and in the summit areas. OMKM's invasive weed pull program brings community volunteers to the Halepōhaku area to pull fireweed, mullein and other invasive plants. It is OMKM's goal to manage invasive weeds and to revegetate the area with native vegetation.

Operations Monitoring, and Maintenance Plan (OMMP)

An OMMP is implemented and identify maintenance needs, protocols and strategies that minimizes impacts to the resources and ensures that permittees comply with the conditions of their CDUPs. The OMMP is updated annually.

CMP Compliance

Twice annually OMKM rangers conduct inspections of all summit facilities for compliance with their Conservation District Use Permits.

CMP Actions and Mitigation

Applicants of projects are required to review the CMP and submit measures to comply with relevant CMP actions as part of the project's proposal. When applicable, mitigation measures are also included in the proposals.

Infrastructure Safety Improvements

Parking, vehicle and pedestrian flow and visitor capacity concerns are being addressed in design improvements to keep parking, drop off and pickup of visitors on the same side of the road as the VIS. It is currently being addressed with the completion of vehicular ingress/egress-parking system. The project involved the construction of a new paved parking lot with 38 stalls. Road repair and improvements are also being evaluated. Capital improvement project funds were provided for this project.

Native Plant Propagation

The CIP project that created new parking stalls (see *Infrastructure Safety Improvements* above) included approval for the installation of a greenhouse for propagating native plants, including māmane to replace trees removed for the Infrastructure Safety Improvement project in addition to other native plants for revegetating the Halepōhaku area.

Vehicle Counter

An automated vehicle counter was installed to count the number of vehicles that drive above Halepōhaku. A portable vehicle counter is being used in conjunction with the automated counter to help determine the number of vehicles go only to the VIS.

Road Condition Sensor

A test road condition sensor installed in 2013 has shown the device accurately senses the presence of ice on the road. Two additional sensors have been installed along hazardous road sections prone to the development of ice, in particular black ice. When ice is detected the sensors automatically send email notifications to rangers who take action such as closing the road to protect the safety of the visiting public. Installation of additional sensors will be based on demonstrated utility of the first three in a network configuration.

Education, Training and Outreach

OMKM recognizes the need to formally educate and train management staff, stakeholders and the general public about the resources and significance of Maunakea. One of the key tenets of the Public Access Plan is that "an informed public is best prepared to make good decisions and act responsibly." OMKM also recognizes the importance of establishing community relationships and keeping them informed of OMKM's activities.

Orientation

The OMKM Maunakea User/Resource Orientation program was launched in 2013. It is a requirement that all observatory and support staff (both office and on-mountain), vendors, construction workers, mid-level support and VIS staff, UH employees, and commercial tour drivers attend the orientation. In 2018 over 400 people attended the orientation. Since the orientation began in 2013, over 2,500 people have attended the orientation. Beginning in 2016 those who took the orientation in 2013 have begun their renewal process. An online version with an assessment quiz is available as a more efficient means of delivery and an alternative to in-person sessions. A video orientation for visitors will also be developed to be shown in the Visitor Information Station (VIS). An orientation plan, approved by the Management Board and DLNR guides implementation and identifies a renewal requirement every 3 years.

Training

Beginning in 2016, a staff/employee training program was initiated. All OMKM and Maunakea Observatory Support Services employees are required to attend.

Volunteer Program

Since its inception in the Spring of 2012, OMKM 's community volunteer weed pull program has held 56 events, filled over 2,300 bags of weeds by 1,470 volunteers putting in over 10,400 hours. Groups participating in 2018 include various UH Hilo student groups, local primary school students and families, Observatories, and

employee organizations, and environmental science students. OMKM is propagating plants for future restoration efforts in the Halepōhaku area.

Outreach

OMKM seeks opportunities to share with the community its activities. OMKM also participates in school and community events showcasing the natural resources found on Maunakea, fun science and keiki activities.

As part of their educational efforts with young children, researchers working on OMKM projects have been going to schools to demonstrate the use of equipment that is used in their scientific studies, such as unmanned aerial vehicles (drones) or conducts experiments with the students. Others mentor students, including those who wish to conduct and enter the results of their studies in the State science fair.

Printed Materials & Public Forums

Education and outreach efforts include the development of educational materials, such as brochures, signage and the dissemination of materials, OMKM regularly updates its heritage and resources guide (brochure). This guide along with the safety brochure, "*Visiting Maunakea Safely and Responsibly*," are distributed at the VIS at the 9,200 foot elevation and at the 'Imiloa Astronomy Center. OMKM also seeks opportunities to speak to groups, such as Rotary clubs, community associations and business organizations about OMKM's activities.

Daily Implementation of Ongoing Actions

OMKM Maunakea Rangers

The Maunakea rangers continue to monitor activities on UH's managed lands on a daily basis. They record pertinent data including the number of vehicles by type (4- vs. 2-wheel drive, observatory, commercial and motorcycles) and observations of visitor activities, including hikers, bikers, vehicle speeds, trash, etc. Through their interactions with the public they help to educate people about Maunakea, including the cultural significance, environmental uniqueness, science, and how to visit safely. Many of the management actions relating to public and commercial activities, and trash pick-up and removal are carried out by the Rangers as part of their daily responsibilities. In addition, twice annually the rangers conduct inspections of the summit and Halepōhaku facilities for compliance with their conservation district use permits.

The Maunakea ranger corps has a target staffing level of nine full-time and one part time rangers. This allows OMKM to schedule three rangers for duty and ensures a minimum of two rangers on duty should one ranger be sick or on vacation.

UH Internal Audit of Maunakea Support Services and Office of Maunakea Management

An audit of finances related to the University of Hawaii's management of Maunakea was presented to the UH Board of Regents Committee on Independent Audit. The audit concluded that the "University entities involved with Maunakea have developed processes and procedures to appropriately account for their respective transactions in connection with their management of Maunakea." The audit evaluated university funds, lease payments and external funds received in support of stewardship, management, education and other activities related to Maunakea.

Administrative Rules

In 2018 draft administrative rules were reviewed by Kahu Kū Mauna and the Mauna Kea Management Board and a recommendation was submitted to the Board of Regents who approved the draft rules for public hearings. In July 2018, Governor Ige gave his approval to move ahead with public hearings. Pursuant to HRS Chapter 91, public hearings were held in September 2018. Changes to the rules based on public comments received are being considered and a second round of hearings is anticipated.

There are 15 CMP management actions that require administrative rules for implementation. These include categories involving natural and astronomy resources, education and outreach, infrastructure and maintenance, infrastructure and maintenance, and in particular, activities and uses. The rule making process continues and it is hoped that rules will be approved by the Board of Regents in 2019.

Table 1. Research Activities

<p>Surveys and studies on:</p> <ul style="list-style-type: none"> • Historic Properties • Arthropods • Geology and erosion • Climate and weather 	<ul style="list-style-type: none"> • 2005 – 2009. Archaeological inventory of historic properties of the Science Reserve, summit access road and Halepōhaku. • 2006. Climatological analysis of meteorological observations at the summit of Maunakea • 2006 – 2011 Modeling the ecology of the wēkiu bug’s Maunakea environment • 2007. Review Mauna Loa weather data dating back to 1958 to assess climate conditions on Maunakea to help with wēkiu bug research • 2012 – 2018. Study to assess presence of native and non-native plant and arthropod species. • 2012 – 2018. Study to assess presence of permafrost and whether conditions for formation of permafrost still exist. • 2011- 2017. A multiyear study on the development of a climate change modeling program to help forecast climate change on the summit to help determine impacts to the summit ecosystem. • 2012. High Altitude Climate of the Island of Hawai‘i publication. • 2013 – ongoing. OMKM is working with the Department of Geography at UH Manoa on the development of a sea level to summit weather monitoring network to help track climate change. OMKM’s participation is to help the location and installation on weather station on the summit. • 2014 –ongoing. Surficial study of the geology and erosion in cinder cone environments above 12,500’. High-resolution topographic maps, and imagery have been completed. • 2013 – 2016. Study to extend the long term temperature records for the State of Hawaii by integrating other climate data for earlier years when temperature was not recorded. • 2017 – ongoing. Study to investigate diet and parasite loads in alpine arthropods.
<p>Surveys on human activities and needs:</p>	<ul style="list-style-type: none"> • 2001 – ongoing. Rangers continue to submit daily reports on human activities; data are input in a database. • 2016 – ongoing. An automated vehicle counter keeps a real time count of all vehicles traversing above Halepōhaku. Rangers also conduct daily counts of vehicles identifying 2 wheel vs 4 wheel drive vehicles. • 2018 – Rangers install an axle vehicle counter to assess in conjunction with the automated vehicle counter, the number of vehicles that go only to Halepōhaku. • 2019 – ongoing. A study of visitor activities and carrying capacity.
<p>Ongoing surveys and studies of the wēkiu bug and other arthropods</p>	<ul style="list-style-type: none"> • 2011. A study of how geology (pu’u and terrain), wind speeds and direction influence insect and snow pack deposits on the summit to help supplement wēkiu bug research. • 2011 – 2018. Multi-year survey of the summit region and at the mid-level area at 9,200 ft elevation to assess the biodiversity of arthropods. Including a 2016 MS Thesis on biodiversity in the Halepōhaku area. • 2014 – 2016. A study evaluating the characterization and mapping of wēkiu bug habitat has been completed. • 2015 – ongoing. A multi-year wēkiu bug habitat restoration plan is being implemented, also part of the TMT CDUP requirements. OMKM is currently supporting this management action. • 2016. Habitat mapping of wēkiu bugs using existing remote sensing and arthropod trap data. • 2017 – ongoing. Study to investigate diet and parasite loads in alpine arthropods.
<p>Alien and invasive species</p>	<ul style="list-style-type: none"> • 2012 – 2015. Development of an invasive species management plan. It is composed of modules addressing various aspects of the invasive species prevention, response, and control. Implementation is ongoing • 2015 – 2018. A study to evaluate measures to prevent the introduction of invasive species, in particular the inspection of vehicles and equipment was initiated in 2015.
<p>Other Studies</p>	<ul style="list-style-type: none"> • 2004 - 2006. Archival study and compilation of native traditions, historical accounts, and oral history interviews for Mauna Kea.

	<ul style="list-style-type: none"> • 2005 – 2009. Archaeological inventory of historic properties of the Science Reserve, summit access road and Halepōhaku. • 2016. Initiated seabird, forest bird and bat inventory study
--	---

Table 2. Monitoring

Historic Properties (archaeological sites)	<ul style="list-style-type: none"> • 2012 - ongoing. Annual archaeological monitoring of historic properties (archaeological sites). The Long-Term Historic Monitoring Plan was approved by State of Hawaii Historic Preservation Division (SHPD) in 2014. • 2014. SHPD approved the Long Term Historic Properties Monitoring Plan for UH Managed lands on Maunakea. • 2011- ongoing. On a monthly basis, OMKM Rangers photo document the level of Lake Waiau in DLNR's Maunakea Ice Age Natural Area Reserve (MKIANAR). Rangers also periodically hike to the adze quarry in the MKIANAR) to assess conditions. Rangers pick up and remove trash from their hikes into the MKIANAR. • 2002 – ongoing. Annual surveys on wekiu bug have been conducted since 2002. • 2007 – ongoing. Annual surveys of alien species are conducted on UH Managed lands • 2013 – ongoing. Monthly surveys for invasive species are conducted at the facilities at the mid-level, 9,200 ft elevation, including the VIS and the support facilities. • 2013 – ongoing. Quarterly surveys for invasive species are conducted at all the summit facilities for invasive species. • 2013 – ongoing. Natural resources personnel accompany archaeologists in their annual monitoring to assess sites and surrounding areas for native and invasive species
Wēkiu bug and alien species.	
Invasive species	

Table 3. Resource Management Programs

<p>Polices and plans related to cultural resources</p>	<ul style="list-style-type: none"> • 2012 – 2014. A burial treatment plan was reviewed by the Hawaii Island Burial Council and approved by the Division of Historic Preservation. It contains a schedule for monitoring. • 2012 – 2018. Policies relating to the placement and removal of offerings, the scattering of human remains, the construction of new cultural features including the stacking of rocks were developed by Kahu Kū Mauna. In 2016 following public consultation Kahu Kū Mauna approved the policies. The MKMB felt that more community consultation was required before finalizing the policy. Community consultation on these policies is on-going. Following additional consultation, MKMB approved in 2018. • 2016 – ongoing. The U.S. Department of Defense was contacted to begin the review process prior to any removal efforts of military aircraft.
<p>Invasive species control</p>	<ul style="list-style-type: none"> • 2012 – ongoing. An active volunteer program to remove fireweed (<i>Senecio madagascariensis</i>) and other invasive plants continues at the mid-level area. Rangers continue to remove fireweed in the upper elevations. • 2013 – ongoing. The Maunakea Invasive Species Management Plan was approved by the MKMB. It is composed of modules addressing various aspects of the invasive species prevention, response, and control. Implementation is ongoing. • 2013 – ongoing. The Hawaii Ant Lab and Big Island Invasive Species Committee continue to support implementation of the Invasive Species Management Plan by providing technical support, and assisting with inspections and monitoring work.
<p>Wēkiu bug management plan and habitat restoration plan.</p>	<ul style="list-style-type: none"> • Data from wēkiu bug, invasive/alien arthropod, biodiversity arthropod studies, topography and wēkiu bug food distribution, and climate studies will provide the basis for developing management and habitat restoration plans for the bug
<p>Public facilities</p>	<ul style="list-style-type: none"> • 2014 – ongoing. An automated vehicle counter was installed to count the number of vehicles (differentiating: public, commercial, tour, observatory, etc.) that drive above Halepōhaku. • 2014 – 2018. CIP funds are used to construct improvements to the ingress and egress at the VIS and to address parking and pedestrian flow. An Environmental Assessment was prepared and published in 2017. A CDUA was submitted for DLNR and a CDUP was approved in June 2018. Funds were also used to study the condition of the summit loop road, make recommendations for repair, including estimated costs. • 2018 – Rangers install an axle vehicle counter to assess in conjunction with the automated vehicle counter, the number of vehicles that go only to Halepōhaku.
<p>Other Plans and activities</p>	<ul style="list-style-type: none"> • 2001. OMKM ranger program established. • 2007 – ongoing. Biannual inspection of facilities for compliance with their CDUPs • 2009. BLNR approved the Maunakea Comprehensive Management Plan (CMP) • 2010. BLNR approved the Cultural and Natural Resources Management Plans, Public Access Plan and the Decommissioning Plan, sub-plans to the CMP. • 2012 – ongoing. Beginning in 2012 applicants of projects are required to review the Comprehensive Management Plan (CMP) and submit measures to comply with relevant CMP actions as part of their project proposals. When applicable, mitigation measures are included in the project proposal. • 2016 – Completed/ongoing. An Operations, Monitoring, and Maintenance Plan has been developed. The plan recognizes the need to identify maintenance needs, protocols and strategies that minimizes impacts to the resources and ensures that permittees comply with the conditions of their CDUPs. It also serves as a reporting mechanism for CMP compliance activities calls for the coordination of maintenance activities and schedules.

- 2017 – ongoing. A Sign Plan was approved by the MKMB. This plan helps ensure appropriate review and consistency in sign design and use.
- 2015 Caltech Submillimeter telescope submitted its Notice of Intent (NOI) to decommission initiating the decommissioning process for its observatory on the summit. MKMB approved the NOI in 2016. Pursuant to the Decommissioning Plan (DP) for Mauna Kea Observatories, OMKM is overseeing the decommissioning process and Caltech is preparing all necessary documents, including Environmental Assessment (EA), Conservation District Use Permit application and DP requirements. An EA is currently being prepared.
- 2015 UH Hilo submitted its Notice of Intent to decommission initiating the decommissioning process for its summit observatory, Hōkū Kea. Public testimony against the decommissioning of UH Hilo's educational telescope resulted in the MKMB deferring approval of the NOI. OMKM is overseeing the decommissioning process and UH Hilo is responsible for carrying out the DP requirements. In 2018, UH Hilo removed the non-operational telescope from inside its summit facility.

Table 4. Education, Training and Welfare

<p>Initiate programs to educate stakeholders, management staff, and the general public.</p>	<ul style="list-style-type: none"> • 2012 – ongoing. OMKM has been conducting orientations relating to the cultural and environmental significance to those who work on UH’s managed lands including observatory and UH personnel, contractors and vendors, and commercial tour operators. • 2016 - OMKM launched an online video version of the orientation as a more efficient means of reaching contractors, vendors, visiting staff, or other interested parties. Regular feedback is solicited from Kahu Kū Mauna and attendees. • A three-year refresher interval requirement has been adopted and original orientation attendees have begun the renewal process. • A video orientation for visitors will be developed and shown in the VIS. • A staff/employee training plan has been implemented. All OMKM and Maunakea Observatory Support Services are required to attend.
<p>Develop and maintain a GIS and database program.</p>	<ul style="list-style-type: none"> • 2013 – ongoing. A GIS-based data storage and reporting system has been developed. The system is continuously being expanded and enhanced. • 2001 – ongoing. Rangers have been and continue to submit daily reports summarizing their observations and their activities, including documenting number of vehicles, hikers, incidents, permitted and unpermitted commercial tour operators, etc. • 2015 – ongoing. An automated vehicle data collection system is operational recording individual observatory, permitted commercial tours, and OMKM vehicles using radio frequency identification tags (RFID) and general public vehicles.
	<ul style="list-style-type: none"> • 2012 – ongoing. In 2018, 200 volunteers, working 1,080 hours, removed 323 bags of invasive weeds. This year’s program once again focused on removing invasive plants in the Halepōhaku parcel and along the summit access road corridor. Since 2012, a total of 1,470 volunteers putting in 10,400 hours pulled and filled 2,300 bags of weeds. • Volunteer groups have included the Hawaii Island Chamber of Commerce, Circle K (Kiwanis youth), Interact (Rotary Youth) Hawaii National Guard Youth Challenge Academy, UH Hilo student groups, school groups, and general community members. • Mentoring young students with science projects and participation in local science and State science fairs. Dr Jesse Eiben, wēkiu bug researcher for OMKM, continued his mentorships with local middle and high-school students. This year one of the mentored students investigating Maunakea’s lycosa spiders advanced to the State Science Fair competition on Oahu. • Dr. Norbert Schorghofer’s (principle investigator for OMKM’s sponsored permafrost study) colleague Dr. Kenji Yoshikawa continues work with Hilo Intermediate School 7th & 8th grade science classes to collect comparable data in their school yard for comparison with Maunakea and other sites across the globe. • Dr. Ryan Perroy visits a community based charter school and demonstrate the use of unmanned aerial vehicles and how they are used for scientific purposes. He also participates in OMKM outreach activities • 2015 –ongoing OMKM participated in Kealahou Elementary School annual “Science Showcase” with interactive materials on ecosystems, arthropods, and art. • 2016. Participated in the Panaewa community Prince Kuhio Day keiki festivities with exhibits, coloring activities, trading cards and resource and safety brochures. • 2017. OMKM participated in the annual Astroday event in Hilo and Astrobash in Kona with exhibits of arthropods found on Maunakea, coloring activities, tattoos and natural science trading cards for the kids, and resource brochures and safety for the adults.

- 2006 – ongoing. The following graduate students and internships are or were engaged to research or assisted OMKM with its stewardship responsibilities:

PhD Candidates

- 1) Jesse Eiben – UH Mānoa; Entomology. 2012. Applied conservation research of the wēkiu bug in Hawai'i: Life table analysis, population genetics, and phylogenetics create a holistic view of a rare and unique species
- 2) Brad Reil – UH Mānoa; Entomology. In Progress.
- 3) Heather Stever – UH Mānoa; Entomology. In Progress.

Master's Degree Students

- 1) Sarah da'Cote – UH Mānoa; Meteorology. 2006. Climatological Analysis of Meteorological Observations at the Summit of Mauna Kea.
- 2) Leigh Anne Eaton – UH Mānoa; Meteorology. 2011. Modeling the Ecology of the Wēkiu Bug's Mauna Kea Environment.
- 3) Heather Stever – UH Hilo; Tropical Conservation Biology and Environmental Science. 2016. Arthropod Diversity Estimates for Three Native Subalpine Plant Species on the Maunakea Volcano of Hawai'i Island.
- 4) Nathan Stephenson – UH Hilo; Tropical Conservation Biology and Environmental Science. 2016. High Resolution Habitat Suitability Modeling for a Narrow-Range Endemic Alpine Hawaiian Species.
- 5) Marie McKenzie – UH Mānoa; Geography. 2016. Regional Temperature Trends in Hawai'i: A Century of Change, 1916-2015.
- 6) Jessica Kirkpatrick – UH Hilo; Tropical Conservation Biology and Environmental Science. 2018. An Assessment of *Nyctius wekiuicola* Populations and Thermal Microhabitat Conditions on Cinder Cones of the Maunakea Volcano, Hawai'i.
- 7) Jordan Zarders – UH Hilo. Tropical Conservation Biology and Environmental Science. 2018. Invasive Arthropod Monitoring Assessments of Construction and Facility Activities on Maunakea, Hawai'i.
- 8) Bret Mossman – UH Hilo. Tropical Conservation Biology and Environmental Science. In progress. Seabird and bat inventory

Interns

- 1) 2012: Jessica Kirkpatrick – arthropod monitoring (partnered with Dr.J.Eiben, UH Hilo)
- 2) 2013: Kerri Nakatsu – invasive species plan development (partnered with Hawaii Ant Lab)
- 3) 2013: Amber Stillman – spatial data support (partnered with Dr.R.Perroy, UH Hilo)
- 4) 14: Darcy Yogi – invasive species plan development (partnered with Hawaii Ant Lab)
- 5) 2014: Margaux Mellot – erosion monitoring (partnered with Dr.R.Perroy, UH Hilo)
- 6) 2015: Christian Kapono – Aloha Art Festival (partnered with 'imiloa)
- 7) 2015: Tisha Piliani-Pelanca – monitoring implementation (partnered with HCC Forest Team)
- 8) 2016: Ku'upua Kiyuna – review of draft administrative rules
- 9) 2016: Kialoa Mossman – erosion monitoring (partnered with Dr.R.Perroy, UH Hilo)
- 10) 2016: Koa Akima – monitoring implementation (partnered with HCC Forest Team)
- 11) 2017: Jake Martin – snowcover and permafrost (partnered with Dr.N.Schorghofer, UH Mānoa)
- 12) 2017: Shola Kahiapo – vegetation restoration
- 13) 2018: Sebastian Wells – bird, bat, and arthropod monitoring (partnered with Dr.P.Hart, UH Hilo)
- 14) 2018: Uli'i Miyajima – permafrost and snow-cover (partnered with Dr.N.Schorghofer, UH Mānoa)
- 15) 2018: Timothy Aaron Medina – erosion monitoring at Halepōhaku (partnered with Dr. R.Perroy, UH Hilo)
- 16) 2019: Pili Quinories – information sheets of Maunakea plant species

Table 5. Printed Materials and Public Forums

<p>Develop and print brochures.</p>	<ul style="list-style-type: none"> • 2016 - ongoing. OMKM updated its resource brochure containing information about the resources and significance of Maunakea incorporating community and Kahu Kū Mauna input. • 2002- ongoing. Also available are Visiting Maunakea Safely and Responsibly and a brochure about the purpose of the Office.
<p>Distribution of informational materials.</p>	<ul style="list-style-type: none"> • Brochures are available for public distribution at the VIS, 'and other public venues, or distributed at public and outreach events.
<p>Participate in public events, community gatherings and other opportunities to inform the community about Maunakea.</p>	<ul style="list-style-type: none"> • Continue to seek opportunities to participate or speak at public forums, including community meetings, local organization membership meetings, etc.
<p>Signs</p>	<p>2012 – An inventory and map of all the signs on UH’s managed lands was completed. The inventory of the signs on UH managed lands is being updated.</p> <p>2017 – ongoing. A Sign Plan was approved by the MKMB. Installation of signs still requires DLNR approval, the plan helps ensure appropriate review and consistency in design and use.</p> <p>With input from Rangers and Kahu Kū Mauna, signs were installed to highlight cultural awareness and safety issues.</p>

Appendix A

**Implementation Status of
Maunakea CMP Management Actions**

MKMB = Maunakea Management Board; MKSS = Maunakea Observatories Support Services; OMKM = Office of Maunakea Management; VIS = Visitor Information Station

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES			
		Implementation Status	Comments
NATIVE HAWAIIAN CULTURAL RESOURCES			
Management			
CR-1	Kahu Kū Mauna shall work with families with lineal and historical connections to Maunakea, cultural practitioners, and other Native Hawaiian groups, including the Maunakea Management Board's Hawaiian Culture Committee, toward the development of appropriate procedures and protocols regarding cultural issues.	Ongoing	<p>Identification of lineal and historical connections was part of the development and State Historic Preservation division approval (2014) of the Burial Treatment Plan (see CR-13). Solicitations were made through announcements in the daily newspapers and the OHA newsletter.</p> <p>There were no responses to the solicitations but OMKM continues to seek out individuals as part of its interaction and relationship building with the community.</p> <p>Fall 2013 the Hawaii Island Burial Council officially recognized several individuals as cultural descendants of Ka'ōhe Anupua'a.</p>
CR-2	Support application for designation of the summit region of Mauna Kea as a Traditional Cultural Property, per the National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq. in consultation with the larger community.	Ongoing	<p>An application for the designation of the summit region of Maunakea as a Traditional Cultural Property has not yet been prepared for filing by State Historic Preservation Division with the appropriate Federal agency.</p> <p>Rangers through their interactions with the visiting public help to educate and raise awareness about Mauna Kea.</p>
CR-3	Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	Ongoing	<p>An informational brochure on cultural and natural resources was developed in 2014, revised in 2016, with periodic updates since then.</p> <p>OMKM sends out eNewsletters informing the public about OMKM and its activities.</p> <p>Resource orientation of those who work on the mountain including observatory personnel, VIS and MKSS staff, rangers, commercial tour operators and staff, and construction workers commenced in 2013. An online orientation is also available. A brief public / visitor orientation is complete and provided for scheduled group visits.</p>

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES

Cultural Practices		Implementation Status	Comments
CR-4	Establish a process for ongoing collection of information on traditional, contemporary, and customary cultural practices.	Ongoing	Archival and oral history (Mauna Kea-Ka Piko Kaulana o Ka 'Āina); Cultural Resources Management Plan; various cultural analyses completed as part of Chapter 343 mandates; Maunakea topics included by related agencies such as USGS subject matter reviews; and other studies. In 2016, Kahu Kū Mauna reviewed and approved the wording of draft policy guidelines. Approval by MKMB occurred in early 2018 after additional consultation by Kahu Kū Mauna.
CR-5	Develop and adopt guidelines for the culturally appropriate placement and removal of offerings.	Completed	The final outcome will likely be formally incorporated in administrative rules for UH's managed lands. Public hearings seeking public comments on a proposed draft were held in 2018. It is noted that the proposed policy acknowledges there are existing statutes and other agency rules governing this type of activity. Note: CR-5 overlaps with CR-7 (constructing new Hawaiian cultural features) being that offerings are usually associated with the construction of new features.
CR-6	Develop and adopt guidelines for the visitation and use of ancient shrines.	Completed	In 2016 Kahu Kū Mauna drafted and the MKMB approved the policy. Visitation is a public access issue and will likely be incorporated in administrative rules for UH's managed lands. Public hearings seeking public comments on a proposed draft were held in 2018. State law also governs.
CR-7	Kahu Kū Mauna shall take the lead in determining the appropriateness of constructing new Hawaiian cultural features.	Completed	In 2012, Kahu Kū Mauna reviewed a draft of a process. In 2016 Kahu Kū Mauna re-evaluated the policy and held a consultation session that included OHA. Approval by MKMB occurred in early 2018 after additional consultation by Kahu Kū Mauna.
CR-8	Develop and adopt a management policy for the UH Mgt. Areas on the scattering of cremated human remains.	Completed	It is noted that the proposed policy acknowledges there are existing statutes and other agency rules governing this type of activity. In 2012 Kahu Kū Mauna developed and approved a draft policy. In 2016 Kahu Kū Mauna re-evaluated the policy and held a consultation session that included OHA. Approval by MKMB occurred in early 2018 after additional consultation by Kahu Kū Mauna.
CR-9	A management policy for the culturally appropriateness of building ahu or "stacking of rocks" will need to be developed by Kahu Kū Mauna who may consider similar policies adopted by Hawaii Volcanoes National Park.	Completed	The final outcome will likely be incorporated in administrative rules for UH's managed lands. Public hearings seeking public comments on a proposed draft were held in 2018. In 2012 Kahu Kū Mauna approved a draft policy. In 2016 Kahu Kū Mauna re-evaluated the policy and held a consultation session that included OHA. Approval by MKMB occurred in early 2018 after additional consultation by Kahu Kū Mauna. CR-7 was combined with CR-9 under the guidance of Kahu Kū Mauna who pointed out that the "stacking of rocks" may be a cultural features.

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES			
Historic Properties		Implementation Status	Comments
CR-10	Develop and implement a historic property monitoring program to systematically monitor the condition of the historic district and all historic properties, including cultural sites and burials.	Completed	SHPD approved OMKM's long term historic properties monitoring plan; monitoring is ongoing according to the plan's schedule.
CR-11	Complete an archaeological survey of the portions of the Summit Access Road corridor that are under UH management.	Completed	An archaeological survey of the Maunakea Science Reserve and summit access road was completed in 2009.
CR-12	Consult with Kahu Kū Mauna about establishing buffers (preservation zones) around known historic sites in the Astronomy Precinct, to protect them from potential future development.	Completed	In 2012 Kahu Kū Mauna determined that this should be reviewed on a case-by-case basis. They identified criteria for when to consult for routine (minimal impact) project proposals, as well as with future development. In 2016, Kahu Kū Mauna revised their policy. MKMB approved their policy.
CR-13	Develop and implement a burial treatment plan for the UH Management Areas in consultation with Kahu Kū Mauna Council, MKMB's Hawaiian Culture Committee, the Hawai'i Island Burial Council, recognized lineal or cultural descendants, and SHPD.	Completed	SHPD reviewed and approved the Burial Treatment Plan for Mauna Kea in 2014.
CR-14	Immediately report any disturbance of a shrine or burial site to the rangers, DOCARE, Kahu Kū Mauna Council, and SHPD.	Ongoing	Rangers report disturbance to OMKM and OMKM in turn notifies other parties.

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES

Implementation Status

Comments

NATURAL RESOURCES

Threat Prevention and Control

NR-1	Limit threats to natural resources through management of permitted activities and uses.	Completed/ Ongoing	<p>OMKM consulted with agencies on a draft of administrative rules governing public and commercial activities. Public hearings seeking public comments on a proposed draft were held in 2018.</p> <p>An Operations, Monitoring and Maintenance Plan (OMMP) relating to the coordination of maintenance plans, activities and schedules was developed and approved by the MKMB, and is being implemented.</p> <p>The Maunakea Invasive Species Management Plan is approved and implemented. Additional topics are addressed as situations arise, and procedures are developed based on scientific, management board, and community feedback.</p> <p>A volunteer program was established to pull invasive weeds on UH's managed lands with emphasis in the Halepōhaku area. Long term goal is to re-vegetate the mid-level area with native plants.</p>
NR-2	Limit damage caused by invasive species through creation of an invasive species prevention and control program.	Completed/ Ongoing	<p>Beginning in 2007 OMKM conducted annual surveys of invasive arthropod species on UH's managed lands. This program was expanded to include monthly monitoring at the facilities at the 9,200 ft mid-level facilities, and quarterly monitoring of the summit facilities. Rapid response strategies were drafted as part of the Invasive Species Management Plan.</p> <p>Inspections of heavy equipment, construction material, and other items too large to be carried by an individual occur prior to coming on to UH's lands. Specific requirements are part of the Invasive Species Management Plan. A MS Student evaluated program efficacy as part of his 2018 thesis, with management recommendations to be incorporated into OMKM policies and procedures. Methods were updated based on thesis recommendations.</p> <p>Non-native plants and arthropods are monitored. The Division of Forestry and Wildlife is completing a circum-Maunakea fence and ungulate removal from Palia critical habitat. OMKM staff investigated māmane leaf curl frequency at Halepōhaku (plant disease response) in coordination with UHH scientists. Arthropod food webs and parasites are being investigated.</p> <p>OMKM coordinates with Forest Reserve, Natural Area Reserve, and Department of Land and Natural Resources technical staff to identify issues, craft appropriate responses, and investigate concerns regarding ecosystems and flora and fauna populations.</p>
NR-3	Maintain native plant and animal populations and biological diversity.	Ongoing	<p>OMKM coordinates with Forest Reserve, Natural Area Reserve, and Department of Land and Natural Resources technical staff to identify issues, craft appropriate responses, and investigate concerns regarding ecosystems and flora and fauna populations.</p>
NR-4	Minimize barriers to species migration to help maintain populations and protect ecosystem processes and development.	Ongoing	<p>OMKM coordinates with Forest Reserve and Natural Area Reserve staff to ensure management activities do not inadvertently impede natural ecosystem response. Research into climate change forecast downscaling and climate monitoring helps inform potential future management action. OMKM participated in Pacific Islands Climate Change Cooperative workshops on climate change to help identify mitigation and adaptation strategies. A climate monitoring sea level to summit network plan is in preparation.</p>
NR-5	Manage ecosystems to allow for response to climate change.	Ongoing	<p>OMKM coordinates with Forest Reserve and Natural Area Reserve staff to ensure management activities do not inadvertently impede natural ecosystem response. Research into climate change forecast downscaling and climate monitoring helps inform potential future management action. OMKM participated in Pacific Islands Climate Change Cooperative workshops on climate change to help identify mitigation and adaptation strategies. A climate monitoring sea level to summit network plan is in preparation.</p>

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES
Comments

		Implementation Status	
NR-6	Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea's unique natural resources.	Ongoing	<p>Rangers help to educate visitors about Maunakea as part of their daily activities.</p> <p>Resource orientation of those who work on the mountain including observatory personnel, VIS and MKSS staff, rangers, commercial tour operators and staff, and construction workers commenced in 2013. An online orientation is also available. A brief public / visitor orientation is complete and provided for scheduled group visits.</p> <p>See also CR-3 and EO-2</p>
Ecosystem Protection, Enhancement & Restoration			
NR-7	Delimitate areas of high native diversity, unique communities, or unique geological features within the Astronomy Precinct and at Hale Pōhaku and consider protection from development.	Ongoing	Botanical survey of UH managed lands is completed. Biodiversity, wēkiu bug, and erosion and surficial geology surveys are ongoing. A study and mapping of wēkiu bug habitat is completed.
NR-8	Consider fencing areas of high native biodiversity or populations of endangered species to keep out feral ungulates (applies to areas below 12,800 ft elevation).	Ongoing	Assisted DLNR with fencing natural population of Silverswords. Other areas will be fenced when areas are identified and needed.
			Māmane seedlings germinated from seeds found in the Halepōhaku area were planted near the VIS
			Worked with DLNR and planted 200 Silversword seedlings in the Halepōhaku area.
NR-9	Increase native plant density and diversity through an outplanting program.	Ongoing	Collaborated with Kamehameha Schools to build plant propagation benches and start seedlings for eventual habitat restoration and enhancement at Halepōhaku. Germination of māmane seedlings continues.
			The construction of a small greenhouse at Halepōhaku for growing native plants was approved by BLNR as part of a project to improve the ingress/egress and parking at the VIS. Over 100 native plants were planted under the ingress/egress improvements permit.
NR-10	Incorporate mitigation plans into project planning and conduct mitigation following new development.	Ongoing	Mitigation and best management practices plans are required for projects as appropriate.
NR-11	Conduct habitat rehabilitation projects following unplanned disturbances.	Ongoing	Damage assessments and rehabilitation following unplanned disturbances are conducted on a case-by-case basis as needed. Generally, unplanned disturbances, such as vehicle oil leaks, occur on previously disturbed areas such as roadways, where humans frequent.
NR-12	Create restoration plans and conduct habitat restoration activities, as needed.	Ongoing	A study of wēkiu bug habitat restoration was initiated in 2015. A study and mapping of wēkiu bug habitat has been completed. Restoration plans and greenhouse for long-term program use are part of a project to improve the ingress/egress and parking at the VIS.

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES

Implementation Status

Comments

Program Management			
NR-13	Increase communication, networking, and collaborative opportunities to support management and protection of natural resources.	Ongoing	OMKM has established and continues to establish working relationships with the community and DLNR through working groups such as the Environment and Big Island Invasive Species committees, and OHA.
NR-14	Use the principles of adaptive management when developing programs and methodologies. Review programs annually and revise any component plan every five years, based on the results of the program review.	Ongoing	Potential CMP revisions are identified in annual program documentation. Program plans, such as the Maunakea Invasive Species Management Plan, are updated and communicated at MKMB meetings as issues are identified. Completion of Envision Maunakea project.
Inventory, Monitoring and Research			
NR-15	Conduct baseline inventories of high-priority resources, as outlined in an inventory, monitoring, and research plan.	Ongoing	Baseline surveys of wēkiu bugs, other arthropods, including invasive species have been completed or are continuing. A botanical survey was completed in the Summer of 2011 and published in 2013. OMKM is funding a multi-year study on permafrost and working on designing a climate monitoring network. OMKM is also studying erosion to better understand surficial geology, cinder cone erosion, and characterize arthropod habitat. A bird and bat inventory commenced in 2017.
NR-16	Conduct regular long-term monitoring, as outlined in an inventory, monitoring, and research plan.	Ongoing	OMKM conducts annual wēkiu bug, alien and invasive species surveys. Botanical and arthropod surveys are conducted as part of the annual archaeological monitoring. Other monitoring plans to be developed following baseline surveys.
NR-17	Conduct research to fill knowledge gaps that cannot be addressed through inventory and monitoring.	Ongoing	OMKM funded a study to develop a long term model relating to climate change and potential impact to the summit ecosystem; a study of native arthropod habitats and vegetation association, arthropod food webs; analysis of historical weather climate conditions on the summit and meteorological and geological influences on insect and snowfall drops on the summit terrain to help inform wēkiu bug research; study to assess the presence and persistence of permafrost; surficial geology and erosion; and several studies related to the wēkiu bug including life history, genetics, habitat restoration, and habitat mapping.
NR-18	Develop geo-spatial database of all known natural resources and their locations in the UH Management Areas that can serve as baseline documentation against change and provide information essential for decision-making.	Ongoing	OMKM funded an international symposium on Tropical Alpine Ecosystems. Invited speakers are experts in research and management of alpine ecosystems. OMKM hopes to develop a network with other researchers and managers to gain knowledge to better manage Maunakea. Wēkiu bug and botanical data, infrastructure and signs have been mapped. A GIS database of resources surveyed utilizing ArcGIS and distributed as GoogleEarth layers has been developed; new data as available is added to this database.

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES

Implementation Status

Comments

EDUCATION AND OUTREACH

Program Development

EO-1	Develop and implement education and outreach program	Ongoing	<p>Volunteer, Orientation, Brochures (Safety, Culture, Resources, What is OMKM) are available. In-school visits (Hilo Inter, Hawaii Academy of Arts and Sciences PCS, Ke Ana Lahana, Waiakea High, Kealahou Elementary) occur regularly. Community organizations and members help support OMKM's volunteer program.</p> <p>Work with Kealahou Elementary School to support their annual Science Showcase at the school.</p> <p>Outreach activities by researchers are conducted at various schools; OMKM research affiliate also helps advise young scientists with their science fair projects</p> <p>Updates on OMKM activities are given to various community organizations. OMKM also participates in community events.</p>
Education			
EO-2	Require orientation of users, with periodic updates and a certificate of completion, including but not limited to visitors, employees, observatory staff, contractors, and commercial and recreational users.	Ongoing	Resource orientation of those who work on the mountain including observatory personnel, VIS and MKSS staff, rangers, commercial tour operators and staff, and construction workers commenced in 2013. Orientation is available to all interested parties in-person or online.
EO-3	Continue to develop, update, and distribute materials explaining important aspects of Mauna Kea.	Ongoing	Proposed administrative rules include a provision for an orientation of visitors. Materials on the cultural and natural resources, visiting safely and responsibly and Mauna Kea hazards are distributed at the VIS. .
EO-4	Develop and implement a signage plan to improve signage throughout the UH Management Areas (interpretive, safety, rules and regulations).	Completed/ Ongoing	A sign plan was approved by the MKMB in 2016 and implemented in 2017. An inventory of sign locations on UH's managed lands has been completed.
EO-5	Develop interpretive features such as self-guided cultural walks and volunteer-maintained native plant gardens.	In Progress	Cultural and safety related signs have been installed. Included as part of ongoing CJP funded project. These will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.
EO-6	Engage in outreach and partnerships with schools, by collaborating with local experts, teachers, and university researchers, and by working with the 'Imiloa Astronomy Center of Hawaii.	Ongoing	See EO-1

COMPONENT PLAN: UNDERSTANDING AND PROTECTING MAUNA KEA'S RESOURCES

Implementation Status

Comments

Outreach

EO-7	Continue and increase opportunities for community members to provide input to cultural and natural resources management activities on Mauna Kea, to ensure systematic input regarding planning, management, and operational decisions that affect natural resources, sacred materials or places, or other ethnographic resources with which they are associated.	Ongoing	<p>OMKM through the MKMB, Kahu Kū Mauna, and Environment Committee provide opportunity for members of the community and other organizations to participate in the management activities of the mountain.</p> <p>Bi-monthly volunteer activities provide an opportunity for the community to participate and share knowledge.</p> <p>Meetings with community groups and open houses were conducted to give the public an opportunity to provide input and feedback on administrative rules being developed by OMKM. Public hearings seeking public comments on a proposed draft were held in 2018.</p>
EO-8	Provide opportunities for community members to participate in stewardship activities.	Ongoing	<p>OMKM through the MKMB, Kahu Kū Mauna, and Environment provide opportunity for members of the community to participate in the management activities of the mountain.</p> <p>Bi-monthly volunteer activities provide an opportunity for the community to participate and share knowledge.</p> <p>Student projects and mentoring provides opportunities (science fair, legacy, etc.) for one-on-one interaction and more in-depth efforts.</p>

ASTRONOMICAL RESOURCES

AR-1	Operate the UH Management Areas to prohibit activities resulting in negative impacts to astronomical resources.	In Progress	<p>These will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.</p> <p>Project proposals requesting the use of radio signals are reviewed by the Institute for Astronomy for potential interference with astronomical research activities.</p>
AR-2	Prevent light pollution, radio frequency interference (RFI) and dust.	Ongoing	<p>At the State level, the Starlight Reserve Advisory Committee was active from 2010 to 2015. Efforts by UH and DBEDT to make the committee permanent were unsuccessful at the 2015 and 2016 Legislature were unsuccessful. They will try again in 2107.</p> <p>UH has been working closely with Hawaii County officials on outdoor lighting issues. This has resulted in the adoption of public-health, wildlife, and astronomy-friendly LED lights to replace the previous low-pressure sodium lights. UH and the County are now requesting the State to use similar lights at Hawaii island airports and harbors. UH continues to provide advice on amendments to the Hawaii County lighting ordinance</p> <p>These will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.</p>

COMPONENT PLAN: MANAGING ACCESS AND USES
Implementation Status
Comments

ACTIVITIES AND USES	
General Management	
ACT-1	<p>Continue and update managed access policy of 1995 Management Plan.</p>
ACT-2	<p>Develop parking and visitor traffic plan.</p>
ACT-3	<p>Maintain a presence of interpretive and enforcement personnel on the mountain at all times to educate users, deter violations, and encourage adherence to restrictions.</p>
ACT-4	<p>Develop and enforce a policy that maintains current prohibitions on off-road vehicle use in the UH Management Areas and that strengthens measures to prevent or deter vehicles from leaving established roads and designated parking areas.</p>
Recreational	
ACT-5	<p>Implement policies to reduce impacts of recreational hiking</p>
ACT-6	<p>Define and maintain areas where snow-related activities can occur and confine activities to slopes that have a protective layer of snow.</p>
ACT-7	<p>Confine University or other sponsored tours and stargazing activities to previously disturbed ground surfaces and established parking areas.</p>
ACT-8	<p>Coordinate with DLNR in the development of a policy regarding hunting in the UH Management Areas.</p>

	Completed Ongoing	<p>The BLNR approved the Public Access Plan for UH Management Areas on Mauna Kea. This plan contains principals and policies regarding public access. Administrative rules will help define UH's public access policy. Public hearings seeking public comments on a proposed draft were held in 2018. UH is in the process of updating the Master Plan and CMP that will address access policy</p> <p>Capital improvement funds are being used to implement an Ingress/egress, and parking plan to address concerns of traffic flow and pedestrian safety. A CDUP was issued to implement the ingress/egress project commenced in late 2018.</p>	<p>Comments</p>
Ongoing	<p>OMKM Rangers assist staff at the VIS with the implementation of their interim parking plan to maintain order, accommodate as many vehicles as possible and to ensure the safety of visitors to the VIS.</p>	<p>An automated vehicle counter counts the number of vehicles (differentiating: public, commercial, tour, observatory, etc.) that drive above Halepōhaku.</p> <p>Mauna Kea Rangers are present year round from 7:15 am to 10:15 pm daily; DOCARE officers and Hawaii County Police are called for assistance on an as needed basis.</p>	
Completed Ongoing	<p>OMKM prohibits the use of off-road vehicles on UH's managed lands. Vehicle access to the top of Pu'upoli'ahu has been blocked since 2001 at the request of Kahu Kū Mauna.</p>	<p>Commercial operators and film crews are required to stay on the road or within the footprint of existing facilities, unless granted permission by OMKM.</p> <p>This will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.</p>	
In Progress	<p>Implement policies to reduce impacts of recreational hiking</p>	<p>This will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.</p>	
Ongoing	<p>Define and maintain areas where snow-related activities can occur and confine activities to slopes that have a protective layer of snow.</p>	<p>Generally, this is a self-regulated activity. People usually do not venture to areas where there is no snow. A map of areas where snow play generally occurs has been developed, but areas change depending on the weather and snow deposition. Administrative rules will also address this activity. Public hearings seeking public comments on a proposed draft were held in 2018.</p>	
Ongoing	<p>Confine University or other sponsored tours and stargazing activities to previously disturbed ground surfaces and established parking areas.</p>	<p>Star gazing activities on UH's lands are limited to parking lots, or in areas in close proximity to the VIS</p>	
Completed Ongoing	<p>Coordinate with DLNR in the development of a policy regarding hunting in the UH Management Areas.</p>	<p>DLNR's hunting rules apply to UH's managed lands. Proposed administrative rules confirms application of DLNR's hunting rules to UH managed lands. Public hearings seeking public comments on a proposed draft were held in 2018.</p>	

COMPONENT PLAN: MANAGING ACCESS AND USES
Implementation Schedule

Comments

Commercial				
ACT-9	Maintain commercial tour permitting process; evaluate and issue permits annually.	Ongoing	UJ oversees commercial tour permits, a responsibility transferred to UJ from BLNR. This will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.	
ACT-10	Ensure OMKM input on permits for filming activities	Completed Ongoing	Film permits are issued by the Hawaii Film Office of Department of Business Economic Development of Tourism. All film permits require OMKM's approval before they are issued.	
ACT-11	Seek statutory authority for the University to regulate commercial activities in the UH Management Areas.	Completed Ongoing	This will also be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018. The function of commercial tour permitting was transferred by BLNR to UJ. OMKM oversees commercial tour operations and film activities.	
Scientific Research				
ACT-12	Ensure input by OMKM, MKMB, and Kahu Kū Mauna on all scientific research permits and establish system of reporting results of research to OMKM.	Ongoing	Statutory authority to promulgate administrative rules was granted by the Legislature in 2009. This will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.	
PERMITTING AND ENFORCEMENT				
Laws and Regulations				
P-1	Comply with all applicable federal, state, and local laws, regulations, and permit conditions related to activities in the UH Management Areas.	Ongoing	All research proposals must be approved by OMKM. Proposals requiring ground disturbing activities or potential impact to the cultural and/or natural landscape are reviewed by Kahu Kū Mauna and MKMB. Permit by DLNR as appropriate.	
P-2	Strengthen CMP implementation by recommending to the BLNR that the CMP conditions be included in any Conservation District Use Permit or other permit.	Ongoing	This is a condition of UH's leases with DLNR. Rangers monitor activities. Regular communication with DLNR's Division of Conservation and Resources Enforcement, County of Hawaii police, and Sheriff's department continues as demonstrated during TMT protests. Relevant CMP management actions were incorporated into the CDUA for the Thirty Meter Telescope project.	
P-3	Obtain statutory rule-making authority from the legislature, authorizing the University of Hawai'i to adopt administrative rules pursuant to Chapter 91 to implement and enforce the management actions.	Completed	The MKMB requires proposals for projects for Maunakea include a review and comments on how the proposer will comply with CMP action items relevant to the project. The Legislature granted UH authority to promulgate administrative rules in 2009. Act 132.	
P-4	Educate management staff and users of the mountain about all applicable rules and permit requirements.	Ongoing	Included as part of the orientation and with new project start-up meetings. This will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.	

COMPONENT PLAN: MANAGING ACCESS AND USES

Implementation Status

Comments

Enforcement			
P-5	Continue coordinating with other agencies on enforcement needs.	Ongoing	OMKM coordinates with DOCARE on enforcement activities. Ranger observations are sent to DLNR, NAR, DOFAW, and US Fish & Wildlife Service.
P-6	Obtain legal authority for establishing, and then establish, a law enforcement presence on the mountain that can enforce rules for the UH Management Areas on Mauna Kea.	Completed	
P-7	Develop and implement protocol for oversight and compliance with Conservation District Use Permits.	Ongoing	OMKM rangers conduct twice yearly inspections of all observatories for CDUP compliance.
P-8	Enforce conditions contained in commercial and Special Use permits.	Ongoing	Rangers' responsibilities includes oversight of commercial tour activities and special use permits issued by OMKM.
COMPONENT PLAN: MANAGING THE BUILT ENVIRONMENT INFRASTRUCTURE AND MAINTENANCE			
Routine Maintenance			
IM-1	Develop and implement an OMMP.	Completed/Ongoing	An Operations Monitoring and Maintenance Plan (OMMP) was reviewed by Kahu Ku Mauna and approved by the MKMB. Implementation is ongoing.
IM-2	Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	Ongoing	A cultural and natural resources orientation program has been developed and is implemented. Orientation sessions on resources and safety are conducted for OMKM and Maunakea Observatory Support Staff. This will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.
IM-3	Conduct historic preservation review for maintenance activities that will have an adverse effect on historic properties.	In Progress	OMKM is currently developing a Programmatic Agreement/MOU relating to maintenance activities that will be submitted to State Historic Preservation Division. A programmatic agreement may not be necessary being that activity that involves major ground disturbance involves a permit from DLNR and SHPD review. Routine activities do not involve major ground disturbance or occur on already disturbed land.
IM-4	Evaluate need for and feasibility of a vehicle wash station near Hale Pōhaku, and requiring that vehicles be cleaned.	Completed/Ongoing	OMKM funded a study to evaluate the efficacy current measures to prevent the introduction of invasive species, including vehicle and equipment wash practices.
IM-5	Develop and implement a Debris Removal, Monitoring and Prevention Plan.	Ongoing	Trash from the HP facilities and VIS are removed daily. Each observatory removes trash from their respective facilities. Rangers routinely check for and pick up trash and debris while on their daily patrols. Rangers pick up and map the location of trash at the parking lot near the trail head to Lake Waiau (NAR). The amount of trash decreased following the installation of a portable toilet. A draft plan is under review.
IM-6	Develop and implement an erosion inventory and assessment plan.	In Progress	OMKM partnered with UH Hilo geography department to study surficial geology and cinder cone erosion issues. It is anticipated the inventory will be completed in 2020
IM-7	Prepare a plan, in collaboration with the Department of Defense, to remove military wreckage from a remote area of the UH Management Areas, while ensuring protection of natural and cultural resources.	Ongoing	An inventory of all known aircraft and military wreckage was submitted to the Department of Defense for review and updating. OMKM is working with DOD, OCCCL, and SHPD to determine appropriate plans for removal or preservation in place.

COMPONENT PLAN: MANAGING THE BUILT ENVIRONMENT**Implementation Status****Comments**

Infrastructure		Completed/ Ongoing	Comments
IM-8	Assess feasibility of paving the Summit Access Road.	Completed/ Ongoing	An engineering study related to the paving of the access road from Halepōhaku to the summit was completed in 1984. This study was the basis for paving the road from the summit to about the boundary of the Science Reserve. Another study was prepared in 2017 of the damage caused by large storms over the past 10 years. The report assessed repairs needed and potential cost.
IM-9	Evaluate need for additional parking lots and vehicle pullouts and install if necessary.	Ongoing	As part of the CIP ingress/egress project at the VIS, additional parking was assessed and parking added. With TMT a recreational parking plan for Batch Plant (Park 3) was submitted to DLNR and approved. A visitor study initiated in 2019 by UH Mānoa will further inform any future efforts.
IM-10	Evaluate need for additional public restroom facilities in the summit region and at Hale Pōhaku, and install close-contained zero waste systems if necessary.	Ongoing	Initial consideration of converting the presentation room building into a rest and eating stop for commercial tours as a means of reducing congestion at the VIS and providing greater access by the independent travelers, has been put on hold until completion of the ingress/egress project is completed, or if another solution presents itself. MKSS is considering options for handling overcrowding at the VIS. Additional portable toilets are available at the summit to address restroom facilities needs at the summit. Waterless urinals were installed in the VIS men's restroom.
Sustainable Technologies			
IM-11	Encourage existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.	Ongoing	The proposed Thirty Meter Telescope is incorporating energy efficiency in its design. Maunakea Observatory Support Services installed a photovoltaic system at Halepōhaku; Gemini observatory installed, and Keck observatory is planning to install photovoltaic systems on their respective summit facilities.
IM-12	Conduct energy audits to identify energy use and system inefficiencies, and develop solutions to reduce energy usage.	Ongoing	Energy audits are part of the photovoltaic system design process, completed or in progress at Gemini, Keck, and Halepōhaku.
IM-13	Conduct feasibility assessment, in consultation with Hawaii Electric Light Company, on developing locally-based alternative energy sources.	Ongoing	MKSS installed a photovoltaic system at Halepōhaku. Additional energy conservation and sustainable generation possibilities are discussed by UHH, MKSS, and Observatories as opportunities arise.
IM-14	Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations.	Ongoing	With the development of new technology, observatories are beginning to reduce their need to use hazardous materials. An example, is the TMT observatory, which will not be using mercury.

COMPONENT PLAN: MANAGING THE BUILT ENVIRONMENT
Implementation Status

Comments

CONSTRUCTION GUIDELINES

General Requirements			
C-1	Require an independent construction monitor who has oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements.	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
Best Management Practices			
C-2	Require use of Best Management Practices Plan for Construction Practices.	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA. A template for adaptation and use by others is also available.
C-3	Develop, prior to construction, a rock movement plan. Require contractors to provide information from construction activities to OMKM for input into OMKM information databases.	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
C-4	Require on-site monitors (e.g., archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agency.	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
C-5	Conduct required archaeological monitoring during construction projects per SHPD approved plan	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
C-6	Education regarding historical and cultural significance	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
C-7	Education regarding environment, ecology and natural resources	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
C-8	Inspection of construction materials	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
SITE RECYCLING, DECOMMISSIONING, DEMOLITION AND RESTORATION			
SR-1	Require observatories to develop plans to recycle or demolish facilities once their useful life has ended, in accordance with their sublease requirements, identifying all proposed actions.	Ongoing	This will be part of the TMT decommissioning plan, with the TMT decommissioning funding plan approved by the MKMB in 2014.
SR-2	Require observatories to develop a restoration plan in association with decommissioning, to include an environmental cost-benefit analysis and a cultural assessment.	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.
SR-3	Require any future observatories to consider site restoration during project planning and include provisions in subleases for funding of full restoration.	Ongoing	Included as part of the proposed TMT Management Plan in its CDUA.

COMPONENT PLAN: MANAGING THE BUILT ENVIRONMENT

Implementation Status

Comments

CONSIDERING FUTURE LAND USE

Facility Planning Guidelines

FLU-1	Follow design guidelines presented in the 2000 Master Plan.	Ongoing	The Design Review Process, which incorporated the 2000 Master Plan's design guidelines, were used in the review of the Thirty Meter Telescope project	
FLU-2	Develop a map with land-use zones in the Astronomy Precinct based on updated inventories of cultural and natural resources, to delineate areas where future land use will not be allowed and areas where future land use will be allowed but will require compliance with prerequisite studies or analysis prior to approval of Conservation District Use Permit.	Ongoing	Areas previously mapped as off-limits for future land use through plans such as the Master Plan or CMP are used to limit any proposed activity. UH President Lassner confirmed that TMT was the last telescope to be built on undisturbed land. Resource data must be part of any proposal for major land use requests. HAR 13-5 allows for different types of land uses with each having its own requirements for preparing a land use application. Thus a single pre-prepared map cannot possibly address all potential scenarios.	
FLU-3	Require cataloguing of initial site conditions for use when conducting site restoration.	Ongoing	TMT project completed a photo documentation of its site.	
FLU-4	Require project specific visual rendering of both pre- and post-project settings to facilitate analysis of potential impacts to view planes.	Ongoing	TMT project completed a photo documentation.	
FLU-5	Require an airflow analysis on the design of proposed structures to assess potential impacts to aeolian ecosystems.	Ongoing	Incorporated into the TMT project.	
FLU-6	Incorporate habitat mitigation plans into project planning process.	Ongoing	Incorporated into the TMT project	
FLU-7	Require use of close-contained zero-discharge waste systems for any future development in the summit region, from portable toilets to observatory restrooms, if feasible.	Ongoing	Incorporated into the TMT project	

COMPONENT PLAN: MANAGING OPERATIONS			Comments
Implementation Status			
OPERATION AND IMPLEMENTATION			
OI-1	Maintain OMKM, MKMB, and Kahu Kū Mauna in current roles, with OMKM providing local management of the UH Management Areas, and MKSS providing operational and maintenance services.	Completed	The MKMB meets regularly, holding numerous public meetings; which includes consultation with Kahu Kū Mauna Council. OMKM continues to submit CMP management actions (such as the OMP) to MKMB. MKSS continues to maintain the road and public services, financially supported by the Maunakea Observatories.
OI-2	Develop training plan for staff and volunteers.	Completed	OMKM requires all staff and volunteers to attend the Maunakea orientation. A training plan was submitted and approved by the MKMB; bi-monthly trainings of all staff is being conducted.
OI-3	Maintain and expand regular interaction and dialogue with stakeholders, community members, surrounding landowners, and overseeing agencies to provide a coordinated approach to resource management.	Ongoing	OMKM has frequent contact in particularly with its neighbor, DLNR on resource management issues. OMKM rangers report unusual or suspicious behavior observed on DLNR lands to DLNR including DOCARE.
OI-4	Establish grievance procedures for OMKM, to address issues as they arise.	Ongoing	The public has the opportunity to address grievances at the MKMB publicly held meetings. This will be addressed in administrative rules. Public hearings seeking public comments on a proposed draft were held in 2018.
OI-5	Update and implement emergency response plan.	Ongoing	Emergency response plan is reviewed annually.
MONITORING, EVALUATION AND UPDATES			
MEU-1	Establish a reporting system to ensure that the MKMB, DLNR, and the public are informed of results of management activities in a timely manner.	Ongoing	Reports are provided at the publicly held MKMB Meetings.
MEU-2	Conduct regular updates of the CMP that reflect outcomes of the evaluation process, and that incorporate new information about the resources.	Ongoing	Five-year CMP revision interval was initiated in 2014. EnVision Maunakea and administrative rules will play a role in the updating the CMP.
MEU-3	Revise and update planning documents, including the master plan, leases, and subleases, so that they will clearly assign roles and responsibilities for managing Mauna Kea and reflect stewardship matters resolved with DLNR.	In Progress	UH is preparing an EIS for a new land authorization for UH's lands on Maunakea. A Prep Notice was prepared and published in February 2018. UH is reviewing comments and is considering them in the development of the draft.

.0

**Cumulative Annual Progression of
CMP Implementation Status**

Management		CMP Implementation Timeframe		Annual Implementation Status								
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	Comment
Native Hawaiian Cultural Resources Management												
CR-1	Kahu Kū Mauna shall work with families with lineal and historical connections to Maunakea, cultural practitioners, and other Native Hawaiian groups, including the Maunakea Management Board's Hawaiian Culture Committee, toward the development of appropriate procedures and protocols regarding cultural issues.	Immediate	Ongoing	In Progress	Ongoing							
CR-2	Support application for designation of the summit region of Maunakea as a Traditional Cultural Property, per the National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq. in consultation with the larger community.	Short-term			Ongoing							
CR-3	Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	Immediate	Ongoing	In Progress	Ongoing							
Cultural Practices												
CR-4	Establish a process for ongoing collection of information on traditional, contemporary, and customary cultural practices.	Short-term								Ongoing		
CR-5	Develop and adopt guidelines for the culturally appropriate placement and removal of offerings.	Immediate		In Progress*						Completed		
CR-6	Develop and adopt guidelines for the visitation and use of ancient shrines.	Immediate		In Progress		Ongoing				Completed		
CR-7	Kahu Kū Mauna shall take the lead in determining the appropriateness of constructing new Hawaiian cultural features.	Immediate		In Progress*						Completed		
CR-8	Develop and adopt a management policy for the UH Management Areas on the scattering of created human remains.	Immediate	Ongoing	In Progress*						Completed		
CR-9	A management policy for the culturally appropriateness of building ahu or "stacking of rocks" will need to be developed by Kahu Kū Mauna who may consider similar policies adopted by Hawai'i Volcanoes National Park.	Immediate	Ongoing	In Progress*						Completed		
Historic Properties												
CR-10	Develop and implement a historic property monitoring program to systematically monitor the condition of the historic district and all historic properties, including cultural sites and burials.	Immediate	Ongoing	In Progress	Completed							
CR-11	Complete an archaeological survey of the portions of the Summit Access Road corridor that are under UH management.	Completed										

Management		CMP Implementation Timeframe		Annual Implementation Status								
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	Comment
CR-12	Consult with Kahu Kū Mauna about establishing buffers (preservation zones) around known historic sites in the Astronomy Precinct, to protect them from potential future development		As needed	As needed	As needed	Ongoing				Completed		
CR-13	Develop and implement a burial treatment plan for the UH Management Areas in consultation with Kahu Kū Mauna Council, MIKIMB's Hawaiian Culture Committee, the Hawai'i Island Burial Council, recognized lineal or cultural descendants, and SHPD.		Ongoing	In Progress	Completed	Completed						A burial treatment plan was approved by SHPD in July 2014. This was incorrectly reported as 'In Progress' in the previously submitted 2014 and 2015 narrative reports.
CR-14	Immediately report any disturbance of a shrine or burial site to the rangers, DOCARE, Kahu Kū Mauna Council, and SHPD		Ongoing									
Natural Resources												
Threat Prevention and Control												
NR-1	Limit threats to natural resources through management of permitted activities and uses			In Progress		Ongoing				Completed / Ongoing		
NR-2	Limit damage caused by invasive species through creation of an invasive species prevention and control program		Ongoing	In Progress		Ongoing				Completed / Ongoing		
NR-3	Maintain native plant and animal populations and biological diversity								Ongoing			
NR-4	Minimize barriers to species migration, to help maintain populations and protect ecosystem processes and development.								Ongoing			
NR-5	Manage ecosystems to allow for response to climate change								Ongoing			
NR-6	Reduce threats to natural resources by educating stakeholders and the public about Maunakea's unique natural resources.		Ongoing									
Ecosystem Protection, Enhancement & Restoration												
NR-7	Delineate areas of high native diversity, unique communities, or unique geological features within the Astronomy Precinct and at Halepōhaku and consider protection from development.					In Progress		Ongoing				

Management		Annual Implementation Status									
CMP Implementation Timeframe		2011	2012*	2013	2014	2015	2016	2017	2018	2019	Comment
Action	Description										
NR-8	Consider fencing areas of high native biodiversity or populations of endangered species to keep out feral ungulates (applies to areas below 12,800 ft elevation).				Ongoing						
NR-9	Increase native plant density and diversity through an outplanting program.						Ongoing				
NR-10	Incorporate mitigation plans into project planning and conduct mitigation following new development.				Ongoing						
NR-11	Conduct habitat rehabilitation projects following unplanned disturbances.				Ongoing						
NR-12	Create restoration plans and conduct habitat restoration activities, as needed.						In Progress	Ongoing			
Program Management											
NR-13	Increase communication, networking, and collaborative opportunities, to support management and protection of natural resources. Use the principles of adaptive management when developing programs and methodologies. Review programs annually and revise any component plans every five years, based on the results of the program review.		In Progress	Ongoing							
NR-14					In Progress			Ongoing			
Inventory, Monitoring and Research											
NR-15	Conduct baseline inventories of high-priority resources, as outlined in an inventory, monitoring, and research plan.										
NR-16	Conduct regular long-term monitoring, as outlined in an inventory, monitoring, and research plan										
NR-17	Conduct research to fill knowledge gaps that cannot be addressed through inventory and monitoring.										
NR-18	Develop geo-spatial database of all known natural resources and their locations in the UH Management Areas that can serve as baseline documentation against change and provide information essential for decision-making.										
Education and Outreach Program Development											
EO-1	Develop and implement education and outreach program										
EO-2	Require orientation of users, with periodic updates and a certificate of completion, including but not limited to visitors, employees, observatory staff, contractors, and commercial and recreational users.										

Management		CMP Implementation Timeframe		Annual Implementation Status								
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	Comment
EO-3	Continue to develop, update, and distribute materials explaining important aspects of Maunakea.	Ongoing		In Progress	Ongoing							
EO-4	Develop and implement a signage plan to improve signage throughout the UH Management Areas (interpretive, safety, rules and regulations).	Immediate						In Progress	Ongoing	Completed	Ongoing	
EO-5	Develop interpretive features such as self-guided cultural walks and volunteer-maintained native plant gardens.	Mid-term						In Progress				Admin Rules will help define areas
EO-6	Engage in outreach and partnerships with schools, by collaborating with local experts, teachers, and university researchers, and by working with the 'Imiloa Astronomy Center of Hawai'i.	Mid-term				Ongoing						
Outreach												
EO-7	Continue and increase opportunities for community members to provide input to cultural and natural resources management activities on Maunakea, to ensure systematic input regarding planning, management, and operational decisions that affect natural resources, sacred materials or places, or other ethnographic resources with which they are associated.	Ongoing										
EO-8	Provide opportunities for community members to participate in stewardship activities.	Ongoing										
Astronomy Resources												
Protection of Astronomical Resources												
AR-1	Operate the UH Management Areas to prohibit activities resulting in negative impacts to astronomical resources.	Ongoing		In Progress								Pending approval of Admin Rules
AR-2	Prevent light pollution, radio frequency interference (RFI) and dust.	Ongoing										
Activities and Uses												
General Management												
ACT-1	Continue and update managed access policy of 1995 Management Plan.	Short-term		Completed Ongoing								Approval of Admin Rules will help define UH's access policy
ACT-2	Develop parking and visitor traffic plan.	Immediate	Ongoing	In Progress					Ongoing			CDUP issued, construction began in 2018
ACT-3	Maintain a presence of interpretive and enforcement personnel on the mountain at all times to educate users, deter violations, and encourage adherence to restrictions.	Completed Ongoing										

Management		CMP Implementation Timeframe		Annual Implementation Status								
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	Comment
ACT-4	Develop and enforce a policy that maintains current prohibitions on off-road vehicle use in the UH Management Areas and that strengthens measures to prevent or deter vehicles from leaving established roads and designated parking areas.	Ongoing										
Recreational												
ACT-5	Implement policies to reduce impacts of recreational hiking	Short-term		In Progress								Pending approval of Admin Rules
ACT-6	Define and maintain areas where snow-related activities can occur and confine activities to slopes that have a protective layer of snow	Ongoing										
ACT-7	Confine University or other sponsored tours and star-gazing activities to previously disturbed ground surfaces and established parking areas.	Ongoing										
ACT-8	Coordinate with DLNR in the development of a policy regarding hunting in the UH Management Areas.	Immediate	Ongoing	Completed Ongoing								Admin Rules will confirm application of DLNR's hunting rules
Commercial												
ACT-9	Maintain commercial tour permitting process; evaluate and issue permits annually.	Ongoing										
ACT-10	Ensure OMKM input on permits for filming activities	Ongoing								Completed Ongoing		
ACT-11	Seek statutory authority for the University to regulate commercial activities in the UH Management Areas.	Completed Ongoing										
Scientific Research												
ACT-12	Ensure input by OMKM, MKMB, and Kahu Ki Mauna on all scientific research permits and establish system of reporting results of research to OMKM.	Ongoing										
Permitting and Enforcement												
Laws and Regulations												
P-1	Comply with all applicable federal, state, and local laws, regulations, and permit conditions related to activities in the UH Management Areas.	Ongoing										
P-2	Strengthen CMP implementation by recommending to the BLNR that the CMP conditions be included in any Conservation District Use Permit or other permit.	As needed		Ongoing								
P-3	Obtain statutory rule-making authority from the legislature, authorizing the University of Hawai'i to adopt administrative rules pursuant to Chapter 91 to implement and enforce the management actions.	Completed										

Management		CMP Implementation Timeframe		Annual Implementation Status											
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	2020	Comment		
P-4	Educate management staff and users of the mountain about all applicable rules and permit requirements.	Immediate	Ongoing												
Enforcement															
P-5	Continue coordinating with other agencies on enforcement needs.	Ongoing													
P-6	Obtain legal authority for establishing, and then establish, a law enforcement presence on the mountain that can enforce rules for the UH Management Areas on Maunakea.	Completed / As needed	Completed												
P-7	Develop and implement protocol for oversight and compliance with Conservation District Use Permits.	Ongoing													
P-8	Enforce conditions contained in commercial and Special Use permits.	Ongoing													
Infrastructure and Maintenance															
Routine Maintenance															
IM-1	Develop and implement an OMMP.	Ongoing			In Progress						Completed/Ongoing				
IM-2	Reduce impacts from operations and maintenance activities by educating personnel about Maunakea's unique resources.	Immediate	Ongoing		In Progress	Ongoing									
IM-3	Conduct historic preservation review for maintenance activities that will have an adverse effect on historic properties.	Short-term			In Progress										
IM-4	Evaluate need for and feasibility of a vehicle wash station near Halepōhaku, and requiring that vehicles be cleaned.	Short-term				In Progress					Completed/ Ongoing				
IM-5	Develop and implement a Debris Removal, Monitoring and Prevention Plan.	Immediate	Ongoing												
IM-6	Develop and implement an erosion inventory and assessment plan.	Long-term				In Progress							Estimated completion XXX		
IM-7	Prepare a plan, in collaboration with the Department of Defense, to remove military wreckage from a remote area of the UH Management Areas, while ensuring protection of natural and cultural resources.	Mid-term						Ongoing							
Infrastructure															
IM-8	Assess feasibility of paving the Summit Access Road.	Long-term			In Progress			Completed/Ongoing							
IM-9	Evaluate need for additional parking lots and vehicle pullouts and install if necessary.	Mid-term							In Progress		Ongoing				
IM-10	Evaluate need for additional public restroom facilities in the summit region and at Halepōhaku, and install close-contained zero waste systems if necessary.	Immediate			In Progress			Ongoing							
Sustainable Technologies															

Management		Annual Implementation Status										
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	Comment
IM-11	Encourage existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.	As needed				Ongoing						
IM-12	Conduct energy audits to identify energy use and system inefficiencies, and develop solutions to reduce energy usage.	Immediate					Ongoing					
IM-13	Conduct feasibility assessment, in consultation with Hawaii Electric Light Company, on developing locally-based alternative energy sources.	Mid-term					In Progress	Ongoing				
IM-14	Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations.	Short-term						Ongoing				
Construction Guidelines												
General Requirements												
C-1	Require an independent construction monitor who has oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements.	As needed				Ongoing						
Best Management Practices												
C-2	Require use of Best Management Practices Plan for Construction Practices.	As needed				Ongoing						
C-3	Develop, prior to construction, a rock movement plan.	As needed				Ongoing						
C-4	Require contractors to provide information from construction activities to OMKM for input into OMKM information databases.	As needed				Ongoing						
C-5	Require on-site monitors (e.g., archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agency.	As needed				Ongoing						
C-6	Conduct required archaeological monitoring during construction projects per SHPD approved plan.	As needed				Ongoing						
C-7	Education regarding historical and cultural significance.	As needed				Ongoing						
C-8	Education regarding environment, ecology and natural resources.	As needed				Ongoing						
C-9	Inspection of construction materials.	As needed				Ongoing						
Site Recycling, Decommissioning, Demolition and Restoration												
SR-1	Require observatories to develop plans to recycle or demolish facilities once their useful life has ended, in accordance with their sublease requirements, identifying all proposed actions.	As needed				Ongoing						

Management		CMP Implementation Timeframe		Annual Implementation Status											
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	2020	Comment		
SR-2	Require observatories to develop a restoration plan in association with decommissioning, to include an environmental cost-benefit analysis and a cultural assessment.	As needed				Ongoing									
SR-3	Require any future observatories to consider site restoration during project planning and include provisions in subleases for funding of full restoration.	As needed				Ongoing									
Considering Future Land Use															
Facility Planning Guidelines															
FLU-1	Follow design guidelines presented in the 2000 Master Plan	As needed		Ongoing											
FLU-2	Develop a map with land-use zones in the Astronomy Precinct based on updated inventories of cultural and natural resources, to delineate areas where future land use will not be allowed and areas where future land use will be allowed but will require compliance with prerequisite studies or analysis prior to approval of Conservation District Use Permit	Short-term							Ongoing						
FLU-3	Require cataloguing of initial site conditions for use when conducting site restoration.	As needed				Ongoing									
FLU-4	Require project specific visual rendering of both pre- and post-project settings to facilitate analysis of potential impacts to view planes.	As needed				Ongoing									
FLU-5	Require an airflow analysis on the design of proposed structures to assess potential impacts to aeolian ecosystems.	As needed				Ongoing									
FLU-6	Incorporate habitat mitigation plans into project planning process.	As needed				Ongoing									
FLU-7	Require use of close-contained zero-discharge waste systems for any future development in the summit region, from portable toilets to observatory restrooms, if feasible	As needed				Ongoing									
Operations and Implementation															
Management															
OI-1	Maintain OMKM, MKMB, and Kahu Kō Mauna in current roles, with OMKM providing local management of the UH Management Areas, and MKSS providing operational and maintenance services.	Ongoing										Completed			
OI-2	Develop training plan for staff and volunteers	Ongoing									Completed				
OI-3	Maintain and expand regular interaction and dialogue with stakeholders, community members, surrounding landowners, and overseeing agencies to provide a coordinated approach to resource management.	Ongoing													

Management		CMP Implementation Timeframe		Annual Implementation Status											
Action	Description	2010	2011	2012*	2013	2014	2015	2016	2017	2018	2019	Comment			
OI-4	Establish grievance procedures for OMKM, to address issues as they arise.	Short-term		Ongoing								Admin Rules will provide a grievance process related to rules violations			
OI-5	Update and implement emergency response plan.	Ongoing													
Monitoring, Evaluation, and Updates															
Management															
MEU-1	Establish a reporting system to ensure that the MKMIB, DLNR, and the public are informed of results of management activities in a timely manner.	Immediate	Ongoing												
MEU-2	Conduct regular updates of the CMP that reflect outcomes of the evaluation process, and that incorporate new information about the resources.	Short-term / As needed			In Progress	In Progress		In Progress		Ongoing		Designation reflects completion of Envision of Maunakea process.			
MEU-3	Revise and update planning documents, including the master plan, leases, and subleases, so that they will clearly assign roles and responsibilities for managing Maunakea and reflect stewardship matters resolved with DLNR.	As needed				In Progress									

*In 2012 the Ongoing category was divided into two groups, Ongoing and In Progress.

* A lawsuit was filed in federal court which was dismissed without prejudice; the plaintiff may still seek further judicial relief

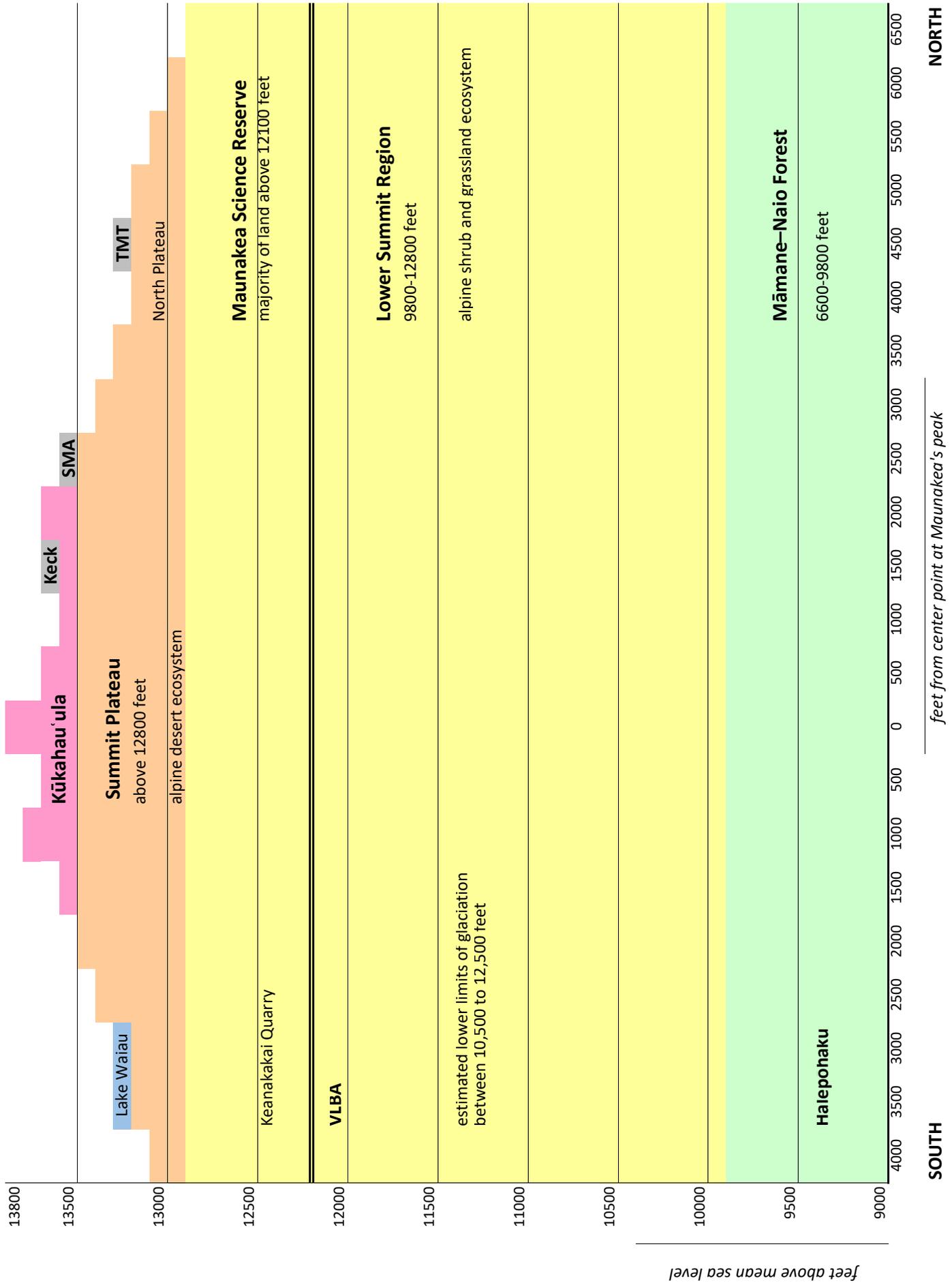


Exhibit 5: Schemata of Maunakea Ecosystems

This map is an approximation intended for reference purposes only. Please note that x and y axes are not to scale.