



# Inventory & Monitoring Program Pacific Island Network Monitoring Plan

## Appendix A: Landscape Report

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### Pacific Island Network (PACN)

#### *Territory of Guam*

War in the Pacific National Historical Park (WAPA)

#### *Commonwealth of the Northern Mariana Islands*

American Memorial Park, Saipan (AMME)

#### *Territory of American Samoa*

National Park of American Samoa (NPSA)

#### *State of Hawaii*

USS Arizona Memorial, Oahu (USAR)

Kalaupapa National Historical Park, Molokai (KALA)

Haleakala National Park, Maui (HALE)

Ala Kahakai National Historic Trail, Hawaii (ALKA)

Puukohola Heiau National Historic Site, Hawaii (PUHE)

Kaloko-Honokohau National Historical Park, Hawaii (KAHO)

Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)

Hawaii Volcanoes National Park, Hawaii (HAVO)

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## EXECUTIVE SUMMARY

All of the parks in the Pacific Island network (PACN) require monitoring of landscapes either inside or adjacent to the park. Most of the PACN parks share similar landscape resources such as ecological gradients and zones, soundscapes, lightsapes, cultural significant resources, viewsheds, management zones and use areas. The larger parks (HAVO, HALE, KALA, NPSA) include designated and potential wilderness areas, which are highly susceptible to anthropogenic noise from air tours. Landscapes are also affected by water quality, land use, light pollution, marine and terrestrial noise, visitor and management impacts.

Monitoring will provide a better understanding of the environmental condition and information to determine selected vital signs of parks ecosystems. Early detection of degraded ecosystems will assist park managers in mitigation efforts, as well as reduce costs for managing landscapes with associated natural resources. Landscape monitoring also provides information on the effects of natural and anthropogenic processes occurring in parks. Monitoring is also essential for the protection of important resources that share cultural and natural value.

The PACN covers an enormous area across the northern and southern hemispheres on both sides of the International Date Line (see map on pg.16). Hawaii is located between 19 and 22 degrees north latitude and situated almost directly in the center of the Pacific Ocean (Juvik & Juvik 1998). Due to its isolation from a larger continental region, natural resources are quickly affected by external activities. Guam, located at 13 degrees north latitude is the largest and southern most of the Mariana chain and part of Micronesia, is 32 miles long and four to nine miles wide. The climate is tropical and is influenced by the northeast trade wind regime. Saipan, also part of Micronesia, is situated at 15 degrees north latitude slightly above Guam (125 miles). Saipan is 14 miles long and 4 miles wide, (approximately 47sq miles), and by the standards of Micronesia it is considered to be a sizable island. The climate is tropical and Saipan is also influenced by the north east trade regime. American Samoa includes five volcanic islands (Tutuila, Aunu'u, Ofu, Olosega, Tau) with a total land area of 76.1 square miles. These islands are located 14 degrees south of the equator. The climate is hot, humid with year round rain and is influenced by the south east tradewinds. The highest elevations are on Lata Mountain located on the island Tau (3,100 feet) and Matafao Peak (2,142 feet), on the island of Tutuila.

One of the unique aspects of the landscape topic is its interaction with natural resources issues and cultural value. The interface of natural resources and cultural values can create a conflict of interest while trying to preserve resources and provide for the enjoyment of future generations. The drivers and stressors affecting landscapes have been identified as both natural and anthropogenic. However, most of the threats affecting landscapes are human induced. They include, but are not limited to, air tours, increased development, subsistence agriculture and fishing, fires, adjacent land use encroaching on park units, light pollution, litter, introduction of alien species (both plant and animal), and visitor impacts.

Some of the needs for the PACN monitoring program regarding landscapes are oral histories from local residents to establish long term trends of subsistence agriculture and fishing. This information is useful in gain a better understanding of pre-European contact of the Pacific Islands. Complete vegetation mapping for all PACN parks to identify native and alien plant species is needed to document terrestrial resources and rapidly respond to changes occurring. Determining the status of cultural resources is also needed as some of these resources are largely responsible for the sustenance of the natural environment.

Partnerships with adjacent landowners to assure contiguous landscapes are vital for all PACN parks. Monitoring land use and land use activities within the parks is essential to preserving natural resources. Some parks have complicated land ownership or lease agreements with local governments that provide NPS with the opportunity to manage land that would otherwise be unattainable.

This document is intended to provide information to resource managers on the status of landscape resources and issues affecting the resources. The document also contains current knowledge of landscape monitoring in PACN parks and other regional monitoring programs related to landscape issues that could be adopted by the National Park Service.

## **INTRODUCTION**

### **SCOPE OF TOPIC AREA**

The landscape topic as covered in this report encompasses natural ecosystem processes that incorporate cultural values and perceptions across multiple scales. The landscape topic incorporates environmental stratification into monitoring site selection (environmental gradients, management zones, cultural resource datasets, human impacts, etc), that is to ensure that site selection is as unbiased as possible based on the criteria desired when selecting sites and that the appropriate or desired resource characteristics are included. Drivers and stressors that affect landscape issues are identified by two categories in this report: natural and anthropogenic.

### **BACKGROUND**

Given the PACN monitoring goal to “provide data to better understand, protect, and manage important resources that share cultural and natural value”, one of the important roles for the landscape report is to improve integration of natural and cultural resource information sources. Examples of this are many, for broad scale ecosystem structure, function, and composition this may mean coordinating within-park species-of-interest monitoring (native or alien) with changes in land use practices by other landowners within or nearby. Whatever the topic however, the small geographic size, with the diverse array of human activities and their integrated relationship to natural resources within NPS sites throughout the PACN, a careful review of both cultural and natural resource issues for either program area is needed.

Many of the natural resource issues in the landscape workgroup are regulated at a political level, with the state or territory often being the highest level of authority. As such, the Territory of American Samoa, Territory of Guam, Commonwealth of Northern Mariana Islands, and State of Hawaii are often treated independently for the context of this workgroup. For some topics, regulation may be at a county level, and regions for these issues are addressed accordingly.

### **MONITORING GOALS AND OBJECTIVES**

A majority of PACN parks have indicated that potential synergies between NPS ‘natural’ and ‘cultural’ resource disciplines should be a priority for the monitoring program. Accordingly, the monitoring program established a goal to “provide data to better understand, protect, and manage important resources that share cultural and natural value”, this landscape report is in part,

intended to help incorporate cultural resource interface with natural resource issues. A few examples of how such data may be used by management include:

- Partnering with adjacent landowners to assure monitoring occurs across multiple environmental gradients, cultural landscapes and management zones.
- Monitor land use activities in accelerating or hindering the distribution of non-native species (especially invasive species), modifying water quality and quantity conditions, and modifying viewsheds and topography.
- Incorporate cultural landscape, ethnographic, archeological site inventory information, along with management zones, and other variables into monitoring site selection decisions.
- Monitor effects of land use activities on natural resources and cultural values that Park administrators view as being beneficial to visitors.

## **LEGISLATION AND POLICY**

As a federal agency, the NPS operates under a hierarchy of legislative mandates, including federal laws, executive orders, Department of the Interior and NPS policies and directives, as well as county, state, commonwealth, and territorial regulations. Further, management of submerged resources is complicated by jurisdictional or administrative issues that are often managerially more challenging than similar issues on land. These complexities require the NPS to cooperate with numerous and often overlapping federal and local agencies to achieve its objectives.

### **I & M - NATURAL RESOURCE CHALLENGE**

The Natural Resource Challenge (NRC), initiated in 1999, is an action plan for preserving natural resources through the National Park Service (NPS). The NRC assisted NPS to establish 32 Inventory and Monitoring networks, which includes 270 National Parks. In the Networks, parks are grouped that share geographical and natural resource characteristics. The Inventory and Monitoring (I&M) Program is designed to first complete basic inventories of natural resources in parks, on which to base long-term monitoring efforts. Monitoring programs are based on monitoring critical parameters (Vital Signs) within each network to incorporate into natural resource management and decision-making. “Vital Signs are measurable, early warning signals that indicate changes that could impair the long-term health of natural systems” (NPS, 2003).

The NRC and Inventory and Monitoring program emphasize integrated information systems for all NPS programs. The ‘landscape’ workgroup is a direct effort to address these integrated needs. Examples of how this integration can occur are through a deliberate ‘environmental stratification’ process when selecting monitoring sites and in making use of NEPA documents and processes that must also address a broad suite of issues.

### **LANDSCAPE RELEVANT LEGISLATION**

This section, reviewing applicable general legislation, park enabling legislation, management policies (NPS [http://www1.nature.nps.gov/im/units/pacn/pacn\\_policy.htm](http://www1.nature.nps.gov/im/units/pacn/pacn_policy.htm) and park specific), and local regulations is reviewed by topic where appropriate. Among the basic scientific tenets

of a landscape approach in ecological monitoring are gradients and ecozones, where there is very little legal mandate.

One analogy of how general legislation can afford partnerships in conservation monitoring is the National Natural Landmarks (NNLs) program. The NPS seeks to periodically verify the condition of NNLs and maintain good rapport with landowners--to comply with 90 Stat. 1940; U.S.C. 1a-5. This law demands monitoring the condition of NNLs in order to prepare an annual report for the Secretary to transmit to the Congress identifying all designated NNLs with known or anticipated damage or threats to the integrity of their resources, and the source of such threats or damage. This report has been commonly referred to as the "Section 8" report. Within the Pacific Island Network, NNL partnerships range from Mauna Kea, Hawaii ('...exposed portion of the highest insular mountain in the United States, containing the highest lake in the country and evidence of glaciation above the 11,000-foot level. Most majestic expression of shield volcanism in the Hawaiian Archipelago, if not the world.') to Puntan Dos Amantes, Guam ('...illustrates the limestone deposition and subsequent subterranean erosion phases of Guam's geologic history. The area contains a 370-foot high cliff exposure of massive limestone.').

## **NPS**

### **Park Enabling Legislation**

Enabling legislation identifies a variety of resources, including: perpetuation and appreciation of traditional cultures, archeological resources, educational purposes, traditional subsistence uses, connecting communities and historical events, ecological balance, scenic resources, and historic values and objects. All of the PACN parks have both significant natural and cultural resources applicable to the landscape workgroup topics.

Park Enabling Legislation may address specific issues in some cases, such as designating wilderness in HAVO and HALE, or more generally address resources.

- WAPA—to commemorate the bravery and sacrifice of those participating in the campaigns of the Pacific Theater of WWII and to conserve and interpret outstanding natural, scenic, historic values, and objects on the island of Guam for the benefit and enjoyment of future generations.
- AMME—30 acre wetland and mangrove is an excellent environment for native bird species including the endangered Nightingale Reed-Warbler. Natural resources also include coral reefs, which are not currently under park jurisdiction, a stream, sandy beach and an estuary.
- NPSA—preserves the only undisturbed mixed species paleotropic rainforest in the United States. Contains the habitat of one of the last remaining populations of Pacific flying foxes, which is responsible for a large part of the pollination of vegetation that maintains a significant portion of the species inhabiting the Samoan tropical forest.
- USAR—also a (National Historic Landmark) contains submerged cultural resources. The memorial is operated and maintained by NPS in a use agreement with the U.S. Navy.
- KALA—to preserve and interpret the Kalaupapa settlement for the education and inspiration of present and future generations. The isolated peninsula provides

habitat for threatened and endangered species (e.g. Hawaiian monk seal pups), which require solitude.

- HALE— enabling legislation states that regulations shall be made and published that preserve from injury all timber, birds, mineral deposits, and natural curiosities or wonders within, and retained in their natural condition as nearly as possible. This legislation has been interpreted to include natural soundscapes, scenery, lightscapes, wilderness, and other topical areas being addressed by the landscape workgroup.
- ALKA—the 175 mile corridor is designated a National Historic Trail to preserve, protect, and interpret traditional Native Hawaiian culture and Natural Resources. Enabling legislation identifies that all significant natural, cultural and historical resources be preserved.
- PUHE—preserves both prehistoric and historic resources. The heiaus are significant resources that facilitate interpretation of ancient Hawaiian religious practices, architectural designs, construction techniques, political activities and lifestyles.
- KAHO—provide a center for preservation, interpretation and perpetuation of traditional native Hawaiian activities and culture, and demonstrate historic land use patterns.
- PUHO—stabilize and preserve resources to protect integrity. Expansion of existing park boundary is proposed in an effort to protect and preserve additional cultural resources.
- HAVO—enabling legislation states that regulations shall be made and published that preserve from injury all timber, birds, mineral deposits, and natural curiosities or wonders within, and retained in their natural condition as nearly as possible. This legislation has been interpreted to include natural soundscapes, scenery, lightscapes, wilderness, and other topical areas being addressed by the landscape workgroup.

The subsequent sections are organized in a hierarchical fashion using the following format; Federal, NPS and Regional if applicable.

### **ECOLOGICAL GRADIENTS & ZONATION**

There is little direct legislation affecting ecological gradations. Where legislation does exist, it is likely based on existing land use practices which may be correlated with ecological gradients.

NPS Management Policies emphasize management zones and habitat types that have historically been of resource interest (wetlands, karst regions, floodplains, and watersheds).

Park management policies typically do not emphasize ecological zones, although designated management zones often correspond to the ecological integrity of selected areas of a park.

No local regulation are known, beyond coastal and watershed protection clauses.

### **SOUNDSCAPES**

The “National Park Service Overflights Act of 1987” (P.L. 100-91) and “National Parks Air Tour Management Act” (P.L. 106-181, Title VIII) are two of the better know legislative efforts

to mitigate or prevent significant adverse soundscape impacts from air tours. Experience with implementing this legislation has identified a two fold concept of sounds: the frequency of occurrence and the decibel noise level (DNL)—FAA and military monitoring has typically focused only on DNL threshold, and limiting monitoring in such a fashion may leave a resource impaired.

Additional legislative references, that apply to a complete array of potential sources of noise, can be obtained from the HAVO and HALE soundscape management plans (in development as of early 2003).

Park enabling legislation that identifies solitude, quiet, or wilderness characteristics may provide the strongest foundation for addressing noise and soundscape issues.

NPS management policies emphasize preservation of natural soundscapes. Natural soundscapes are the aggregate of all natural sounds (within and beyond the range of human)

within a park, together with the physical capacity for transmitting natural sounds, through air, water, solid, or other materials. “Director’s Order #47: Soundscape Preservation and Noise Management”, identifies planning goals. This order also identifies inventorying and monitoring the soundscape as essential to understanding the relationship between the baseline natural soundscape and human-made components of the soundscape--existing and proposed. This information (1) makes it possible to better understand the resource that needs to be protected and the appropriate and inappropriate sources of noise; (2) enables a park to define acoustic goals for different parts of the park, and to determine the nature and level of impacts; and (3) suggests where management intervention can most effectively contribute to protecting park resources and improving the visitor experience consistent with park purposes. Monitoring over time will allow measurement of progress toward defined acoustic goals.

These NPS soundscape policies do not clearly communicate that underwater/marine soundscapes are on equal footing with terrestrial issues, and that sounds from non-native (invasive or exotic) species are also impacts that represent ‘inappropriate noise’, or ‘non-natural sounds’.

HALE and HAVO are in the process of developing soundscape plans consistent with NPS Management Policies. Of special note is also KALA, with a commercial airport within park boundaries under the jurisdiction of the FAA and the Hawaii Department of Transportation, and KAHO, USAR, and WAPA which are all in the vicinity of large airports. (The FAA approved HAVO heliport will be addressed as part of the HAVO soundscape plan).

While municipalities may have noise regulations, 36 CRF Section 2.12 Audio Disturbances, provides additional regulation on federal property. It is also expected that Department of Transportation and FAA regulations (and agreements with parks) for local airports are relevant for aircraft related noise.

### **LIGHTSCAPES**

The George Wright Forum (Vol 18, No. 4, 2001; <http://www.georgewright.org/pubslst.html>, visited 01/29/03) dedicates the entire issue to protecting dark skies. A review of applicable/example legislation is provided therein. Air pollution also affects lightscapes, with the potential to both limit and enhance the propagation of light pollution. The clean Air Act (CAA) can also be interpreted to address light pollution and is discussed in the Air Quality/Climate workgroup section of this report.

NPS management policies identify that the service will protect natural darkness and other components of the natural lightscape in parks—working in cooperation with visitors, neighbors, and local government agencies to achieve these goals.

Park specific policies would likely be a combination of Maintenance/Facility Management documents (for developed areas) and Resource Management documents and practices in areas where such concerns have been identified (such as for turtle or seabird habitats). No documents addressing park policies regarding lightscares have been identified.

Hawaii County Code—Chapter 14, Article 9. Outdoor Lighting (enacted Ord. No. 88-122, sec. 3, in 1988), specifies timing, shielding, and wattage/lumens requirements for outdoor lighting. More restrictive lighting practices are implemented in selected locations, such as on Mauna Kea in the vicinity of the astronomical observatories. The County of Maui proposed an updated ordinance, but it was not enacted. Oahu County currently has a lightning ordinance regulating outdoor lighting use. House Bill 1743 the so called “light pollution bill” is currently awaiting approval by legislation, which would prohibit artificial light from shining into the ocean unless authorized and required for public safety or ocean navigation.

American Samoa, Guam, and Commonwealth of the Northern Mariana Islands currently have no lighting ordinances regulating outdoor lighting.

### **VIEWSHEDS & SCENERY**

The NPS Organic Act identifies “scenery and the natural and historical objects therein” as resources. This has evolved, at least in part, to mean viewsheds and scenery. Scenic qualities have also been addressed through the Clean Air Act and amendments.

Scenery, enjoyment, appreciation, and inspiration are common purposes identified in park enabling legislation that may pertain to this topic.

NPS management policies identified in Reference Manual #77, Natural Resource Management (<http://www.nature.nps.gov/RM77/>, visited 1.9.2003), identify National Park Service Mandatory Class I Area Integral Vistas: Haleakala NP, Red Hill Observatory (observation point), 280° - 320° and 120° - 165° (view angles) and Hawaii Volcanoes NP, Hawaii Volcanoes Observatory (observation point), 220° - 350° (view angles). There are no regulations requiring special protection of these integral vistas, but the Service will strive to protect these park-related resources through cooperative means. Communication (cell phone) towers are another issue that often affect scenic vistas, and regulated through NPS policy.

Park specific policies allow a variety of additional scenic views to be identified through Cultural Landscape inventories, historic maintained views established through maintenance programs, or other less formal designation.

Local regulations may be significant when a viewshed originating from within a park includes private or other land governed by local regulations.

### **LAND USE**

Legislation that permits the NPS to address external threats, protect lands, or adjust boundaries is pertinent. Other legislation may apply to within-park ‘land use’ activities, such as wetlands legislation or in relation to archeological sites.

Park enabling legislation for KAHO and ALKA both identify traditional land use or land use practices as park purposes.

NPS management policies identify the need for land protection plans for lands or interests in public ownership, and provide guidance on cooperative efforts with neighboring jurisdictions for the protection of park resources.

Park management policies may vary based on previously identified needs—for example, HALEs history of interest in airport expansion and changes in ranching management practices may not be similarly expressed in other park management policies.

Local regulations incorporate a wide array of issues, from zoning, coastal zone management programs, specific commercial uses such as airports, to building codes governing catchment tanks, or agricultural pesticide policies. There are no local land use regulations pertaining to NPS units.

### **CHEMICAL INFORMATION & ODORS**

Legislation regarding chemical information & odor is often addressed through the Clean Air Act and amendments. No specific legislation tied to this topic was identified.

Park enabling legislation would likely be applicable through reference of the general preservation and protection of resources, although no specific enabling legislation was identified.

NPS management policies state that the service will preserve, to the greatest extent possible, the natural flow of natural chemical information and odors—while acknowledging that its own activities may disrupt these processes. The service will comply with all applicable laws, regulations, and policies, and seek to minimize harm to the environment.

The park service may take action to inhibit the natural chemical composition with varying techniques.

Local regulations pertaining to water quality & solid waste regulations may be most pertinent to chemical information & odor.

### **MANAGEMENT ZONES—USE AREAS**

Legislation related to park management zones or use areas is most likely to be applicable through the Wilderness act or coastal zone legislation, although no explicit legislation has been identified.

Park enabling legislation may correlate with management zones based on purpose, especially where traditional land use practices are identified such as at KAHO. Also, management zones may reflect the parcel acquisition history of the park, and as such, having spatial data detailing previous landowners and the parcel acquisition process is essential.

NPS management policies identify that park GMPs will delineate management zones where there are differences in intended resource conditions, visitor experience, and management activity.

Park Management policies have identified management zones, although the terminology and definitions may differ slightly among PACN parks. This identification is prescribed by the individual park's General Management Plan.

Cultural based designations include wilderness (HALE & HAVO), historic districts, and traditional use areas.

Natural designations include: Special Ecological Areas (SEAs) (HAVO & HALE), Research Natural Areas (HALE). SEAs are priority places designated for intensive management, including control and removal of exotic species.

Ecological zones are often designated through Threatened or Endangered Species management plans, for example where seabird nesting areas corresponds with general ecological zones or habitat types. Hawaii ecological zones have been delineated from elevation, alpine zone >9,000 feet with the highest point, 13,796 feet, located on the summit of Mauna Kea on Hawaii Island, the subalpine zone ranging between (6,000-9,000), montane (3,000-6,000), lowland (0-3,000), and the coastal zone (0-100) feet (Juvik & Juvik 1998). Ecological zones for Guam are based mainly on the substrate of the landscape, with the northern region comprised primarily of limestone and the southern part consisting of volcanic soils. The ecological zones for NPSA are relative to elevation, rainfall, and type of vegetation. This is evident in the strand, shrubland, forest, and rainforest communities. These zones have been recognized for the PACN parks but from a global perspective the World Wildlife Fund (WWF) scientists have designed the Global 200, which is a scientific ranking of more than 200 critical terrestrial, freshwater, and marine habitat areas. This ecoregional approach seems to be the most appropriate for the Pacific Islands Network given the large scale geographic range it encompasses.

The Wilderness Act (P.L. 88-577) provides the basic guidelines for wilderness. NPS Management Policies, “Director’s Order #41: Wilderness Preservation and Management”, and “Reference Manual 4” provide NPS specific guidance. This includes various categories for consideration, including designated wilderness (so designated by Congress), recommended wilderness (by the Secretary of the Interior to the President), and potential wilderness (requiring removal or elimination of non-conforming uses). In addition, parks may identify in the course of wilderness studies, areas suitable as wilderness and buffer zones that need to be maintained to protect existing or potential wilderness. NPS Management Policies require monitoring of conditions and long-term trends to identify the need for and effects of management activities.

HAVO and HALE are the only 2 parks with legally designated wilderness. In addition, the general policy of the NPS is to support scientific activities in wilderness, and to use science to improve wilderness management. Moderate sized parks (especially NPSA and KALA) incorporate areas that may be managed similar to wilderness areas, and provide similar resource benefits for the scale of their island landscape. NPS management policies states a formal wilderness study may identify park lands that are being recommended for immediate wilderness designation, as well as any other lands identified as “potential” wilderness.

## **ECOLOGICAL CONTEXT**

### **GEOGRAPHY**

All the network parks are found on tropical islands in the Pacific Ocean. Eight of the parks are in the Hawaiian Islands in the Central Pacific between 19 and 22 degrees North latitude. HAVO, KAHO, PUHE, PUHO, and the recently designated ALKA are on the island of Hawaii, the youngest of the main Hawaiian Islands at the southern and eastern end of the archipelago. HAVO is located on the southeast slope of Hawaii Island, where it extends from sea level to the

summits of Kilauea and Mauna Loa Volcanoes. The newly designated Kahuku unit of HAVO is positioned on southern Mauna Loa and extends down both the eastern and western flanks of the volcano. PUHE, KAHO, and PUHO are coastal parks on the western side of the island; KAHO is centrally located with PUHE to the north and PUHO to the south. HALE is on Maui, the second youngest Hawaiian Island; HALE extends from sea level to the summit of East Maui. KALA is on a peninsula projecting from the north shore of Molokai, centrally located in the main Hawaiian Islands. USAR is within Pearl Harbor on southern or leeward Oahu. Two PACN parks are situated in the western Pacific Ocean between 13 and 15 degrees north latitude in Micronesia. WAPA is on the western side of the island of Guam and AMME is on the west coast of Saipan, one of the Northern Mariana Islands. NPSA is on Polynesian islands of American Samoa, approximately 13 degrees south latitude. One unit of NPSA is on the island of Tutuila; three others are on Tau, Ofu, and Olosega of the Manua Island group 96 km (60 miles) east of Tutuila.

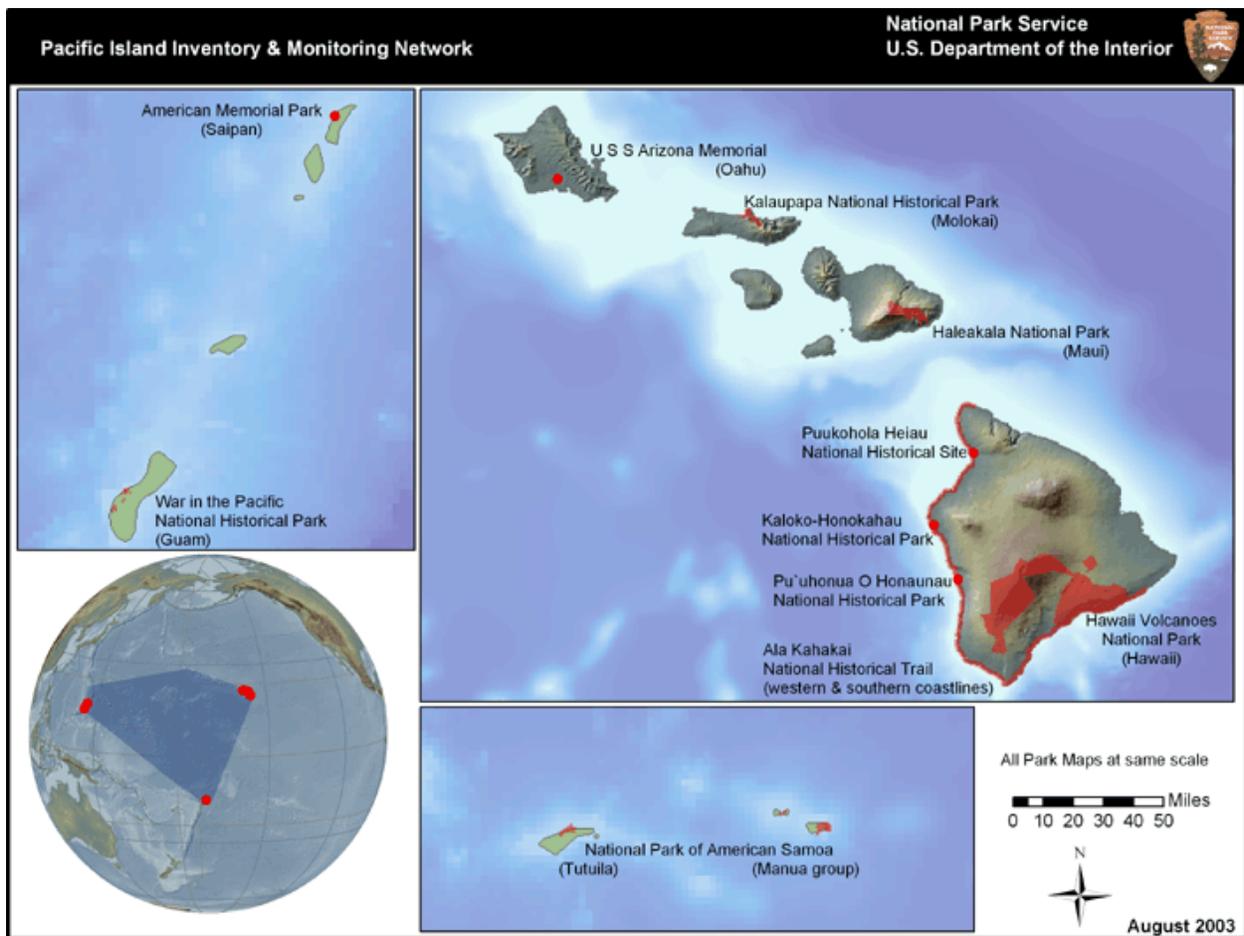


Figure 1. Pacific Island Network National Parks

## **GEOLOGY**

The parks of the Western Pacific (WAPA, AMME) are on islands (Guam and Saipan) with long-extinct volcanoes. These islands have complicated geologic origins involving both volcanism and subduction of the Marianas Trench. The northern half of Guam and portions of Saipan have

limestone substrates elevated above a weathered volcanic base. WAPA units are on the volcanic substrates of the southern half of Guam, but at least one unit includes elevated limestone caps.

The islands of American Samoa and Hawaii are oceanic volcanic islands arising from hotspots. The oldest of the Samoan Islands are dated at more than two million years, but there was volcanic activity between Tau and Olosega approximately 150 years ago (Whistler 1994). In Hawaii, HALE protects the summit of the inactive Haleakala Volcano and its impressive crater, which is the result of stream erosion, the merging of Kaupo and Keanae Valleys, and subsequent volcanic activity. KALA encompasses the Kalaupapa peninsula, formed on the north shore of Molokai during the Pleistocene (MacDonald and Abbott 1970). The volcanoes of both Molokai and Oahu are extinct.

The five parks on Hawaii Island are on active or dormant volcanoes. A significant portion of HAVO is covered with recent lava flows that are sparsely vegetated. HAVO also contains the rift zones and summit calderas of both Mauna Loa and Kilauea Volcanoes, two of the most active volcanoes on earth. PUHO is on prehistoric pahoehoe flows of Mauna Loa, and PUHE substrates are old weathered soils of Kohala Volcano. All substrates of KAHO are flows from Hualalai Volcano less than 10,000 years old, including one sparsely-vegetated lava flow dated at 1,000-3,000 years (Moore *et al.* 1987).

### **ELEVATION GRADIENTS**

Among the Hawaiian parks, HAVO and HALE have the greatest elevational range, extending from sea level to the summits of tall volcanoes >3,000 m (>10,000 ft) in elevation. KALA has an elevational range from sea level to almost 1,220 m (4,000 ft) elevation. The three parks of leeward Hawaii Island are coastal parks and extend upslope to an elevation no more than 100 m. ALKA is also in the coastal lowlands of western and southern Hawaii Island.

Among the three Western Pacific parks, AMME is restricted to coastal lowlands on the western shore of Saipan. WAPA includes both coastal units and inland sites on the slopes of Mt. Alifan and Mt. Tenjo; one unit extends to above 305 m (1,000 ft) elevation. NPSA is composed of four units; Ofu and Olosega are largely coastal but the Tutuila and Tau units range from sea level to 491 m (1,610 ft) and 966 m (3,170 ft) elevation, respectively.

### **RAINFALL AND CLIMATE:**

The largest two Hawaiian parks, HAVO and HALE, include within their boundaries several climatic zones with a range of rainfall regimes. HAVO contains two of the four rainfall minima of Hawaii Island, the Kau Desert with mean annual rainfall <750 mm and the interior lands of Mauna Loa with <500 mm annually. The highest mean annual rainfall within the park is found in Olaa Tract, a rain forest with >4,000 mm per year (Giambelluca *et al.* 1986). In general, the eastern windward portion of HAVO has high rainfall, which diminishes upslope, particularly above the trade wind inversion layer near 1,830 m (6,000 ft) elevation. The upper elevations of the park are moist to very dry, and the summit of Mauna Loa receives on average <500 mm precipitation. The leeward, western portions of HAVO are in rain shadows of Mauna Loa and Kilauea summit, and are typically dry.

HALE also has a range of climates, as it extends from sea level on the windward, eastern slope of Haleakala to the summit of East Maui. This park also includes lands in the leeward rain

shadow of Haleakala, down to 1,220 m (4,000 ft) elevation. Annual precipitation in the park varies from 1,250 mm in the Crater, southern slope, and Kaupo Gap to >6,000 mm on the upper northeastern slopes of Haleakala. KALA, on the north shore of Molokai receives 1,000 mm of precipitation annually at sea level and >3,000 mm at the upper elevations of Waikolu Valley (Giambelluca *et al.* 1986). USAR on Oahu is located within Pearl Harbor on the dry leeward side of the island in an area that has on average 600 mm rainfall per year.

The four Hawaii Island parks are in relatively low rainfall areas with constant warm temperatures and pronounced daily wind patterns of land and sea breezes (Blumenstock and Price 1967). KAHO has a mean annual rainfall of approximately 600 mm and a seasonal climate with higher rainfall during summer months (Canfield 1990a). The climate of PUHO is similar to that of KAHO, with mean annual precipitation of 659 mm. PUHE is located within one of the four rainfall minima of the island of Hawaii and receives <250 mm of rain annually (Giambelluca *et al.* 1986).

The climate of Guam and the Northern Marianas (CNMI), including Saipan, is warm, wet, and tropical. Temperature varies between 90 and 70° F. Relative humidity is high, often exceeding 80% and seldom falling below 50%. The rainfall pattern is strongly seasonal with a wet season from July to November and a pronounced dry season from December to June. Average annual rainfall of the Marianas is 2,160 mm (85 in) (Baker 1951), and on Guam the annual mean is 2,175 mm (Mueller-Dombois and Fosberg 1998). Typhoons are yearly events, which occur during the monsoonal wet season. Trade winds blow from the northeast, but easterly and southeasterly winds prevail during several months in the spring (Baker 1951). Because Guam and the Marianas are relatively low islands, there is no pronounced rain shadow effect, and leeward shores are not drier than those of the windward sides (Mueller-Dombois and Fosberg 1998).

NPSA has a warm tropical climate with little seasonal variation in temperature. Rainfall is high in the four units of the park. On Tutuila, annual rainfall averages 3,200 mm (at the airport), and may be even higher on the upper mountain slopes within the park. Rainfall is seasonal with greater monthly means from October to May and a dry season from June to September. Hurricanes are occasional but not annual events (Whistler 1994). Tau Island unit is only about 96 km (60 miles) east of Tutuila and shares its warm and wet tropical climate. Tau average rainfall is more than 2,500 mm per year and is highest in December. The dry season is June to September, and droughts sometimes occur on the island (Whistler 1992).

## **CONCEPTUAL ECOLOGICAL MODEL**

The landscape ecological conceptual model provides a basis for identification of potential vital signs (indicators) that may be selected for monitoring (Fig 2.). This conceptual model illustrates linkages between the forces of change (drivers) to the affected landscape topics (attributes) and the measures.

### **Ecological Gradients and Zonation**

Ecological gradients and zones are based on the substrate, topography, climate, and vegetation of the landscape. Many factors (drivers) influence these zones such as climate, windward-leeward orientation (orographic), and water regimes, and fires. Changes in gradients and zones impact species composition (attribute) which can be measured with detection maps to illustrate cover

frequency, distribution and age classes (measures). Fragmentation, degraded water quality, and changes in water quantity (measures) can also occur as a result of disturbance regimes causing modification to gradients and zones. These events significantly alter landscapes via erosion or addition to the land (measure). Where pollination syndromes (attribute) occur detection can be observed by monitoring presence and/or absence, phenology, and seed set (measures). Pollination syndromes are characteristics such as shape, depth, color, and scent, which help predict the pollinator.

### **Land Use**

Land use may be classified as urban, rural, agricultural, or commercial. Contiguous landscape through partnerships is another important aspect of land use. Partnerships provide a mechanism for both uniform land management and for the introduction of drivers/stressors. Partnerships are driven by anthropogenic inputs such as population, economics, and legal pressures. Land use (stressor) has the ability to directly affect air quality, viewsheds, lightscaapes, soundscaapes, and chemical information and odor (attributes). Ecosystem responses are measured by the levels of change in the attributes such as light pollution, increased decibel levels, behavioral changes, and trail use (measures). Satellite imagery and GIS have also been instrumental in providing measures to accurately identify land use.

### **Lightscaapes**

Lightscaapes (attribute) are essentially driven by land use (stressor) and refer to the status of the night sky (presence/absence) of light pollution (measure). The alteration of the nocturnal lightscape can be detrimental to wildlife. Low-pressure sodium (narrow spectrum yellow lights), often preferred by the astronomical community, have not been shown to be beneficial across all life forms. Changes in lightscaapes can be measured by spatial distribution, temporal frequency and light intensity (measures).

### **Soundscaapes**

Soundscape (attribute) refers to the total ambient acoustic environment, which is made up of both natural and human caused sounds. Human caused sounds are not just the sounds that people themselves produce, such as talking, but also the many varied sounds that attend the presence of people such as autos, aircraft, radios, and pets. Acoustic ecology and research in bio-acoustics is an important tool for defining the health of natural habitats. For the purpose of the landscape ecological conceptual model, Land use is a driver/stressor of a soundscape (attribute); thus, the measure is changes in decibel levels.

### **Viewsheds & Scenery**

Viewsheds (attribute) are vistas from specified locations which offer scenic views into volcanic craters, lava flows, mountains, native forests, natural geological faults, the Pacific Ocean and volcanic steam vents. Other types of viewsheds include culturally and historically significant vistas. They are driven by both natural and anthropogenic inputs such as climate, land use and disturbance regimes. Ecosystem responses can be detected in changes in air quality and visibility (measures). Other examples of drivers are vegetation growth, forest succession, and degraded air quality, which significantly alter the viewscape.

### **Visitor & Management Impacts**

Visitor and Management Impacts (attribute) include an increase in the number of people within parks, which is the presence of humans in and of itself upsurge in paths and trails (measures), stewardship efforts on the part of management and removal of objects. They are entirely human induced and can be measured by the changes in cultural resources, erosion and plant cover.

### **Management Zones & Use Areas**

Management Zones and Use Areas (attribute) are generally marked out into various categories such as the Development, Natural and Historic zones respectively. They are influenced by number demographics (stressor) of park users and measured by counting visitors and quantifying visitor uses and extent by mapping.

### **Wilderness**

Wilderness, (attribute) as stated by the Wilderness Act of 1964, is “an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain.” Wilderness managers require scientific research to understand the character of wilderness ecosystems, the biological and social impacts of human activities on wilderness ecosystems, the role of wilderness in larger social systems, and the impact of different policy and management alternatives. Measures for impacts to wilderness area are related to Limits of Acceptable Change (LAC). LAC refers to management efforts to determine how much change is acceptable to an area before it adversely impacts the natural resources. LAC runs parallel with demographics, immigration and emigration (stressors). Measures are determined by monitoring buffer zones, trail use and visitor counts.

### **Chemical Information & Odor**

Natural chemicals released by animals, plants, and geologic materials are transmitted through the air and water. These chemical odors (attributes) modify animal behaviors (measures) such as mating, migration, feeding, predator avoidance, prey selection, and the establishment of social structures as a response. Land use (driver) has the potential to create an increase in chemical odor. Unfortunately, this topic has not evolved like soundscapes (due to increases in air tours) and lightscares (with a decrease in the dark night sky). Hopefully, as this topic develops, it will get the level of attention it deserves. Presently, measures for this topic run counterpart with air quality at parks such as HAVO, where there is an increase in sulfur levels.

### **Culturally Significant Resources**

An increase in immigration and emigration along with other drivers such as disturbance regimes and land use would indicate the potential for impacts on culturally significant resources (attribute).

Measures for this attribute can be detected in noticeable changes of cultural resources such as reduction in species (marine & terrestrial). Systematic monitoring of harvested species with collection statistics would apply for this ecological model.

Pacific Island Network, Monitoring Plan

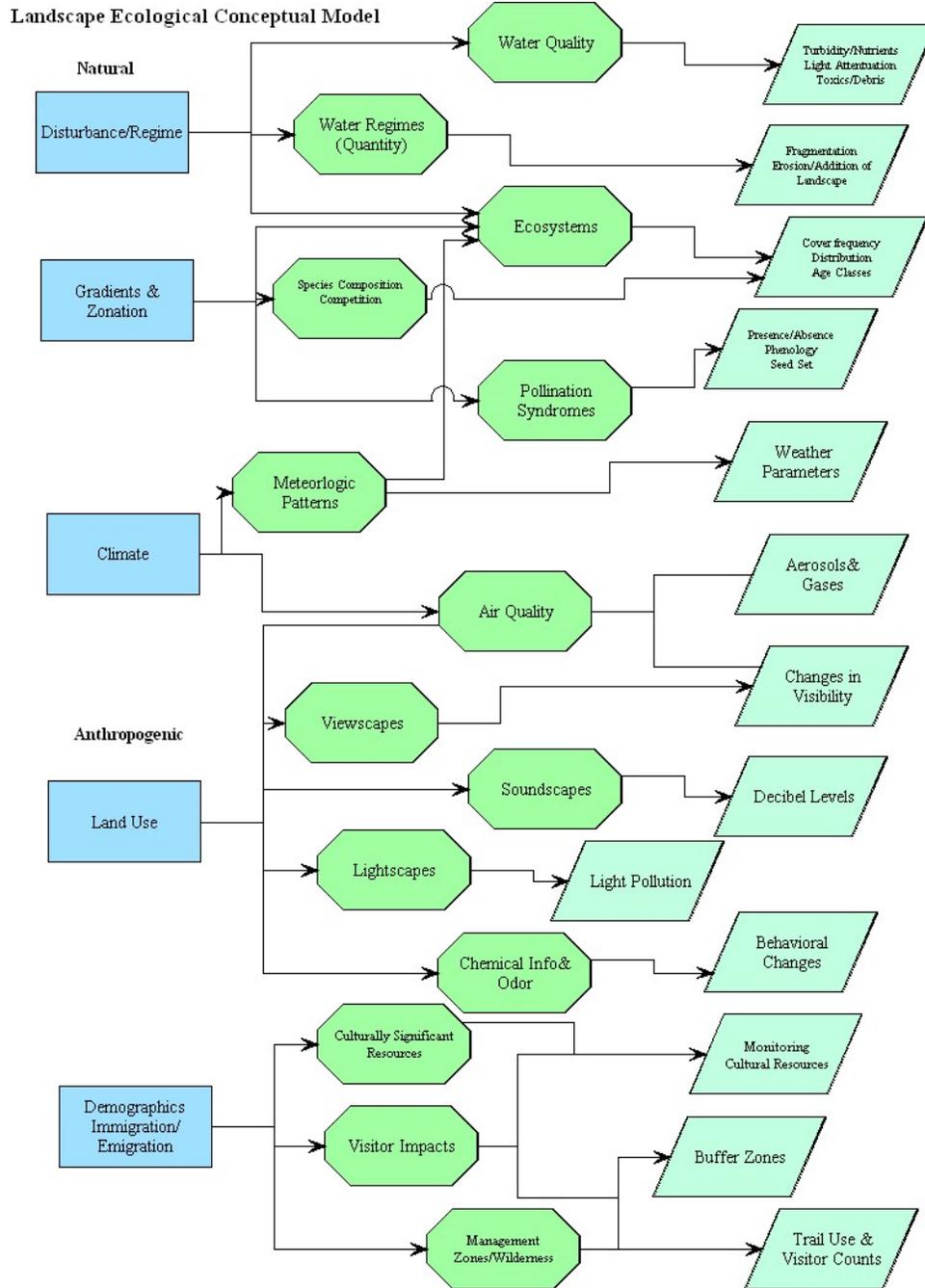


Figure 2. Ecological Landscape Conceptual Model: Symbols represent drivers (rectangles), landscape ecosystem attributes (octagons), and ecological measures (parallelograms)

## **PARK AND NETWORK-WIDE ISSUES**

### **LAND USE**

In Hawaii, there are several issues regarding land use, such as, regulatory takings, the compensation issue, conditions on land development permits, preservation of protected “P” subzone lands in the conservation district, and preservation of coastline and agricultural land versus housing needs. As far as the parks are concerned, most of the parks in Hawaii are owned by the Federal Government with a few exceptions such as KALA where some of the land is owned by the Department of Health, Hawaiian Homes and the Federal Government.

In Guam, the government seeks to promote an orderly land use pattern and provide for increased development when appropriate. The land at WAPA is primarily owned by NPS with a few private inholdings. Submerged lands are managed by NPS with 2/3 of it owned by the territory of Guam and the other 1/3 is unconfirmed but believed to be federally owned.

AMME has much more complicated land ownership with ownership belonging to the commonwealth, leased to the military and then given to the NPS. NPS has management jurisdiction over the land but CNMI has the overall authority and sometimes exercises that power.

Some land use issues for American Samoa revolve around the lease agreement in which the NPS has authority to care for only a small part of the natural resources. Cooperating with ASG agencies, the village councils, and others to assure long term feasibility of sufficient habitat for native species, such as flying foxes or fruit doves, which are presumed to be strong interactors in the ecosystem has been a high priority for park management.

### **Within PACN parks**

Traditional use areas (special & historical use areas): The ability to obtain past and current land use data to accurately identify special and historical land use areas is a major concern for some if not all parks subsumed in the PACN due to historic land use practices. Continuing to preserve historical use areas and conserve natural and cultural resources within the parks without limiting access to native peoples has been a particular issue for park management. This requires the balancing of management policies with traditional use of lands.

Monitoring special use areas where subsistence farming is occurring or reoccurring in an effort to track long term trends while obtaining a natural history of the area is an important aspect for all PACN parks (e.g. NPSA) (Fig 3.). On the island of Tutuila subsistence agriculture has been reoccurring where the land has been fallow for a number of years. Due to inholdings inside park boundaries, it is important for park managers to monitor land use for early detection of resource degradation.

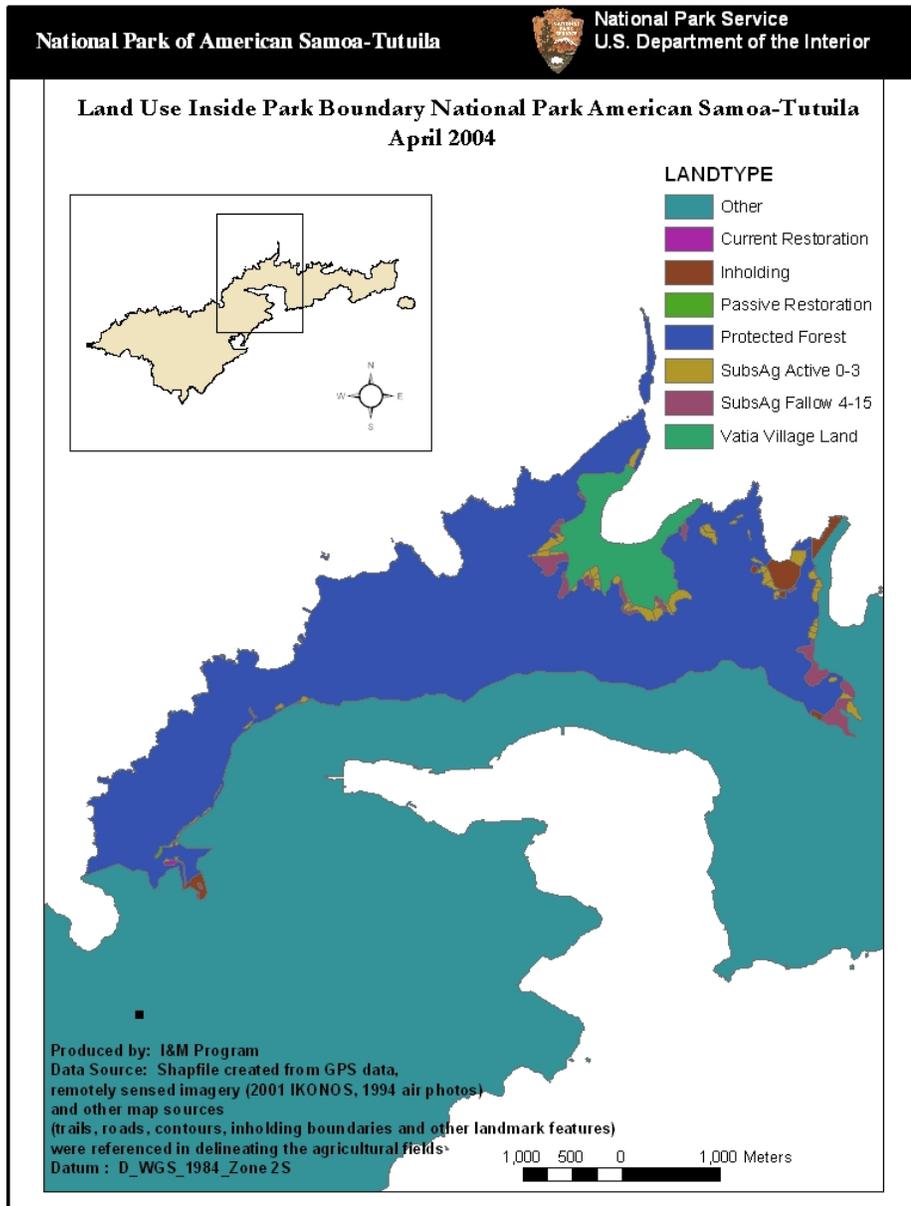


Figure 3. Land Use Map; National Park of American Samoa-Tutuila

Cultural landscape- loss of Ainahou pastureland: The loss of the pastureland sacrifices the endangered population of the Nene. Lack of availability of new grass growth may inhibit the reproduction and potential population of the Hawaiian goose. The grassland provides a much needed source of protein for nesting Nene and young goslings (Banko 1998).

### Adjacent/external

KALA Airport-federally subsidized, admin by HI DOT: The Kalaupapa Airport occupies 55 acres on the northern peninsula of Molokai, which is 2 miles north of the Kalaupapa community. Facilities at the airport are minimal including a single runway, small passenger terminal and

airport support area. There are no planned improvements for the airport to abide by the wishes of the community and lessen any disturbance for the surrounding National Park.

Adjacent land use changes surrounding KAHO have significant impacts and threaten park resources. Increased pressure on potable water due to urban development, housing, small boat harbor expansion, oil and fuel line development as well as increased traffic along major highways will adversely affect the aquatic water system and park resources.

The expansion and development of “Science City” a multi-institutional collection of facilities comprised of observatories and antennas, located on state land just southwest of the summit of HALE is aesthetically and ecologically degrading.

HAVO helipad, FAA approved emergency landing site: The helipad located behind the rainshed is used by Park Service for resource management efforts, emergency purposes and sometimes in conjunction with Drug Enforcement Agency efforts. There are currently no issues regarding the helipad or its uses.

### **Vector/barrier for species introduction**

Ag/ranching collapse w/Miconia (sugar on Big Isle), Molokai & Maui (sugar & pineapple): Access seems to be the major issue for the eradication of Miconia in densely populated forested areas. The decline in agricultural and ranching practices has led to the increased infestation of Miconia due to the nature of the species characteristic in open forested areas. Miconia is an invader of light gaps and provides a forest understory not conducive with fostering a native ecosystem. In addition, feral ungulates, particularly pigs, are responsible for increased infestation of disease by creating habitat for mosquitos, which carry avian malaria and pox, in native forests. They also play a role in the dispersal of alien plant seeds which have significant impacts on native forests.

Gorse & Myrica faya w/decline in ranch/range management activities and industry: *Myrica faya* successfully invades rain forested areas of high elevations (sub-montane) where ranching activities commonly occur. The decline in these activities has led to a higher dispersal of the *faya* tree due to inactivity in these areas. Because access to these landscapes is extremely limited, physical removal of the tree is difficult due to the inability to use machinery in these areas.

The demise of the sheep industry has had a significant impact on the spread and invasion of Gorse, which has been introduced for foraging by the sheep. The noxious weed is nearly uncontrollable except for a biological control agent (mite predator) used to damage the plants. The problem with biological control is the time to control the noxious pest.

### **Water quality & quantity**

NPS-75 requires parks to provide data based on physical, chemical, and biological characteristics. The Clean Water Act requires states to specifically identify types of uses. Land use change surrounding natural areas can have impacts on water quality especially in situations like Kaloko-Honokohau where the natural area has become surrounded by commercial and light industrial. Marine ecosystems are affected by increased runoff from upslope development. In addition, Guam is faced with water quality issues due to traditional burning resulting in increased sedimentation impacting water resources.

## **Wildlife movement and foraging**

Human activities in special areas obstruct wildlife movement and foraging of endangered species populations (e.g. Nene breeding season Ainahou Ranch House).

Pasturelands at Ainahou Ranch have been managed by NPS to promote foraging of the Nene. There appears to be more protein in the grass when it is shorter providing more nutrients for the endangered species. This is especially important during breeding season and during the first year for goslings.

## **LIGHTSCAPES**

### **Wildlife impacts**

**Birds:** Nocturnal birds are at risk from light pollution because they use the moon and stars to guide their migration patterns. They are susceptible to collisions with night lit towers across North America. Sea birds such as the Petrels feed offshore and are fatally drawn to high intensity lamp lights from fisherman, lighthouses and offshore drilling platforms.

**Turtles:** Due to the lack of lighting ordinances on Maui, the critically endangered hawksbill turtle habitats are threatened from light pollution. Floodlights from shoreline homes have negative impacts on the turtles, which sometimes end up on land instead of heading back into the ocean. When the turtles hatch they go to the light instead of the ocean, jeopardizing a significant number of the potential population.

### **Cultural**

**Night sky viewing & brightness:** Night sky viewing has been termed “The Ultimate Cultural Resource”. The loss of remaining night sky due to light pollution continues to affect humans who value this once significant resource.

**Celestial navigation:** The recalling of cultural heritages in recent times has empowered indigenous peoples of the Pacific Islands to resurrect the art of celestial navigation, which uses the stars to navigate ocean voyages. The Hokulea project, which began in the 1970s, is an example of how the Hawaiians demonstrated their traditional abilities of navigation, and exploration by canoe voyage to Tahiti and other South Pacific expeditions. Lack of shielding for outdoor lighting is increasing sky brightness which in turn reduces the contrast between the background and fainter stars making them invisible to the eye; therefore greatly reducing the ability to apply the traditional art of celestial navigation

### **Scientific**

**Astronomy:** Astronomical light pollution is when stars and other celestial bodies are washed out by light that is either directed or reflected upward (Longcore & Rich 2004). While shielded lights significantly reduce the amount of light pollution, they still cause ecological light pollution.

Light pollution on Maui creates adverse conditions for astronomical research. The primary source of light pollution is the “cobra head” street lights that shine 30% of light into the night sky

instead of on the street. Athletic field lights and partially shielded lighting in parking areas also contribute to the light pollution as well.

## **SOUNDSCAPES**

### **Native/natural sounds**

Preserve the natural sounds and take action to prevent and minimize all noise which affects the natural soundscape. Managing by enforcing regulations, monitoring human activities and mitigation efforts are used to protect the native ecosystem. Desired conditions achieved by management are assessed in the EA/EIS.

Focal species (birds/bats, diurnal/nocturnal): Adverse affects in reproduction due to hearing loss in mating calls. High stress levels result in an increase of susceptibility to disease, learning disabilities and weight loss. Loss of territory and migration also affect endangered species.

The Nene at HAVO have been adversely impacted during feeding from helicopters flying overhead at the Ainahou Ranch (Knight pers.comm.). The endangered Hawaiian goose (nene) have reportedly been seen to lay flat on the ground during air tours in the park (Knight pers. comm.). The stress they encounter from air tours has been evident in the time it takes them, (several hours), to resume their normal feeding activities. Nene has also been observed to change their normal behavior during overhead flights. Anecdotal information has been provided by NPS for the purpose of this report.

Role of exotic species removals: The highly noxious and invasive coqui frog has been found in isolated locations at HAVO. The frogs have been eradicated by the NPS in effort to preserve the native ecosystem. Removal of the exotic species creates favorable conditions for the increase in native populations due to the ability to distinguish between mating calls.

Pre & post Fire: Lava ignited fires at HAVO have resulted in the increased use of helicopters for water drops. These operations are carefully monitored by management to ensure the safety of visitors and personnel. The noise during these operations is unavoidable for obvious reasons.

Accessible (road noise)/inaccessible (wilderness) areas: Road noise is inevitable due to the component of wilderness areas within the development, special use and transportation zone. The objective is to keep the human induced noise levels as low as possible to reduce significant adverse impacts. Buffer zones may be enforced to reduce considerable impacts on wilderness areas.

Biologic component to acoustic monitoring: The National Park service will restore degraded soundscapes to the natural condition wherever possible. NPS will take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values.

Wilderness solitude-quiet as a resource value: In general, along trails corridors that traverse through wilderness areas some human induced noise is unavoidable. But the main goal is for the visitor to experience the natural sounds of the environment. In larger landscapes, such as backcountry areas, the objective is to have no intrusion from human induced noise to experience the entirety of the wilderness.

### **Exotic Species sounds**

Invasive (coqui, cat, etc): The loud noise from the coqui frog has had negative impacts on the native ecosystems in Hawaii. The loud continuous chirp of the male frog, which exceeds 90 decibels, interferes with the mating calls of native birds. This results in adverse effects on the potential of native populations.

### **Anthropogenic Noise**

Aircraft, boats, vehicles, people (recreational noise): Noise from aircraft is the primary source of human induced noise. Air tour flights have been increasing over the years. Although the SRAR-71 requires Air Tour Operators (ATO) to maintain a Above Ground Level (AGL) of 1,500', the FAA has granted a number of waivers to lower the (AGL) to 500'.

Park operations: As stated in the management plan, park operations are to be limited to those necessary for achieving park purposes, and maintaining the health and safety of employees and visitors.

Interruption/stress of wildlife communication: Noise can adversely impact animal communication by disrupting territory establishment, courtship, nurturing, predation, avoiding predators, migration, and foraging functions. Physiological effects can range from excessive alertness, health affecting stress, decrease in lactation of nursing females, and changes in the metabolism and hormone balances. Indirect effects can include injury, abandonment of or damage to young, and avoidance or abandonment of habitat. Where populations of species are already threatened, habitat abandonment could be detrimental to existing communities.

Marine sounds: Marine sounds come from two identifiable sources: (1) natural ambient noise from wind, waves, earthquakes, volcanic activity, rain, movement or breaking of sea ice, animal activity and thermal noise; (2) noise from human activity (Dotinga & Elferink 2000).

Fauna: Effects of noise on marine life is dependent on the species, their sensitivity level and the environment conditions in the area where noise is present. Baseline conditions and the activities of the particular species at the time of disturbance are variables that determine changes in species behavior or habitat. Most of the documented impacts from noise have been on larger marine mammals such as whales, dolphins and porpoises. Some of the effects from noise on marine species include interruption of resting, feeding, or mating. In the case of cetaceans, noise can affect respiration, surfacing, or diving (Dotinga & Elferink 2000).

Pollution: Anthropogenic activity including vessel activity, seismic surveys, sonars, oil and gas drilling, dredging, construction and military activities is the main source of noise pollution in the marine environment. These processes disrupt marine life adversely affecting potential population, behavior, and migration patterns.

### **Event related**

Fire: Prescribed burns are a tool used by fire management to re-establish ecological integrity; therefore helicopters are used to rehabilitate burned areas. Helicopters are also needed to detect and evaluate fires for further action, Often reconnaissance is needed during periods of lava flow activity to assess ignitions and fire spread to evaluate the need for a suppression

response. Practically daily helicopter reconnaissance is needed with long lasting flow activity. Helicopters are also the primary tool for fire control lines.

Pre-post feral animal removal: Noise from feral animals can push away endangered species from their original habitat, which is conducive to their survival and potential offspring.

### **CHEMICAL INFO & ODOR**

While emissions of aerosols and gasses at HAVO are a natural geologic process, they are often a health hazard and impact visitor experience, employees, interpretation, and visibility. This process can also hinder wildlife from tracking scents in an effort to forage and reproduce.

Alien vegetation, such as the kahili ginger, is another issue at HAVO. This highly invasive plant has a strong aroma and is able to impede the smell of native *ohia*.

The septic system located at Spencer Beach Park, which is managed by the County of Hawaii has a tendency to emit a noxious odor upon high tide conditions. This situation negatively impacts visitor experience as well as water quality for both ALKA and PUHE.

The stench from tuna canneries located near NPSA is known to penetrate into park boundaries and have similar effects to wildlife and visitor experience. Visitors may not be able to experience the natural processes occurring such as flowering plants and naturally fresh air.

### **VIEWSHEDS & SCENERY**

#### **Protection of designated areas**

The significance for protecting viewshed and scenic vistas are essential for any natural area. Identify areas in need of visibility monitoring to regulate air quality in conjunction with the IMPROVE and Clean Air Act. Determine if changes in the landscape have occurred by implementing a monitoring plan which is conducive with improving viewshed and scenic vistas. Document the encroachment of invasive species hindering the scenery of the natural landscape to assist in park management.

#### **Undesignated areas**

Roadside clearing for vistas: Clearing commonly visited areas can help in managing traffic flow along roadways and corridors as well as provide a safe place to pull off the shoulder of roadways. Identify the site to ensure there is no cultural, historical or architectural significance within a locale. Establish goals to assist in the preservation of the natural landscape without sacrificing critical resources.

The Fonte Plateau Unit located at WAPA is a proposed area containing a tunnel with historic significance from WWII and a native plant community on the slopes below the potential overlook. This scenic vista is in need of clearing to restore the landscape to the historic scenery.

### **External land use changes**

Modification of landscapes usually occurs with a change in the conditions such as vegetation where the character of a landscape change occurs when there is volcanic activity, catastrophic fires, tornadoes or hurricanes.

### **Vegetation changes (internal & external) either obstructing or modifying area being viewed**

Vegetation management to preserve a completely open view (e.g. Kilauea Iki Crater) is necessary to maintain the historical view. As stated in The National Park Service Management Policies Chapter 4.4.2 (Management of Native Plants and Animals), permit the management and removal of native and exotic plants, to protect specific cultural resources of parks (NPS Management Policies) (HVNP Viewshed Inventory and Assessment).

Non-native vegetation at PUHE has obstructed the historical open view of the John Young homestead. Overgrown kiawe trees have adversely impacted the viewscape from the parks historical focal point, which is the historical open ocean approach to the coastline.

### **Inventories and Assessment**

Some of the main goals of a viewshed inventory and assessment are to identify and inventory historic and proposed viewsheds of outstanding beauty and scenic quality, assess vegetation management actions necessary to reestablish historic viewsheds and conserve and maintain existing and proposed viewshed quality and character.

### **VISITOR & MANAGEMENT IMPACTS:**

#### **Disturbance of species/habitats**

In general, national parks in the Pacific continue to experience an increase in visitation. Impacts from visitation are devastating to natural resources within the parks. NPSA is faced with the possibility of diminishing resources due to traditional subsistence practices inside the park. Park management is confronted with the task of reaching agreements with village councils in determining rules regarding subsistence uses. They are also in need of an assessment to document the relationship of subsistence users with the land and water both past and present in an effort to track long term trends occurring within the national park.

Although visitor impacts have been minimal due to interpretation and education, national parks in Hawaii still experience a variety of impacts from human activity. Air tours for the purpose of visitor enjoyment have been and continue to adversely affect the natural ecosystem. High levels of noise interfere with the natural soundscape. Some direct physical impacts on natural resources from visitors include the trampling of native vegetation, soil/cinder compaction and waste disposal.

While park managers are tasked with managing park resources “*unimpaired for the enjoyment of future generations*”, their efforts can sometimes cause more harm than good. For example, HAVO resource management has been involved in fencing areas to control ungulate activity. These efforts have been found to negatively impact the native dark rumped petrels that nest on

the slopes of Mauna Loa and forage offshore. Several of the birds have been found dead along the fence line routinely engaging in foraging activities. Resource management has since been using a 6 foot fence in an effort to minimize any further impacts on the species.

### **Removal of objects**

The basic management strategy of NPS is *in situ*, to leave objects undisturbed. Despite increased efforts by park management to educate visitors on natural resources, visitors continue to remove objects as souvenirs. Although the PACN share natural resource characteristics, individual parks have their own unique resources. Parks such as WAPA, NPSA, & KAHO continue to experience impacts from the daily collection of sealife from reefs and reef flats within the park. The impacts of this activity are unknown but are presumed to be deleterious to the outstanding natural values the park was created to conserve.

### **Resource components important to visitor experience**

Ironically, some of the same significant resources visitors come to experience are adversely affected by them. For instance, the heiaus at PUHE are the primary attraction for visitors and they continue to degrade them by trespassing. These heiaus built without mortar are fragile and remain an integral park component. Likewise, the fishponds at KAHO are the principal focus for visitor attraction and experience, but they are subject to ruin by visitor use.

### **Road Corridors**

Herbicidal roadside spraying is necessary to control the spread of invasive plant species in terrestrial areas. Resource management crews at HAVO commonly use a mixture of Round-Up in a localized effort to combat and control exotics. An example of this has been documented in the control efforts of mullein, a biennial herb naturalized in temperate areas on the island of Hawaii. Mullein has been located along roadsides of the Mauna Loa road beginning in the 1970s but control efforts did not start until 1989 (Loh et al. 2000). These practices are necessary not only with mullein but with other invasive species posing a threat to the native ecosystem.

### **MANAGEMENT ZONES & USE AREAS**

Like most of the parks in the PACN, HAVO is comprised of four different management zones (1) The Natural zone (2) Historic zone (3) Development Zone (4) Special Use and Transportation Zone. The natural zones primary focus is on conservation of natural resources and its processes. The historic zone includes a variety of separate sites within the park where early human habitations are found. The development zone is comprised of administrative, residential and visitor facilities. The special use zone includes trails used by park employees to access administrative facilities and visitors to access attractions. This area would also include Kilauea Military Camp located at the caldera site. Although the trails traverse through the natural zone they are best managed in this zone.

## **WILDERNESS:**

### **Management actions of appropriate intensity/manipulation**

All areas designated as wilderness are restricted to motorized equipment and mechanical transport except in the case of emergency. In the case of HALE where 27,719 acres is designated as wilderness, access is permitted and limited to trails only. Fires are permitted in designated fire places and pets are highly restricted. At HAVO fencing has been and continues to be instrumental to limit feral animals from entering the area. Wildfires are controlled to prevent the loss of wilderness lands, life and property. Population control of predation is encouraged with trapping to control and eliminate alien animal species. Roads, timber harvesting, water development projects and mining are restricted to wilderness areas in an effort to manage the lands. Grazing and hunting is also restricted except where permitted.

### **Encroachment of boundaries**

Boundaries for backcountry areas can be jeopardized when the buffer zone surrounding wilderness regions are infringed upon by the restructuring of roadways. Although there has been some issues regarding the recommended buffer, (200 meters wide), agencies have adopted the informal policy of creating *de facto* buffers outside of wilderness to protect wilderness (Kelson 1998). Monitoring these areas over a period of time can reduce the amount of loss in wilderness areas.

### **Limits of Acceptable Change (LAC)**

Carrying capacity seems to be the main issue. Visitor use seems to be unevenly distributed amongst wilderness areas with the highest volumes occurring around the periphery. This is where management can determine how much change is acceptable. Protecting resources and implementation of monitoring programs are essential for natural areas. (LAC) has been studied over a number of years to address problems associated with recreational use in natural areas. National Parks often refer to (LAC) as Visitor Experience and Resource Protection (VERP) (National Park Service 1993).

### **Increasing human activity**

In general, wilderness areas have seen a tremendous increase in recreational activities in the past 40 years (Cole & Landres 1996). Wilderness areas are becoming more frequented by visitors seeking solitude, and scientists conducting research in an outside laboratory. At HAVO, backcountry use is found frequently along the trail leading to Halape as well as visitors viewing lava flows. Some of the issues for these areas are lack of fresh water and shade along the coastline and an increase in trash in campground areas, which can lead to investment of rats and other predatory animals that adversely affect natural resources. Use is highly discouraged to mitigate potential dangers resulting from adverse conditions.

Backcountry areas at HALE experience significant impacts from increased visitors to the area. The high elevation “aeolian zone” is most susceptible to visitor use due to the spectacular scenic vistas of the crater and campground sites. Cinder compaction is a direct physical impact to the landscape threatening the unique endemic fauna on Haleakala. Local impacts at campground

sites range from leaving food and garbage to inappropriate use of fire rings using native trees and shrubs for fire wood resulting in the sprouting of alien fruit tree in cores and infestation of roaches and rodents.

Table 1. Comparing Network-wide issue by Parks

	WAPA	AMME	NPSA	USAR	KALA	HALE	ALKA	PUHE	KAHO	PUHO	HAVO
Land Use	x	x	x	x	x	x		x	x	x	x
Lightscape		x			x	x	x	x	x		
Soundscape	x		x		x	x		x	x		x
Chemical Info&Odor				x		x		x			x
Viewsheds & Scenery	x		x		x	x		x			x
Visitor & Management Impacts	x		x			x		x	x	x	x
Wilderness			?		?	x					x
Cultural Resources	x	x	x	x	x	x	x	x	x	x	x

## CRITICAL RESOURCES

### WAPA

*Ecological gradients:* Native savannah grasslands can still be found on the slopes of the Agat and Asan units in Guam. They consist of native swordgrass with scattered iron wood trees. The savannah area dominated by grasses, low shrubs, and small trees is threatened by large and frequent fires, which has been a past practice to manage the landscape, and the invasive tangentangen used by the Navy during WWII as a ground cover to decrease erosion. Savannah areas are highly susceptible to erosion and encroachment of the exotic mission grass. It is unknown if the wildfires will contribute to the conversion of the savannah to the exotic mission grass due to the change in vegetative composition of the savannah.

Some limestone forest can be found in the beach area, river valleys, and Fonte Plateau slopes of the Asan Unit as well as the slopes of the Mt Chachao Unit and the coastal islands and slopes of the Agat Unit. These forest occur on exposed limestone with a typical mosaic of intergraded subtype communities resulting from local dominance of one or two typical species (Raulerson 1979). Mt. Lamlam, the highest point on Guam, consists of a well-developed limestone forest. Due to its inaccessibility, this limestone forest has been able to escape degradation and remains an intact ecosystem.

*Soundscapes:* Terrestrial soundscapes are pretty much ruined on the island due to urban noise from increased population. Natural quiet can be found in remote areas, but even then the natural soundscape has been altered due to loss of bird sounds to the brown tree snake. Marine soundscapes have also been severely distorted from military sonar testing. Artificial sounds can be heard underwater and links between sonar and marine mammal injury have been made.

*Lightscares:* There is a considerable amount of light pollution at WAPA and some generated by the park. But the impacts are minimal compared to surrounding urban areas.

*Management Zones:* Zones for WAPA consist of the historic, natural and development zones. The historic zone consist of land and water areas necessary to preserve the integrity of individual sites, features, and structures, major battle areas, beach and offshore areas surrounding the invasion beachheads. The natural zone provides protection of natural resources where it environs developments and focal historic resources. The development zone contains areas of concentrated park development. These areas have been altered subsequent to WWII and do not contain significant historic or natural resources.

*Culturally Significant Resources:* Most of the culturally significant resources linked to biological resources, at the War in the Pacific are terrestrial and marine species. Due to cultural practices such as hunting, fishing, and collecting of plants for food and medicinal purposes, which are important aspects of the culture, natural resources are subjected to intense impacts due to anthropogenic harvesting activities within the park boundary. Increased fires in upslope savanna lands have been a particular issue creating sedimentation in stream and rivers, which in turn affect freshwater shrimp and other species as well as plants along the river banks. In addition, the Pacific Fruit Bats (*Pteropus*), has a cultural significance to the Chamorro people of Guam. The Mariana fruit bat has been favored as a “delicacy” among the Chamoros (Sheeline 1991). Therefore, the decline in the population of *Pteropus* has been attributed to hunting and poaching as well as an increase in the market demands for this species.

## **AMME**

*Lightscares:* Light pollution is more serious for AMME due to the lighted walkway that runs along the beach. Sea turtles have been known to pull out on the beaches but have never nested.

*Ecological gradients:* The 30 acre wetland containing mudflats, mangroves, and marshes is a significant resource in the Northern Mariana Islands due to the scarcity of its type. It is a critical habitat for native bird species such as the Nightingale Reed Warbler. Mangroves provide food and shelter for fish. They are also useful in the protection of coral reefs as they filter out sedimentation.

*Management Zones:* Management zones for AMME consist of the development, natural and marine zones respectively. The development zone are those areas where intensive development has taken place such as picnic facilities, comfort stations, access roads, parking, trails, sports complexes, cultural center, historic center, administrative facility, community plaza and docking facilities. The natural zone is composed of the near pristine wetland and mangrove communities consisting of habitat for native species. Although the park does not include marine resources, the marine zone has been proposed to include about 100 meters width along the park shoreline.

*Viewsheds:* Scenic views from the man-made peninsula and the Micro beach area provide views across the broad lagoon to Managaha Island as well as inland to the high hills forming the center of the island.

*Culturally Significant Resources:* Night sky is a culturally significant feature for American Memorial. Traditionally, the park beaches were used by the ancient Chamorros as a teaching beach for navigators, because it is one of the few spots on the islands where  $\frac{3}{4}$  of the sky can be seen to the horizon with no land in the way. This resource has been sacrificed by the lighted walkway installed along the beach.

## **NPSA**

*Management Zones:* Management zones for NPSA overlay between Natural and Cultural zones therefore reflect both natural and cultural resource value. There is also a subzone within the natural/cultural zone designed for strict protection as Protected Natural Areas because of their unusual fragility, scarcity, or ecological significance. Within this zone traditional gathering of plants for medicinal and other cultural purposes are permitted. Marine areas are included in the natural zone and ecological carrying capacity is being used to ensure the protection of the natural resources from subsistence reef fishing and gathering. On the unit of Tutuila, proposed park development will occur along the existing paved road leading to the village of Vatia and the top of Mt. Alava surrounding the upper aerial tramway tower. A visitor use facility is also proposed for this area. The Tau unit will include a ranger station and visitor use facilities near Saua. Proposed development on the Ofu Unit are to be low-key with little effect on natural processes and cultural resources.

*Viewsheds:* NPSA has many spectacular scenic vistas such as Pago Pago Harbor, the Mt. Alave-Maugaloa ridge, and Mt. Pioa. Proposed development such as upgrading the existing pavilion located a short distance from the tramway's upper terminus on Mt. Alava will improve views of the harbor below. Furthermore, the development of a new tramway system designed to bring large numbers of visitors into the Tutuila unit will allow visitors to experience the prime views without constructing new roads. There are also many other proposed overlooks to be installed along the existing unpaved service road leading up to the TV transmitters atop Mt. Alava, which will be narrowed reconditioned, and rehabilitated.

*Significant cultural resources: (ethnobotanically significant plants-effects of use/disuse over time):* Extensive baseline surveys along with an ethnographic overview and assessment have been conducted for park purposes. These surveys assist park management in understanding ancient samoan plant lore when making important management decision that directly affect samoan culture. Plant uses generally fall into various categories such as crops and wild plants used for food, plants used for plaiting and clothes making, herbal medicines, timber used for building boats and houses, fashioning tools, artifacts, dyes, personal adornment, ornamentals, and fish poisons (Whistler 2000).

Table 2. List of plant uses; American Samoa (Thaman 1990 &amp; Whistler 2000)

Mats	Decoration	Toys
Clothing	Ornaments	Fishing gear
Sails	Perfumes/scents	Floats
Hats	Toilet paper	Tools
Baskets	Abortifacients	Weapons/hunting
Cordage	Weed control	Insect repellent
Timber	Traps (pig/fish)	Wrappers
Canoes/boats	Soil improvement	Embalming corpses
Artifacts	Totems	Preservatives
Fuel	Switches	Containers
Fire-making	Masticants	Brushes
Torches/lamps	Boundary markers	Dyes
Staple foods	Deodorant	Glues/adhesives
Famine foods	Insulation	Caulking
Spices/seasoning	Recreation	Poisons
Teas	Toothbrushes	Aphrodisiacs
Drugs/medicines	Cages/roosts	Fertility control
Wild/animal food	Commercial products	Abrasives
Soap/shampoo	Supplementary food	Meat tenderizers
Magio-religious	Musical instruments	Shade
Brooms	Fans	

At present time, taro patches are currently being cultivated inside the park for subsistence uses while some land used for this type of cultivation remain fallow to restore soil nutrients and rejuvenation of land (Fig 3.). In addition to taro, bananas and breadfruit continue to grow when the taro crops go fallow. While most of the cultivated lands have been abandoned by villagers in an effort to pursue higher education and jobs in Hawaii and the U.S. mainland, the Botanical and Ethnobotanical Inventories report, states there are still many cultivated species scattered throughout the Park (Ragone & Lorence 2003).

Traditional plant uses are a way to acknowledge and preserve a culture. These practices remain a primary component in samoan culture, even though traditional plant lore has declined over the years due to the onslaught of western culture (Whistler 2000). Some matai still perform a variety

of cultural practices using traditional plants such as making rope from coconut husks and fishing traps from roots found on native trees in high elevations. But these activities are becoming increasingly uncommon due to a lack of knowledgeable people. Many of the plant uses listed in the table above have been replaced with imported goods and services due to globalization. The effects of globalization result in loss of culture from the disuse of traditional plants uses and cultural practices. As people adopt western ideas and customs, they surely lose the concept of ancient Samoan culture (*fa asamoā*).

*Other culturally significant resources:* The ancient star mounds in Samoa are massive stone platforms known as *tia* built by the ancient Samoans as piggin trapping sites. They serve as a cultural role in ancient Samoan society and are of great importance in religious and ritual practices. The Pacific Pigeon *lupe* Samoa's royal bird is the largest forest bird and is the only one able to transport large seeds of the natural rainforest trees. The habitat of the *lupe* has been reduced as the natural forest has been cut down; therefore, a ban on hunting the *lupe* is in place to preserve the remaining populations.

*Wilderness:* While there is currently no wilderness designation for NPSA but there is a potential for wilderness lands on the island of Tau. Designation would provide a channel for preservation of significant resources and reduce potential impacts.

## **USAR**

*Culturally Significant Resource:* The submerged warship lost in World War II remains a critical resource due to the 900 US sailors who lost their lives aboard the ship. This tomb is highly decorated, (National Historic Landmark), with the highest level of national historic significance. The memorial serves as a place where visitors can go to honor and remember those who fought and sacrificed their lives in attack on Pearl Harbor. Natural resources include the organisms attached to the hull, which are providing structural stability for the sunken ship and assisting in preservation of the national shrine.

## **KALA**

*Ecological Zones:* Special Ecological Areas (SEAs) have been designated to preserve native plants and animals in the most intact diverse, unique and manageable sites in the park. There are eight SEAs within Kalaupapa including the coastal spray zone on the northeast shore of the peninsula, Puu Alii Natural Reserve Area, Waikolu Valley, the Kauhako Crater, caves and lava tubes, the Kauhako Trench/Lava Tube, the cliffs (pali), and the submerged lands surrounding the peninsula.

*Viewsheds:* Spectacular views can be noted by the immense cliffs, 2000-3000 feet, separating the peninsula from the rest of Molokai. These cliffs along the northeast shore are a National Natural Landmark (1972). They are the result of a gigantic landslide occurring some 400,000 years ago. In addition, three steep narrow valleys bordering the cliffs are the Waikolu, Waialeia, and Waihanau, which were cut in and formed by stream erosion. Offshore islands can also be viewed from Kalaupapa enhancing the viewscape. The Kauhako volcanic crater is another element of the pristine viewscape Kalaupapa has to offer. The crater is a remnant of the Puu Uao volcano, which uplifted from the sea floor about 230,000 years ago. The crater located at the rim of the volcano contains a crater lake more than 800 feet in depth. These features of the

landscape provide an unspoiled experience for visitors as well as an excellent illustration of natural history.

*Culturally Significant Resources:* The Hansen's Disease patients, who inhabit the area of Kalaupapa are the primary resource for the park. The history of Kalaupapa dates back 900 years ago when native Hawaiian people inhabited the area. The entire area containing several thousand historical features such as rockwalls, (which were used by the ancient Hawaiians as an agricultural field system), cemeteries, churches, concrete house platforms, clusters of buildings, and coconut groves depict how humans adapted and interacted with the environment. Many of the historical places and features reveal the uses and the lifestyles of the people of Kalaupapa in earlier times as they relate to the Hansen's disease patients. These cultural resources are directly tied to the prehistoric inhabitants who relied on both marine resources and subsistence agriculture.

*Soundscapes:* There is an airport located inside the park on the tip of the peninsula. The park is currently in the process of gathering sound levels information for the upcoming Air Tour Management Plan (ATMP).

*Lightscaapes:* Night sky has not been adversely affected by light pollution. The shoreline remains dark with no significant impacts to marine resources. Likewise, terrestrial ecosystems have had no known significant impacts from light pollution.

## **HALE**

*Viewsheds:* The views and vistas of Haleakala's pristine landscape can be noted from various locations through out the park including the summit area in the aeolian zone, scenic lookouts, and along hiking trails in the Kipahulu District.

*Gradients and Zonation:* The Biosphere Reserve designed in 1980, with the purpose of conserving important biological resources, development of environmental sound economic growth, and support for research, monitoring, education and information exchange related to conservation issues. This strategy involves zoning regional landscapes into areas that range from total protection with minimal human activity (Kipahulu Research Area) to areas of intensive human use.

*Soundscape:* Although there is currently no ATMP for the park, there is a gentlemen's agreement with the ATO's for no fly zones at the summit area to reduce significant impacts on natural resources.

*Wilderness (designated):* Haleakala crater, Koolau and Kaupo gaps, and the Kipahulu Valley, above the level of Palikea Peak (600 meters), comprise the Haleakala Wilderness Area.

The Kipahulu District, consists of 10,600 acres and holds some of the most pristine habitat in Hawaii having up to 95% endemic species in the upper elevations, and includes old growth Hawaiian forest.

The upper portions of Koolau and Kaupo gaps comprise parts of the summit district. This area is best known for its scenic volcanic landscape and the endemic Haleakala silversword. Common shrubs include mamane (*Sophora chrysophylla*), pukiawe (*Styphelia tameiameia*), pilo (*Coprosma montana*), Ohelo (*Vaccinium reticulatum*), aalii (*Dodonea viscosa*) and kupaoa (*Dubautia menziesii*). Grasses include *Deschampsia nubigena*, pili uka (*Trisetum glomeratum*), and *Agrostis sandwicensis*.

Kīpahulu Research Natural Area: The native koa (*Acacia koa*) dominates the forest from 600 to about 1,200 meters, while the `ohi`a (*Metrosideros polymorpha*) dominates the forest above 1,200 meters. A rich variety of subcanopy species exist throughout the valley, especially in the mid-elevation (900 to 1,500 meter) range. Tree ferns (*Cibotium* spp.) are important in the understory. Lobelioids (*Cyanea* spp., *Clermontia* spp., *Lobelia* spp., and *Trematolobelia macrostachys*) and mints (*Stenogyne*

spp. and *Phyllostegia* spp.) are among the rare and spectacular endemic plant species of the valley. The upper portion of Kīpahulu Valley is habitat for several federally-listed

endangered honeycreepers, some of them thought to be extinct prior to the 1967 Kīpahulu expedition. The rarest are the Maui Nukupu`u (*Hemignathus lucidus affinis*) and the Maui Parrotbill (*Pseudonestor xanthophrys*). The endangered `Akohekohe or Crested Honeycreeper (*Palmeria dolei*) is still fairly common within the high elevation `ohi`a forest of East Maui, but is found nowhere else. The valley also provides an important flyway for the endangered `U`au and may contain breeding areas yet to be discovered. Kīpahulu Valley also hosts large numbers of endemic invertebrate species.

*Culturally Significant Resources:* Protecting and preserving the natural resources for future generation has been and continues to occur at Haleakala. The park is unique given that it is located within an ahupuaa, stretching from the land to the sea, providing the needed resources for survival. The concept of “*Malama Aina*” “to care for the land” is used in native Hawaiian culture and has been cultivated at Haleakala. Kīpahulu Ohana is a group responsible for the revival and cultivation of 14 ancient taro patches (*loi*) within the valley with historical significance. The group provides public tours of the taro patches for residents and visitors and is dedicated to educating of the “*ways of the old*” through cultural interpretation and hands on activities.

*Historic District:* The historic district of Haleakala has gained its existence to the presence of archeological sites. The entire Crater area, which consist of 279 archeological sites, all of which are listed on the National Register of Historic Places are part of the historical district at HALE. In addition, parts of the Kīpahulu area (lower portions of the valley, the former pasture lands, and the Oheo coastal region) have all been declared eligible for the listing on the register and are considered part of the district as well.

## **ALKA**

*Environmental Gradients & Zones:* The 175-mile historical trail passes through diverse ecosystems which include significant natural resources. Due to the nature of the trail along the coastline, most of the natural resources are marine based. Native damselflies, birds, and native bees along with rare plants and animals are known to be associated with anchialine pools and other wetland areas. Other marine organisms include endangered sea turtles, Hawaiian monk seals, and humpback whales. In addition, beaches and intertidal areas provide habitat for migratory shorebirds to forage and rest.

*Land Use:* The park also provides for recreational beach and shoreline activities including fishing, diving, and collecting resources for food purposes.

*Culturally Significant Resources:* In the past, the trail has been associated with many population centers of the island, especially the royal centers and most major temples. Therefore, the cultural landscape has distinctive Hawaiian resources including a variety of heiaus, fishing settlements

and gardening terraces. Along the trail there are also stone surfaces for which games have been played (e.g. konane) ancient game resembling checkers and long inclined basalt tracks, (holua slides), used by the alii as a competitive game to test their courage and skill. Anchialine pools containing significance resources such as the native damselfies (*Magalagrion sp.*) and possibly rare shrimp can be found along the trail system and have been used by the ancient Hawaiians practicing aquaculture (Dunbar 1997).

*Lightscares:* The lightscares along the Ala Kahakai are subjected be degradation as the trail passes through several resorts within the south Kohala coastal region. Outdoor lighting is common along the beaches and poses a threat for nesting sea turtles such as the endangered hawksbill.

## **PUHE**

*Culturally significant vegetation:* Although most of the vegetation presently located inside park boundaries and on nearby adjacent lands are introduced species such as kiawe, buffelgrass, haole koa, and lantana, there are some native species growing. According to the survey conducted in 1992-1994, (Pratt & Abbott 1996), *Ilima*, a native shrub, is known to grow away from the coast in vicinity of the heiau and a rare native fern, *pololei* (*Ophioglossum polyphyllum*), which has been classified in the past as a threatened and endangered plant species, has been identified growing in a isolated area east of Puukohola heiau. This fern has been listed in the past as Category 1 by the U.S. Fish and Wildlife Service, which supports the biological appropriateness to list as endangered species, but has since been removed (Smith 1993) due to proper identification and distribution in other areas. Other natives found growing along coastal areas are *naupaka kahakai*, *milo*, *pohuehue*, and *akulikuli*. These plants are “hardy” and are likely to spread as the removal of the kiawe continues. Another native plant with significant cultural ties is the *pili*. At the time of the survey, it was found in only one site, but is not uncommon to the area as it has been used for thatching in ancient times. *Pili* grass has been replanted along the old Spencer Beach Park road and 100 yards north of the visitor’s center.

*Cultural landscape:* The entire site at PUHE has strong ties with Hawaiian history and Kamehameha the Great. The Puukohola *heiau*, Mailekini *heiau*, Hale o Ka Puni *heiau* and the John Young homestead are all part of the cultural landscape and included within the historical site. The site is a primary attraction for visitors with the cultural landscape being the most significant resource. Due to the importance of these resources, the heiaus as well as the John Young Homestead have been subject to preservation treatment in an effort to restore and stabilize by the NPS for the *enjoyment of future generations*.

*Viewscares:* Much like the cultural landscape, the viewscares at PUHE consist primarily of the heiaus located on the western slope. The Puukohola heiau located atop “the hill of the whale” is the site’s key resource, while the Mailekini heiau is another component of the historical scenic vista. The ideal location to experience the historical integrity of the landscape is from the coastal area. While the views are still remarkable from the water or even the coral flats across the water, the development along the shore has adversely impacted the viewscape from the heiau and the surrounding slopes of the park. The viewscape to the ruins of the John Young homestead has been significantly altered and impacted by the overgrown kiawe. This historic view has lost its integrity and is no longer contributing to the historical vistas. Another critical resource is Pelekane Bay, where the unverified Hale o Ka Puni heiau, is located.

*Soundscapes:* Park management has been concerned with overflights impacting the heiaus. Vibration seems to be a major concern for the heiaus as they have been constructed without mortar and are highly susceptible to impacts.

*Lightscares:* The expansion of the boat harbor has resulted in an increase in light pollution with negative impacts to the natural resources. Turtle nesting is not known to occur at Pelekane Bay but there is always a chance for this type of activity.

### **KAHO**

*Land Use:* Habitat for native species are greatly affected by adjacent land use. Anchialine pools are known to have high levels of endemism and rely on high-quality surface waters. Coral reefs are also an important resource for this coastal park and are impacted by land use.

*Soundscapes:* Both the underwater and terrestrial soundscapes have been subjected to anthropogenic noise. Expansion of the Honokohau harbor has increased noise for marine resources. Likewise, noise from the nearby Keahole Airport has direct impacts to terrestrial resources.

*Lightscares:* Light pollution from the adjacent harbor significantly impact the endangered Hawksbill turtles as they are known to nest along the beach.

*Culturally Significant Resources:* KAHO is considered a sacred place with many culturally significant resources. There are many significant resources at KAHO including the Kaloko and Aimakapa fishponds,(habitat for native species), to surrounding structures, heiaus, house platforms, gravesites, trails, and fishing shrines, which are directly related the ancient Hawaiian fishing customs and beliefs.

### **PUHO**

*Environmental gradients:* Remnants of dryland forest, coastal strand, a salt marsh, anchialine pools, man-made fish ponds, historical resources, coral reefs and sparsely dispersed native fauna and flora are dispersed along the gradients and zones. Plant species found along the coast and near the ponds adjacent to the Great Wall include native trees, sedges, a vine and a sprawling herb. Native trees found along the shoreline include milo (*Thespesia populnea*), hala (*Pandanus tectorius*), and naupaka kahakai (*Scaevola sericea*). Native sedges found near the ponds and the Great Wall consist of makaloa (*Cyperus laevigatus*) and mau'u 'aki'aki (*Fimbristylis cymosa*). The Hawaiian Hoary bat (*Lasiurus cinereus semotus*), the only mammal native to the Hawaiian Islands, commonly forages for flying insect prey over open areas such as forest clearings, lava fields and nearshore coastal waters such as those found adjacent to the park.

*Land Use:* Currently lands surrounding PUHO consist mostly of open space. Although trends indicate future development of this area, especially along the coastal area, plans are indefinite and the future is unknown. The park service is still in the process of acquiring the former village of Kiilae (238 acres) located along the southern boundary of the park. This parcel is rich in archeological resources as it has been undisturbed since ancient Hawaiian times.

*Culturally Significant Resources:* Cultural resources at PUHO include a remnant dryland forest, which was used historically for dry terrace cultivation of crops such as taro, sweet potato, sugar, and *wauke*. There are also sparse patches of traditional plants such as pili grass (used for

thatching), ahuhu (*Tephrosia purpurea*), used as a fish poison in tidal pools, and Peperomia, which has been used for medicinal purposes as well as a dye for *kapa* cloth. Marine resources also have cultural significance, such as *opihi*, which has been and continues to be utilized by Native Hawaiians. There is a historic fishing shrine located near the cliffs of Keanaee, which is still used today.

## **HAVO**

*Environmental Gradients and Culturally Significant Resources:* Data taken from the distribution of permits show collection of plants are mostly Aalii, Liko lehua, Palapalai, and Pukiawe with the majority of collection occurring during the Merrie Monarch Festival for halau-hula purposes. Most plants are collected at the Kipuka Ki area, which is a Special Ecological Area, the Mauna Loa Road above and below Kipuka Ki, southwest side of Kilauea Crater adjacent Crater Rim Drive and Highway 11 west of park entrance. All of the collecting occurring on the dry side of the park and less occurring on the wet side (Langlas 2003).

Table 3.1. *Plants with Dye Qualities; HAVO Plant Species*

Akala fruit	<i>Rubus hawaiiensis</i>	Olaa Tract, Kipuka Ki, Mauna Loa Strip
Kukui bark	<i>Aleurites moluccana</i>	Mid elev east-open woodland
Noni bark	<i>Morinda citrifolia</i>	Coastal Plain
Ohelo berries	<i>Vaccinium reticulatum</i>	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Ohia bark	<i>Metrosideros polymorpha</i>	All zones
Olapa berries	<i>Cheirodenron trigynum</i>	Mid elev (east), Olaa Tract
Olomea berries	<i>Perrottetia sandwicensis</i>	Mid elev east-rain forest, Olaa Tract
Uki uki fruit	<i>Dianella sandwicensis</i>	Coastal, Mid elev west, Mid elev east-open woodland, Upper Mauna Loa Strip

Plants with dye qualities have been used by members of halau hula to dye their costumes and also by Hawaiians in the creation of artwork (Langlas 2003).

Table 3.2. *Plants for Crafts or Cordage; HAVO Plant Species*

Hala	<i>Pandanus odoratissimus</i>	Coastal
Hao	<i>Rauvolfia sandwicensis</i>	
Hau	<i>Hibiscus tiliaceus</i>	

Ie ie	<i>Freycinetia arborea</i>	Mid elev (east), Olaa Tract
Koa	<i>Acacia koa</i>	Mid elev west, Olaa Tract, Kipuka Ki, Upper Mauna Loa
Kou	<i>Cordia subcordata</i>	
Lama	<i>Diospyros ferrea</i>	Coastal, Mid elev west, Mid elev east-open woodland
Milo	<i>Thespesia populnea</i>	Coastal Plain
Niu	<i>Cocos nucifera</i>	
Ulei	<i>Osteomeles anthyllidifolia</i>	Coastal, Mid-elev (west), Mid-elev(east)-open woodland, Kipuka Ki, Upper Mauna Loa
Wiliwili	<i>Erythrina sandwicensis</i>	

More often than not plants used for crafts and cordage are used for non religious purposes (e.g. floor mats, bracelets and baskets). This demand creates an insufficient number of plants in the park, therefore plants of this nature can only be collected with special permission from the superintendent (Langlas 2003).

Table 3.3. *Plants for Medicinal Uses; HAVO Plant Species*

Kukui nuts	<i>Aleurites moluccana</i>	Mid-elev(east)-open woodland
Kukui bark		
Liko/mu o lehua	<i>Metrosideros polymorpha</i>	
Mamaki	<i>Pipturus albidus</i>	Mid-elev (west), Mid-elev (east)-rain forest, open woodland
Noni fruit	<i>Morinda citrifolia</i>	Coastal Plain
Ohelo	<i>Vaccinium reticulatum</i>	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Ohelo kaula au	<i>Vaccinium calycinum</i>	
Popolo	<i>Solanum nigrum</i>	Mid-elev (east), Olaa Tract, Kipuka Ki
Uhaloa root	<i>Waltheria americana</i>	Coastal, Mid-elev (west)

Table 3.4. *Plants with domestic values; HAVO Plant Species*

Aalii	<i>Dodonaea viscosa</i>	Coastal, Mid-elev (west), Mid-elev (east)-open woodland, Kipuka Ki, Upper Mauna Strip
Akia bark	<i>Wikstroemia</i>	Coastal, Mid-elev (west), Mid-elev (east), Kipuka Ki,
Akia fruit		
Iliahi	<i>Santalum ellipticum</i>	Mid-elev (west), Mid-elev(east)-open woodland, Kipuka

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		Ki
Kauna oa pehu	Cassytha filiformis	Mid-elev (east)-open woodland
Koa leaves	Acacia koa	Mid elev west, Olaa Tract, Kipuka Ki, Upper Mauna Loa
Liko lehua	Metrosideros polymorpha	All ecological zones
Liko ohelo	Vaccinium reticulatum	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Maile	Alyxia oliviformis	Mid-elev(east), Olaa Tract, Kipuka Ki
Mamane	Sophora chrysophylla	Mid-elev(west), Kipuka Ki, Upper Mauna Loa Strip
Ohelo fruit	Vaccinium reticulatum	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Olona	Touchardia latifolia	Olaa Tract
Pa iniu	Astelia sandwicensis	Mid-elev (east), Olaa Tract
Palapalai	Microlepia strigosa	Mid-elev(east), Olaa Tract, Kipuka Ki
Pala a	Sphenomeris chinensis	Mid elev (east, west), Olaa Tract
Pukiawe	Styphelia tameiameia	All ecological zones
Uki	Machaerina angustifolia	Mid-elev (east)

All of the plants with domestic values are used as a decorative element for lei making or as cordage to tie leis together (Langlas 2003).

While HAVO has numerous culturally significant resources, the cultural landscape at the Ainahou Ranch is a site used for the Hawaiian endangered nene goose breeding and conservation program. Locally renowned Wildlife conservationist Herbert C. Shipman built the house in 1941 and has been credited with saving the nene goose from extinction

*Soundscapes:* The natural soundscape has been altered due to commercial air tour operations, park aircraft use, diesel tour buses, highway vehicles, park operations and concessions and other cooperator operations.

*Wilderness:* Over half of the park has been designated wilderness and has been recognized as an International Biosphere Reserve. These lands provide unique hiking trails and campgrounds. The addition of the 116,000 acre Kahuku Ranch has significantly increased the amount of wilderness for HAVO. Kahuku runs along the southwest slopes of Mauna Loa from 2,000 feet

to 13,000 feet in elevation and encompasses diverse native ecosystems, from montane mesic forest and shrubland, to dry forest, to the subalpine and alpine communities above 6,500 feet.

**TABLES OF CRITICAL RESOURCES AND STRESSORS FOR LANDSCAPE WORKGROUP**

*Table 4.1. Critical resources and stressors of WAPA*

WAPA	Critical Resources	Stressors
	Gradients/Zonation	Burning/Fires
	Soundscape	Urban Development, Military Sonar Testing
	Lightscares	Urbanization, Street Lights
	Viewsheds	Invasive Species
	Land Use	Adjacent commercial, industrial & residential development
	Management Zones/Use Areas	Feral Animals
	Culturally Significant Resources	Over fishing

*Table 4.2. Critical resources and stressors of AMME*

AMME	Critical Resources	Stressors
	Gradients/Zonation	
	Soundscape	
	Lightscares	Outdoor lighting
	Viewsheds	Storm surge activity
	Land Use	Encroaching development, illegal dumping
	Management Zones/Use Areas	Feral animals
	Culturally Significant Resources	Light pollution

*Table 4.3. Critical resources and stressors of NPSA*

NPSA	Critical Resources	Stressors
	Gradients/Zonation	
	Soundscape	Potential development of landing strip on Ofu
	Lightscares	
	Viewsheds	
	Land Use	Subsistence Agriculture
	Management Zones/Use Areas	Proposed Development
	Culturally Significant Resources	Subsistence Ag & Fishing

*Table 4.4. Critical resources and stressors of USAR*

USAR	Critical Resources	Stressors
	Culturally Significant Resources	Land use

*Table 4.5. Critical resources and stressors of KALA*

KALA	Critical Resources	Stressors
	Gradients/Zonation	Alien vegetation and ungulates, mass wasting
	Soundscape	Airport inside park boundary, air tours, barking deer, myna birds
	Lightscares	Lighthouse
	Land Use	Dumps
	Management Zones/Use Areas	Marine activity (fishing)
	Culturally Significant Resources	Climate

Table 4.6. *Critical resources and stressors of HALE*

HALE	Critical Resources	Stressors
	Soundscape	Air tours
	Lightscares	Floodlights from shoreline homes & resorts
	Viewsheds	Visibility
	Land Use	Summit facilities
	Culturally Significant Resources	Visitor impacts, alien vegetation

Table 4.7. *Critical resources and stressors of ALKA*

ALKA	Critical Resources	Stressors
	Soundscape	
	Lightscares	Light pollution from resorts
	Viewsheds	
	Land Use	Development
	Culturally Significant Resources	Visitor impacts

Table 4.8. *Critical resources and stressors of PUHE*

PUHE	Critical Resources	Stressors
	Gradients/Zonation	Erosion/Sedimentation
	Soundscape	Overflights
	Lightscares	Harbor Expansion
	Viewsheds	Non-native vegetation
	Land Use	
	Management Zones/Use Areas	
	Culturally Significant Resources	Overflights, Increased visitation

Table 4.9. *Critical resources and stressors of KAHO*

KAHO	Critical Resources	Stressors
	Gradients/Zonation	Land use
	Soundscape	Boat Harbor Expansion, Increased visitation
	Lightscares	Adjacent Boat Harbor
	Land Use	Upslope Development
	Management Zones/Use Areas	Feral Animals
	Culturally Significant Resources	Human activity

Table 4.10. *Critical resources and stressors of PUHO*

PUHO	Critical Resources	Stressors
	Gradients/Zonation	Invasive species
	Soundscape	
	Lightscares	
	Viewsheds	
	Land Use	Potential development
	Management Zones/Use Areas	Increased visitation
	Culturally Significant Resources	Climate change(rise in sea-level)

Table 4.11. *Critical resources and stressors of HAVO*

HAVO	Critical Resources	Stressors
	Gradients/Zonation	Fires
	Soundscape	Increased air tours
	Viewsheds	Invasive species, air quality
	Land Use	Adjacent lands
	Chemical Info&Odor	Volcanic Emissions
	Management Zones/Use Areas	Demographics
	Wilderness Areas	Adjacent land use, buffer zone, fires
	Culturally Significant Resources	Visitor impacts

## MONITORING

### PARKS MONITORING

#### WAPA

The park is in the process of establishing baseline conditions to document sedimentation (rates and composition) on the island's coral reefs. They are also trying to gain a better understanding of the effects of wildfire on tropical savannah grasslands in an effort to establish best the management practices for reducing erosion. Other data currently collected includes water temperature and Photosynthetically Active Radiation (PAR). Studies on coral recruitment and percent cover are underway. A study examining fishing pressure within the park waters is also underway. Stream flow gauging stations at Asan and Namo Rivers measuring peak flows and stages in conjunction with rain events are maintained by the USGS Water Resources Division. A climate station at Mt. Chachao is also kept up by the USGS Water Resources Division. A plant inventory to identify species within the park is scheduled for June 2004 by PCSU staff. Results from this survey will generate a species list to be certified and entered into the NPSpecies database.

#### WAPA Monitoring Needs

There is a great need for oral histories from local residents to establish trends related to subsistence agriculture and fishing. Establishing this data will assist park management in long term planning for park resources. In addition, baseline conditions are needed for terrestrial (vegetation mapping), freshwater resources and also marine toxicants. Other research needs for the park's most significant resources include coral reefs, native limestone forests, tropical savanna forests and other marine ecosystems. Also, a survey is needed to determine the extent of submerged cultural resources to determine unexploded ammunition where snorkeling and fishing is taking place.

#### AMME

CNMI Department of Environmental Quality is conducting ongoing monitoring at the artificial wetland inside the park boundary. But there is still a need to obtain the information from this project. In addition, the University of Guam is also involved in ongoing monitoring of Tanapag lagoon. While most of the past monitoring projects have been conducted outside of park, such as reef fish population survey by CNMI DFW in 1996 and CNMI-DEQ measurements of salinity,

fecal coliform, pH, DO, turbidity, nitrates, and orthophosphate in artificial wetland in 1996 and 1997 the results of the study certainly affect the park.

### **AMME Monitoring Needs**

In general, there is a need for more information on coral reefs, due to its national significance and possible indicator of global and regional climate change as well as critical resource for the park. There is also a need for more information on the wetlands mangroves, particularly the inland mangrove wetland, because it's the only one of its kind in the Mariana Islands. In addition, additional research is necessary for endangered bird species including the Nightingale Reed-Warbler.

### **NPSA**

The ethnographic overview and assessment report was completed in April 2003 by the National Tropical Botanical Garden to monitor the effects of significant plant use and disuse over time. Detailed interviews were conducted (25 hours) with individuals and recorded in effort to better understand cultural practices over the last five decades. In addition, the Am Samoa Department of Marine and Wildlife Resources has been involved in the long term monitoring of trees to determine new recruits and mortality patterns of trees and the Coral Reef Ecosystem Monitoring Program which provides information on changes in coral reef ecosystems. The University of Hawaii- Manoa has been involved in the inventory and monitoring of seabird population around the island of Tutuila. In December 2001 and 2002 sound recordings were conducted at Mount Lata on Tau Island in an effort to reinvent the historic natural soundscape when Polynesia was only populated with seabirds, fruit bats and other native species. The recordings filtered out wind and surf so bird calls could be more easily distinguished. Although this was technically not a form of monitoring, it was a way of documenting presence or absence of the focal species.

### **NPSA Monitoring Needs**

Monitoring needs for the landscape workgroup revolve around harvested resources and effects to terrestrial and marine ecosystems.

### **USAR**

The Legacy Resources Management Fund Project (No. 02-170) has been designated for research directed to understanding the nature and rate of natural processes affecting the deterioration of the USS Arizona in Pearl Harbor, Hawaii. The project is designed to provide a foundation for long-term preservation and management of this immensely significant site. The corrosion process is being measured In Situ using pH and corrosion and by x-ray diffraction and scanning electron microscope using samples collected from different locations along the sunken vessel. Samples of oil, sediment, water & concretion are all being collected as a part of this study. GPS points are being taken for movement detection. GIS development via photographs & maps are also being developed.

## **USAR Monitoring Needs**

Continued collection of baseline data including wind, wave, and current patterns around the vessel as well as some environmental parameters, such as pH, temperature, salinity, dissolved oxygen, oxygen reduction potential and conductivity to determine and model overall corrosion rates is essential for understanding the varied processes occurring within the sunken ship.

## **KALA**

Weed removal project in Kukaiwaa of java plum to determine control efficacy for restoration is on ongoing in 6-8 month intervals. Low density pig project comparing soil fauna at wet forest sites with low densities of pigs with plots from which pigs have been excluded to see if complete eradication of pigs is necessary for forest recovery. Rare plants of Kauhako Crater have been tagged, measured, and evaluated, monitoring of resident monk seal beach and shoreline use, restoration of coastal Pritchardia forest, lowland dry/mesic forest, and coastal strand vegetation are all monitoring projects that are ongoing. There is a great need for, bird populations, hiiwai populations in Waikolu stream, and long-term monitoring of known rare plants, especially in Kauhako Crater, and more detailed monitoring of the Kauhako Crater lake fauna. Vegetation mapping has been the most recent monitoring project being conducted by USGS. In addition, some preliminary sound testing was conducted at KALA in May of 2003 by the Natural Sound Program. This information will be primarily used to assess the natural soundscape for the upcoming ATMP.

### **KALA Monitoring Needs**

- Upper elevation forest including native forest boundary mapping.
- All bird inventory (abundance and distribution) throughout park, including native forest bird trends.
- Coral reefs including abundant reef and open ocean fish populations.
- Monk seal habitat including current pupping beach in the Main Hawaiian Islands.
- Rocky shorelines (thick opihi populations).
- Coastal strand community
- Endangered plants
- Petrels

## **HALE**

Monitoring projects related to landscape workgroup are as follows: Repeat photography will be used to monitor viewsheds using past photographs to compare change. Global climate change is being determined and changes in tree line are being monitored in an effort to monitor ecotone boundaries and gradients. Integrating Hawaiian culture w/natural resource issues (historic and contemporary) will commence as park personnel is establishing a relationship with kupuna to discuss park resources. Acoustical data has been gathered to monitor the natural soundscape for the upcoming air tour management plan.

## **HALE Monitoring Needs**

Information is needed on the recovering alpine aeolian cinderland, subalpine shrub and grassland, montane bogs, cloud and rain forest, leeward shrublands, mesic and dry forests and associated ecotones distributed in close proximity along a sharp climatological gradient. Subalpine lakes and associated biota, highly impacted systems which may contain rare threatened and endangered species (TES), perennial and intermittent streams and associated biota and riparian habitat including water quality. In addition, threatened and endangered plant and animal species, distribution and health including endangered bats distribution and health is another area for which information about status and trends is considered necessary. There is also a great need for invertebrate research. Little is known about life history of invertebrates and many species are undescribed especially in the rain forest areas (NPS, 2004). Cave ecosystems is yet another area lacking research and information on the status and trends especially due to the unique geologic features, rare invertebrate species and unrenovable cultural resources. An ethnographic overview and assessment is also needed to document places and features. Lastly, the most important issue is the distribution of alien species, mostly plants. As these invasives become more widespread it is extremely necessary to learn about their presence in the park.

## **ALKA**

Due to the nature of the trail traversing through several parks along the coastal plain, monitoring projects occur concurrently with other Kona park projects. For instance, anchialine pools are located along the Ala Kahakai and within KAHO, HAVO, and PUHO, therefore ongoing research for these ecosystems can be used for dual purposes. Likewise the monitoring of Pelekane Bay for PUHE is another aspect of where the parks overlap. Another example is the wetland bird population project at the Aimakapa Fishpond.

West Hawai'i Aquarium Project (WHAP) is studying the distribution and abundance of aquarium fishes in 23 sites along the West Hawai'i coast since 1998 to analyze the impacts of aquarium fish collecting and the effectiveness of Marine Protected Areas and Fish Replenishment Areas in Hawaii. Natural Energy Laboratory of Hawaii Authority participates in ongoing monitoring of groundwater, nearshore marine areas, and aquaculture outfalls. This research fulfills NPDES and county permit requirements.

## **ALKA Monitoring Needs**

There is no defined distance of corridor width. Planning efforts to assist in management for care resources along with community involvement in the development of monitoring segments of the trail would be useful in tracking trends and predicting changes along the trail in an effort to preserve natural and cultural resources. Also listed below are some general topics that need further research.

- Marine water quality monitoring at strategic points along the 175-mile corridor
- Nearshore groundwater quality monitoring
- Alien vegetation assessments
- Cave protection plan
- Anchialine pool protection plan
- General ecosystem status, through indicator communities along coast

- Feral animal impact assessment and control plan
- Effects of urbanization on marine and shoreline communities

## **PUHE**

Park Service monitoring include shark observations at Pelekane Bay, which include daily shark sighting that are recorded on a calendar and pololei monitoring by park employees after a rain event. In addition, ongoing monitoring of pili grass in areas where propagation has taken place is another project the park has undertaken. The MKSWCD in conjunction with the USDA-NRCS has been conducting on going monitoring of erosion rates, vegetation growth, and precipitation in the watershed using rain gauges in the Makeahua Stream and gulch to determine sedimentation rates in Pelekane Bay. Future projects for the park include monitoring shoreline resources, assessing consumptive use, assessing Kawaihae Harbor impacts on the park including collection of core samples to assess sediment contaminants and to monitor changes in sediment composition and deposition, and debris clean-up.

### **PUHE Monitoring Needs**

Historical accounts (oral histories) of vegetation to aid in native plant restoration projects, baseline information for endangered turtle populations, and additional information on pololei fern regarding status and recommendations are some of the areas in need of information in an effort to track long term trends.

## **KAHO**

The park has been conducting cooperative green sea turtle monitoring with the National Marine Fisheries Service Marine Turtle Research Program and the Hawaii Preparatory Academy in the park since 1999, The University of Hawaii at Hilo has recently began sea turtle forage studies, as well as anchialine pool studies. Wetland bird populations are monitored at `Aimakapa Pond through an agreement with Ducks Unlimited. Effectiveness of resource management is monitored by recording number of animals trapped in the predator management effort, as well as results of alien plant eradication efforts and native plant propagation. Previous monitoring includes shorebird surveys by park staff (this has been discontinued, but there are plans to continue). The Kula Naia Project has recently launched a underwater sound monitoring project to gather information on the underwater soundscape.

### **KAHO Monitoring Needs**

There is a great need to monitor ground water both inside and outside the park due to continued development in upslope areas and planned resort/golf course development adjacent to the park. There is also a need for water quality research of ponds, pools, nearshore waters and groundwater. Also, population and life history information of marine turtles and endemic waterbirds and inventory of anchialine pool species are other areas to be studied. Other areas include coral reef (algae, coral species and cover, fish, target fish in fisheries), native plant species populations and locations, and pond systems (biotic components). Addition needs for the park, which are planned, include coral reef health (composition, fish numbers, and marine water quality), and groundwater and anchialine pool water quality.

## **PUHO**

Monitoring the distribution and abundance of aquarium fishes in adjacent waters to PUHO has been ongoing by the West Hawaii Aquarium Project (WHAP). The University of Hawaii at Hilo and Washington State University, Vancouver have both been actively involved in this project to estimate impacts of aquarium fish collecting, estimate critical habitat characteristics for adult and juvenile aquarium fishes, document recruitment patterns of aquarium fishes, and evaluate the effectiveness of the Fish Replenishment Area (FRA) plan to increase aquarium fisheries. In addition, the USGS has been monitoring the presence of weeds on major roadsides on Hawaii Island. The purpose of this project is to document the presence of weeds, incipient invaders in and near the park. The information will allow resource management to more rapidly address priority weeds, frequency of weed species, new records, and distribution. Visitor use statistics is also being monitored at the entrance gate to track and record incoming visitors for cultural reasons.

### **PUHO Monitoring Needs**

Baseline water quality data is needed for anchialine ponds, tidepools, springs, waterholes and coastal waters. Additional data is also needed for marine resources especially in coral reef areas outside of park boundary, due to increased human impacts from snorkeling, diving and tourist activities. Population surveys for threatened and endangered species, native (indigenous, endemic, polynesian introduced), invasive and non-invasive plant and animal species is also another need to assist park managers in determining and identifying resources at risk. Information on status and trends of biotic communities in anchialine ponds and coastal strands, especially heavily impacted areas is one more area where additional information is needed.

## **HAVO**

Visitor Statistics at Hawaii Volcanoes National Park are monitored daily, including the number of vehicles, total visits, recreational vehicles, non-recreational vehicles, bus vehicles, campground tents, Volcano House use, Kilauea Military Camp use, Backcountry use at Halape, Kaaha, Keauhou, ML Summit cabin, Napau, Pepeiau and the Red Hill cabin. This data can be used to monitor the impact of visitor on the parks backcountry resources and other resources but no such monitoring in place at this time. There are also a number of monitoring projects the National Park Service is involved in, such as, Overflight Noise for the upcoming ATMP, Air Quality Monitoring, which can be used to assess visibility in relation to historic viewsheds and various vegetation monitoring to track trends in ecological gradients.

### **HAVO Monitoring Needs**

Although Hawaii Volcanoes is an intensively managed landscape, there are many areas in need of information about status and trends. The Kahuku Ranch addition is one section where baseline surveys are needed to determine status and trends of significant resources. Additional information is needed to assess the natural soundscape and effects from air tours. Other areas in need of information include mesic forest ecosystems on the lower slopes of Mauna Loa, Kilauea and above Kalapana Trail, upper montane, subalpine and alpine ecosystems as koa and mamane colonize native shrubland/grassland and other lowland ecosystems proposed for restoration. In addition, information on culturally significant native communities (e.g. traditional gathering

areas and species, and relict dry forest ecosystem and species would be useful to determine the status and trends of the ecosystem.

## **REGIONAL MONITORING PROGRAMS AND METHODS**

### **LAND USE**

#### **GIRAS/Land Study Bureau/USGS Landcover/NOAA-CCAP/HIGAP/USGS NAWQA**

NOAA-CCAP Land Cover Classification System starts with three superclasses (1) Uplands (2) Wetlands (3) Water and Submerged Land. These superclasses are then subdivided into classes and subclasses at the second and third levels respectively.

USGS LULC Program is cooperating in a research project with the Environmental Systems Research Institute to collect and integrate land use and land cover data for a standard USGS 1:100,000-scale. The LULC data collection techniques interpreting Landsat Thematic Mapper 30-meter resolution, spectrally clustered images, interpreting 1-meter resolution digital panchromatic orthophoto images and for comparison aggregating locally available large scale digital data of urban areas.

### **LIGHTSCAPES**

#### **Satellite**

The United States Airforce Defense Meteorological Satellite Program (DMSP) is monitoring the night sky by measuring the upward light flux emitted by the sources on the surface of the earth. The satellite F12 is in a low earth polar orbit and carries an oscillating scan radiometer, the Operational Linescan System (OSL), with a photomultiplier tube (PMT) as detector. The OSL scans a narrow swath of the Earth, about 3,000 km wide, perpendicular to the orbit and as the satellite moves it constructs a bi-dimensional image of the Earth surface.

#### **Astronomical Observatories**

Mauna Kea Observatories is currently monitoring the night sky using a "CONCAM" so everything can be viewed above the horizon from its location. It monitors the sky for transience such as meteors, stellar variability and rare transient events. It also acts as a cloud monitor for large telescopes looking only at a small piece of the sky and serves as an educational tool allowing anyone with a web browser to see the night sky at any time.

#### **County monitoring**

Hawaii and Oahu counties currently have lighting ordinances enacted regulating light uses. An amendment to Chapter 14 to aid in the conservation of energy and restrict the permitted use of outdoor light fixtures emitting undesirable light rays into the night sky having a detrimental effect on astronomical research has been designed to address problems with light pollution.

## **Wildlife programs**

U.S. Fish & Wildlife Services (DOFWS) has partnerships with the DLNR, USDA Wildlife Services, USGS Biological Research Division, Ducks Unlimited, and the University of Hawaii participating in conservation programs in Hawaii and the Pacific Islands. The Service's program has four primary areas of concern (1) Population Assessment (2) International, national and flyway coordination (3) Habitat Management (4) Regulating take.

The DOFWS partnered with the University of Wisconsin, Department of Zoology and conducted a study on the island of Kauai to determine if shielding of lights to prevent upward radiation of the largest resort decreased the number of attractions of Hawaiian seabirds. The results indicated a 40 percent decrease in attraction (Reed et al. 1985). The monitoring was conducted during 1980 and 1981 with diurnal patterns analyzed after sunset.

## **SOUNDSCAPES**

### **OSHA/health regulations**

The OSHA standard states when information indicates that any employee's exposure may equal or exceed an 8-hour time weighted average of 85 decibels; the employer shall develop and implement a monitoring program.

### **Airport**

The Federal Aviation Administration (FAA) in cooperation with the National Park Service (NPS) has initiated the development of an Air Tour Management Plan (ATMP) for HAVO, HALE, KAHO, PUHE, PUHO, KALA to mitigate or prevent the significant adverse impacts of commercial air tour operations upon the natural resources, cultural resources, and visitor experiences of the subject national park unit. The ATMP is in accordance with the National Parks Air Tour Management Act of 2000, which is required for all those who apply for authority to conduct air tour operations over a park. The ATMP shall be developed by means of a public process to assure all important issues are addressed.

### **NEPA**

The National Environmental Act of 1969 was designed to eliminate damage to the environment and biosphere and promote the understanding of the ecological systems and natural resources by declaring a national policy to encourage harmony between man and his environment. Mandated by Congress the policies set forth require all federal agencies to follow specific guidelines in accordance with NEPA in an effort to protect and conserve the nation's resources for the benefit of future generations.

### **Soundscape Plans**

The HAVO soundscape monitoring plan is used to regulate human generated noise in natural areas by establishing a baseline for human induced noise. It has four principal components (1) Frequency of occurrence of human caused noise (2) Duration of human caused noise (3) Time of day of human caused noise and (4) Sound pressure level (SPL) of the noise relative to the

existing natural ambient SPL. In addition, the level of intensity (high, moderate, low) in relation to the various zone (natural, development and special use and historic) is measured to accurately assess the soundscape levels. Digital recordings are necessary for managers to identify the location of the sounds to begin management efforts of specific sound sources caused by humans. The plan is based on the premise if the noise is audible to animals and humans with normal hearing then the noise has the potential to adversely affect the natural soundscape.

Baseline ambient data has been collected in HAVO using a continuous monitoring system developed by the Volpe Center for low level noise measurements. The system deployed consists of a solar panel array, ultrasonic anemometer and a large foam windscreen and microphone system. The data received will be primarily for the Air Tour Management Plan which is currently in the phase of collecting information for the preparation of an EA to mitigate significant adverse impacts to natural and cultural resources in the park.

### **Focal Species**

Bandwidth sufficient to detect focal species; Acoustical obs groundtruthing (detection and id); Acoustical activity and population parameters; Frequency of occurrence (any noise): not to exceed 50% of time; Decibel noise level (DNL) not to exceed 60 decibels measured on an A weighted scale at 50 feet.

### **Marine:**

Acoustic Thermometry of Ocean Climate Project (ATOC) acquired acoustical data from U.S. Navy SOSUS arrays located throughout the North Pacific. Two sites, one located on Pioneer Seamount off the coast of California and the other north of Kauai were selected to allow much of the acoustical energy to leave the source without the interaction of the ocean bottom. The data is used to accurately determine range and depth averaged ocean temperatures. Studies have been conducted to determine effects on marine mammals. The change in behavior of humpback whales has been subtle when exposed to signals transmitted from (ATOC) sound projector located off the coast of Kauai. It is not certain whether the transmission is affecting the sightings of the whales near the (ATOC) source or changes in sightings reflect population variation in seasonal peaks.

Passive acoustic techniques have been used to identify and locate species distribution in Massachusetts. It is also useful in obtaining knowledge of the behavior of fish and examines the impact of anthropogenic (noise) activity, especially on spawning behaviors. Researchers from the University of Massachusetts Dartmouth and the University of Massachusetts at Amherst have recently begun conducting passive acoustic surveys in estuaries of the northeastern United States. These surveys contribute to the census of marine life and are a useful tool for identifying essential fish habitat. Hydrophones are used underwater to convert sound pressure into an electrical signal which is then recorded by a data acquisition system.

### **Terrestrial:**

While most of the documentation has been anecdotal, such as flocks of birds scattering at the sound of low-flying jets, photos have been taken documenting the effects of overflights on wildlife, such as the Dall sheep in the Grand Canyon (Lee 1994). Due to the scarcity of data for

effects to wildlife, this type of monitoring is becoming more popular, to assist in scientific research.

Because songbird distribution is strongly tied to habitat structure, songbirds provide a unique monitoring tool for assessing and detecting changes in the landscape. Species tend to evolve to regulate to their acoustic environment as far as other species voices in the same biome. Bird song is also highly dependent on seasonality, habitat, and gender. Sampling of bird song was conducted to differentiate between an ambient environment and an environment where transmission experiments were conducted (Slabbekoorn & Smith 2002).

Many threatened and endangered species are located in inaccessible areas making traditional transect monitoring difficult. The ability to monitor these areas using acoustics, result in the collection of data to determine presence or absence and estimated population density of target species. The Department of Defense is required by the Endangered Species Act to collect such data for management plans in minimizing impacts of military activities on threatened and endangered species. This monitoring system consists of three components: (1) a microprocessor-controlled digital data recording system that can be deployed either on the ground or on an airborne platform; (2) a helium filled lift vehicle that can carry the recording system aloft for drifting or tethered deployments; and (3) a software package for automatic extraction, identification, and localization of sounds of interests. The completely implemented monitoring system will result in the ability to map sound source locations with a log of species and time of call.

## **VIEWSHEDS & SCENERY**

### **Designated vistas**

The HAVO Viewshed Inventory and Assessment has specific goals designed to preserve the character of historic views by creating maintenance guidelines for each site including an existing photo, GPS locations, and maintenance recommendations.

### **National Natural Landmark Program**

The National Natural Landmark Program recognizes and encourages the conservation of outstanding examples of our country's natural history. It is the only natural areas program of national scope that identifies and recognizes the best examples of biological and geological features in both public and private ownership. National Natural Landmarks (NNLs) are designed by the Secretary of the Interior, with the owner's concurrence. NPS administers the NNL Program, and if requested, assists NNL owners and managers with the conservation of these important sites.

### **Repeat photography**

During the winter of 1988, a time lapse camera (VHS format) was set up at PUHE during the day to document the surf events off of Kawaihae. This monitoring was done in an effort to track tsunamis. Pete Hendricks a tsunami observer volunteer, who is currently employed at the County of Hawaii has the video footage. He also has air photos (35mm) of Pelekane Bay taken

in 1975 when several boats were moored and several other air photos taken in 2000 of black tip reef sharks in the Bay.

### **Cultural Landscape Inventories (CLI)**

HAVO and WAPA are currently working on a (CLI) to identify, inventory and document attributes in an effort to preserve integrity and contribute to the nomination of the National Register of Historic Places. Cultural Landscape Inventories are a multi-level process with each level corresponding to a specific degree of effort and detail. Keep in mind the CLI is a comprehensive inventory of all historically significant landscape and is not a method for monitoring culturally historic landscapes. CLI's are used as a method for tracking goals within the National Park Service.

### **Historic Viewsheds**

Based on the HAVO Viewshed Inventory and Assessment, some of the goals for maintaining historic viewsheds include providing vegetation removal methods, location maps of all sites, inventory and identify existing and proposed viewsheds with a general description of each site, describe vegetation maintenance guidelines for each site, consider buffered views to screen vehicles, traffic, parking lots and building, recommend removing or retaining vegetation to create or enhance a scenic view and screen visual detractors in order to preserve and enhance historic or proposed viewsheds, and reassess and maintain viewsheds every five years.

The main focus regarding the maintenance of viewsheds is vegetation removal, especially where native vegetation is concerned. NPS follows the Management Policies 2003, regarding plant removal. The goal of management is to minimize native plant removal by having a landscape architect on site during vegetation removal to carefully assess views during trimming by trained park staff and then to reassess the view to see if additional trimming is necessary.

### **Scenery assessment at the ecoregion scale**

There are two elements used with scenery assessment and analysis including landscape character and scenic integrity. Landscape character includes four primary attributes comprising of landforms, vegetation, water forms, and cultural forms. Scenic integrity is the wholeness or intactness of the landscape serving as a baseline measurement for which potential changes can be measured. The methods used in the scenery assessment are 1) Identify landscape themes, as a component of landscape character, at the ecological subsection scale; 2) Evaluate current levels of scenic integrity at the watershed scale (Galiano and Loeffler, 2000).

## **VISITOR & MANAGEMENT IMPACTS**

### **Visitor Experience and Resource Protection (VERP)**

The purpose of the VERP is to address desired conditions for both visitor experience and protecting natural resources. Guidelines and regulations for addressing visitor capacity include the National Parks and Recreation Act, the Wild and Scenic Rivers Act, and the 1982 Wild and Scenic Rivers Guidelines. The VERP framework consists of nine elements (Fig 4.).

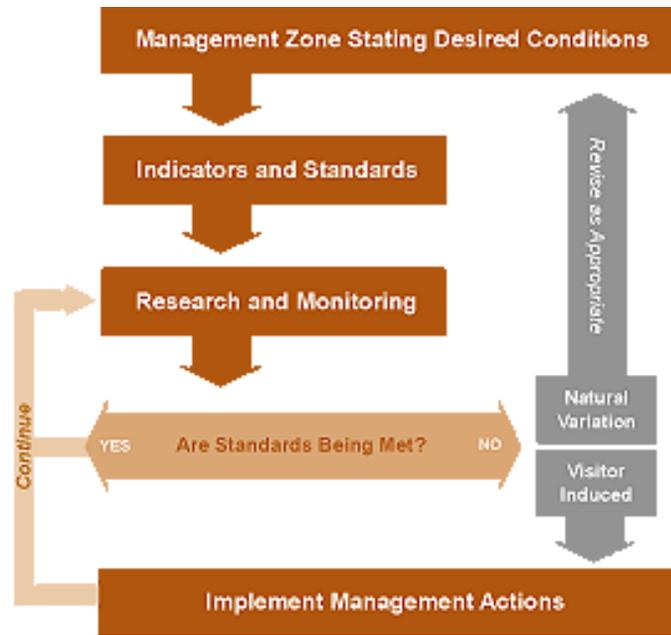


Figure 4. VERP Conceptual Model; NPS Yosemite Planning

The Merced River Plan is an example of a method used to contribute to the management and planning process in Yosemite National Park. The goal of the plan is to allow the natural processes to prevail within the river and the corridor.

### Interpretive programs

Provide the education to preserve and protect cultural and natural resources in an uninhabited state. They help visitors to be accountable and responsible for their actions when visiting natural areas. NPS interpretive programs is a method used by the park service to offer visitors the opportunity through wayside exhibits, viewing audio-visual, museum objects, park guided tours through trails and forested areas, to gather information pertaining to the traditional native culture and practices with a basic understanding and introduction to the significant and unique natural and cultural resources the park has to offer.

### Demographic and cultural profiles of visitors

Cultural profiles of visitors to the National Parks in the Pacific vary from park to park. The larger more developed park like HAVO, HALE, and PUHO experience more recreational visitors from the mainland tourists than the smaller less developed parks. The majority of visitors (three-quarters) at WAPA are Japanese traveling in tour groups. On the other hand, parks like NPSA consist mainly of residents Samoans from the village adjacent the park that uses the park for subsistence in the harvesting of fish and agriculture. In the case of KALA where access is extremely limited it is surprising that 57,759 visitors visited the park in 2003. This high number of visitors can be attributed to the natural beauty it offers. Statistic reports can be accessed from the NPS website.

### **Factual knowledge vs. perception**

Acquiring data related to visitor perception is commonly done with a questionnaire survey which is coded and then placed in a statistical program where cross-tabulations and frequencies are run for analysis. Park officials conducted an open ended survey at KALA to rate visitor experience and perception of the area.

### **MANAGEMENT ZONES & USE AREAS**

The framework for management zoning had been designed to meet the needs of all National Park units. Zoning categories are based on the location of historically significant resources and objects, nature resource values, and patterns of visitor use. Zoning provides the basis for future management and use needs.

### **Wilderness**

Undeveloped forested areas are often designated and classified as wilderness lands. Access to these areas is permitted with restrictions in place in an effort to preserve the natural ecosystem. Parks with designated wilderness lands are required by wilderness management policies to prepare a wilderness management plan. The purpose of the plan is to guide the management of resources, visitor and administrative use, and research

in the wilderness, provide guidelines, standard operating procedures, and decision-making tools for meeting legislative and NPS policy mandates to protect wilderness qualities in the park, and ensure the continuity of wilderness management philosophy and management as park staff and managers change.

Limits of Acceptable Change has been initiated in the Arches National Park and served as the pilot for other parks such as Glacier National Park in Montana. It provides the basis for general management in National Parks and assists in the planning efforts to address the issues surrounding visitor use. The major features of Limits of Acceptable Change include Visitor Impact Management (VIM), Visitor Experience and Resource Protection (VERP), and (LAC) (McCool and Cole 1997). The recording of conditions over time can help to evaluate management plans and address problems. The process outlines issues for recreational development and management. This course of action is needed for National Parks to preserve the important values for which they have been recognized.

### **CHEMICAL INFO & ODOR**

Presently the monitoring of chemical emission run parallel with air quality monitoring. SO<sub>2</sub> seems to be the main component in volcanically active areas such as HAVO creating noticeable traces of chemical odor. Continuous monitoring at HAVO to measure emission rates from Kilauea Caldera is ongoing by HVO. Eruptions at Guam and Saipan have also created noxious odor. But there is no monitoring currently being done to assess the situation.

### **CULTURALLY SIGNIFICANT RESOURCES**

Cultural Landscape Inventories are currently being determined at HAVO and WAPA to identify, document and evaluate cultural resources in an effort to preserve them for the enjoyment of future generations.

Archeological resource surveys for KAHO are essentially complete in the Kaloko parcel. The mission for the park is to preserve rather than restore the significant resources using similar materials for historical accuracy.

The landscape surrounding the Ainahou Ranch House is managed and monitored by the park service at HAVO primarily for preserving the habitat of the Nene and providing a cultural experience for visitors.

### **ECOLOGICAL GRADIENTS AND ZONATION**

WAPA is about to start to a watershed-level project looking at the effects of wildfire on tropical savanna community structure and erosion rates, and the subsequent downstream effects of this erosion (sedimentation) on WAPA's nearshore reefs. The marine work will be linked with WAPA's marine monitoring program.

### **CONCLUSION**

The stratification of the landscape topic is a relatively new concept. This grouping allows for monitoring to occur across multiple scales while integrating natural resources and cultural values. NPS is involved in numerous projects (e.g. Air Tour Management Plans) used to develop a comprehensive plan for national parks. The NPS is mandated by legislation laws, which provide a framework for landscape monitoring. Information from various ongoing monitoring projects can be used by NPS to provide other parks in the PACN a plan for undertaking similar projects as they apply to respective parks and natural resources.

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