

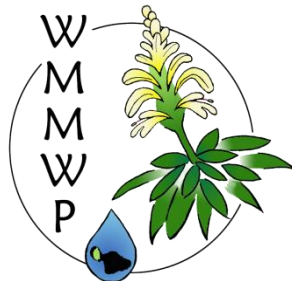
# West Maui Mountains Watershed Management Plan

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Prepared by



West Maui Mountains  
Watershed Partnership

2013

# WEST MAUI MOUNTAINS WATERSHED MANAGEMENT PLAN

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## **Executive Summary**

On November 20, 1998, state, county and private landowners officially formed the West Maui Mountains Watershed Partnership (WMMWP). The members included major landowners and land managers of the upland areas of the West Maui Mountains. Although the members had different priorities, mandates, and constituencies, all shared in a common commitment for the long-term protection and preservation of the West Maui Mountains Watershed. Today, the Partnership has grown to include new landowners and stakeholders, yet held remarkably true to those original intentions while making significant on-the-ground progress mitigating the worst threats to the watershed.

The formation of a West Maui Mountains Watershed Partnership and preparation of a start-up watershed management plan were identified priorities of the West Maui Watershed Management Advisory Committee, supported by Hawai'i State Department of Health, and the U.S. Environmental Protection Agency. The start-up plan was funded by the Department of Health and prepared by The Nature Conservancy working in collaboration with the WMMWP in 1999. Now, this updated plan supersedes and builds on the previous plan and outlines future management goals, objectives, and costs for over 47,319 acres of forest and watershed vegetation occupying the summit and slopes of the West Maui Mountains.

In a similar process as the start-up plan, the members of the West Maui Mountains Watershed Partnership participated in discussions and meetings identifying the most important watershed management actions. However, unlike the first plan, the writing and organization of this updated comprehensive document was carried out by the knowledgeable and dedicated staff of the WMMWP. This plan combines the information and rationale of the previous watershed planning efforts with new information gathered through thirteen years of project implementation experience. The plan continues to present the consensus interests and goals of the now thirteen members of the WMMWP. It describes current watershed management programs and activities occurring in the West Maui Mountains, and projects future programs in each of eight priority management areas: 1) invasive animal management and control; 2) invasive plant control; 3) wildfire program; 4) human activities management; 5) public education and awareness; 6) rare species protection; 7) water and watershed monitoring; and 8) management coordination. The plan is intended to guide the Partnership's efforts for the next five to ten years.

The WMMWP Executive Committee (EC)

## **I. INTRODUCTION**

### **A. History of The WMMWP**

On November 20, 1998, state, county and private landowners officially formed the West Maui Mountains Watershed Partnership (WMMWP). Today, the members of WMMWP include the major landowners and land managers of the West Maui Mountains: Hawai'i State Department of Land and Natural Resources (DLNR), Maui County Department of Water Supply (DWS), Ka'anapali Land Management Corp. (KLMC), The Nature Conservancy of Hawai'i (TNCH), Kahoma Land Company, LLC (KLC); Kamehameha Schools (KS), Makila Land Co., LLC (MLC); Wailuku Water Company, Inc. (WWC); Maui Land & Pineapple Company, Inc. (MLP); the General Finance Group (GFG) and the County of Maui. In 2012, the Partnership also welcomed two "Associate Partners," Tri-Isle Resource Conservation & Development Council, Inc. (RC&D) and the U.S. Fish & Wildlife Service. Although the members of the Partnership have differing priorities, mandates, and constituencies, they all share a common commitment: the long-term protection and preservation of the West Maui Mountains Watershed. As the preamble to the WMMWP case statement indicates:

*"The purpose of forming and maintaining a WMMWP is to protect the West Maui watershed and prevent further degradation. Water has long been recognized as the most important resource of the forests of the West Maui Mountains. These tropical forests are the essential recharge area for west, central, and south Maui's urban, industrial, and agricultural water needs as well as for sustaining the island's ecological resources."*

*Case statement of the West Maui Mountains Watershed Partnership --  
November, 1998*

Concepts which helped to initiate watershed protection in Hawai'i began as long ago as 1876 with traditional land management systems and modern forest reserve practices. At that time, King David Kalākaua, armed with the research and recommendations of professional foresters, signed an Act for the Protection and Preservation of Woods and Forests that included the construction of fences and barriers to prevent hoofed animal trespass into forests important for water resources (DLNR, 2011). In a cooperative effort to continue this legacy, the first protected forest reserves of West Maui were established in the late 1890's, bringing together government and private land managers. On December 7, 1907 the West Maui Forest Reserve boundaries were formalized by the superintendent of Forestry, Ralph S. Hosmer. In the late 1980s, ongoing management activity in the West Maui Mountains watershed intensified. In recognition of the overall quality of the West Maui Mountains, the State of Hawai'i designated Panaewa, Lihau, Honokōwai, and Kahakuloa as units of the West Maui Natural Area Reserve. Soon thereafter, the Pu'u Kukui Watershed Management Area and the Kapunakea Preserve were also created.

Following in the footsteps of the original forest reserve system, State, County, and private landowners in East Maui joined forces in 1991 to form the East Maui Watershed Partnership (EMWP). This partnership entity was the first of its kind in the State, serving as a model for the future formation of the West Maui Mountains Watershed Partnership in 1998. Since then, 10 additional cooperative watershed management agreements have developed across the state, forming collectively the Hawai'i Association of Watershed Partnerships (HAWP).

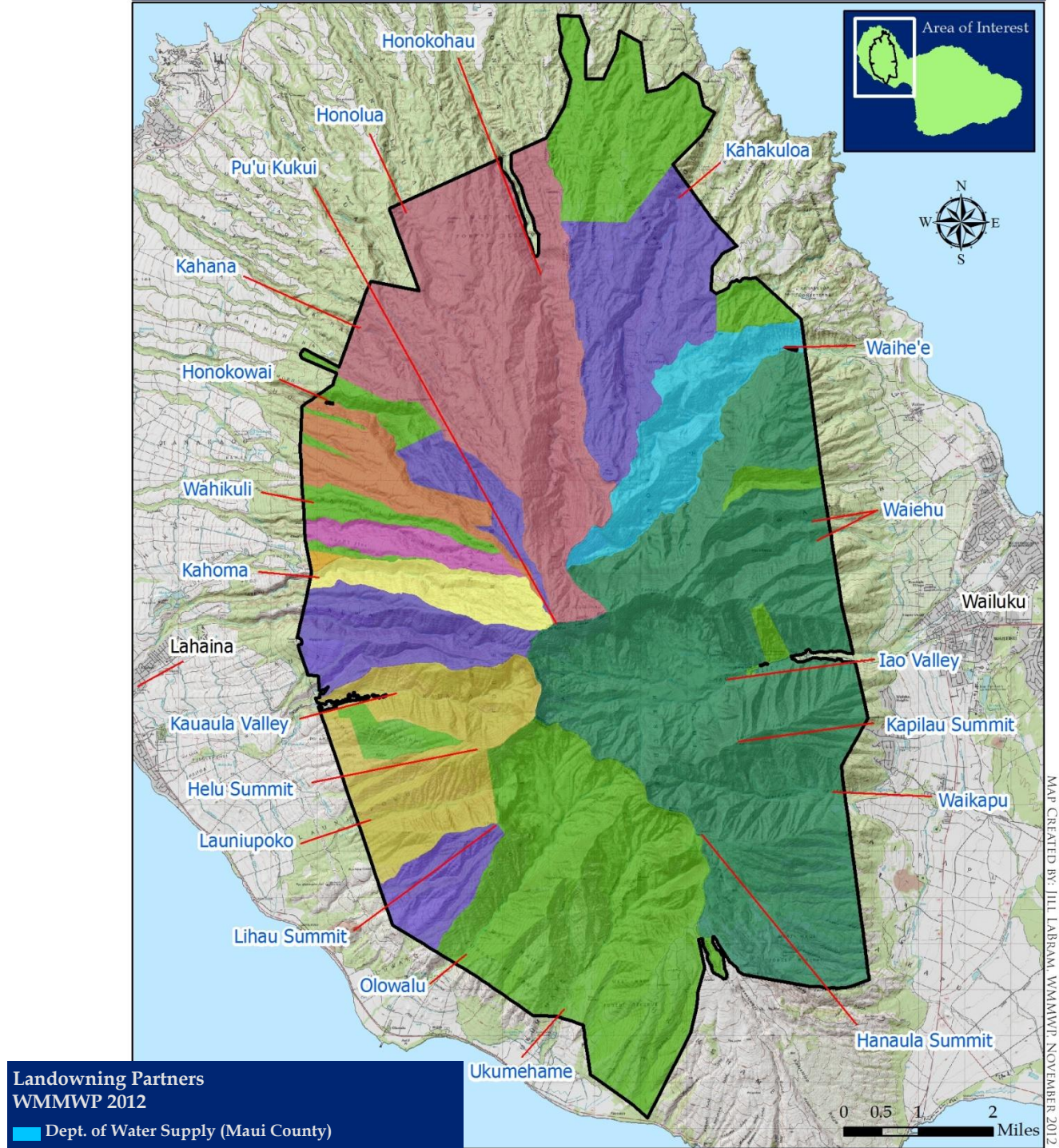
## **1. THE PARTNERSHIP LANDS**

The lands of the West Maui Mountains Watershed Partnership encompass 47,319 acres of Mauna Kahalawai in the Lahaina and Wailuku Districts of Maui Island (Figure 1). Elevations on Mauna Kahalawai range from near sea level on the southwest coast to 5,788 feet on the wet rainforest summit of Pu'u Kukui. Rainfall varies from averages of about 10 inches per year on the lower leeward slopes to 364 inches per year on the summit (Giambelluca *et al.*, 2012). The eastern half of the West Maui watershed includes the 'Īao Aquifer, beneath the lands of Wailuku Water Company (dark green areas in Figure 1) and the Maui County Department of Water Supply (blue area in Figure 1). The largest landowner in the Partnership is the State of Hawai'i which owns eleven sections of the West Maui State Forest Reserve (purple areas in Figure 1) and four sections of the West Maui Natural Area Reserves, Kahakuloa, Honokōwai, Panaewa, and Lihau (light green areas in Figure 1). Lands owned by Ka'anapali Land Management Corp. are managed as the Kapunakea Preserve by The Nature Conservancy of Hawai'i via a perpetual conservation easement (orange area in Figure 1). High quality watershed lands mauka of Lahaina are also held by General Finance Group (magenta area); Kahoma Land Company, LLC (light orange area); Kamehameha Schools (light yellow area); and Makila Land Co., LLC (dark yellow area). Also, the Maui Land & Pineapple Company, Inc. owns and manages 8,600 acres of land perpetually conserved as the Pu'u Kukui Watershed Preserve (light red area in Figure 1).

## **2. FISCAL AND ADMINISTRATIVE SUPPORT ORGANIZATIONS**

Program implementation of WMMWP is supported and enabled by a number of administrative support organizations. The Research Corporation of the University of Hawai'i (RCUH) and the UH Pacific Cooperative Studies Unit (PCSU) perform human resources management, payroll, and certain accounting functions which align with the University's goals of understanding natural resources and their threats. Tri-Isle RC&D, an Associate Partner of WMMWP, serves as a fiscal agent, managing spending on certain grants and performing accounting functions. Malama Kahalawai, Inc. (MKI), the dedicated 501(c)(3) non-profit of WMMWP was created to facilitate Partnership activities. The mission of MKI is to "assist in the administration and implementation of the goals and tasks set forth in the West Maui Mountains Watershed Partnership Memorandum of Understanding, dated November 20, 1998." In practice, MKI serves WMMWP by acting as a contracting and fiscal conduit while providing an additional liability buffer between the Partners and field activities. Together, these three organizations stand in the background of WMMWP operations, yet they are integral to the current functionality of WMMWP.

# West Maui Mountains Watershed Partnership, 2012



*Figure 1. Map of WMMWP boundaries, Partner landholdings, key management areas, and major landmarks.*



## **B. Purpose of this Plan**

When the West Maui Mountains Watershed Partnership (WMMWP) was developed in the 1990s, it was recognized by all involved that cooperation is the key to a timely and successful watershed management program that will protect lands from alien pest animals, invasive plants, inappropriate human activities, and other threats. Our original Watershed Management Plan (1999) was modeled after the original East Maui Watershed Management Plan (1993) and that initial document outlined much of the common structure and purpose of a typical watershed partnership. The 1999 Management Plan stressed the importance of watershed management and outlined the cost and contents of a comprehensive management strategy for the 47,319 acres of WMMWP lands that encompass the summit and slopes of the West Maui Mountains. After more than 13 years of successfully implementing the original management plan, the Partners reconvened to update the plan to direct management efforts for the next five years.

It is not the scope of this plan to review in detail the ongoing management activities within the parcels; however, initial management planning documents and periodic reports on management for each of these areas are available for review, and they were reviewed in the preparation of this plan. Management activities in the West Maui Mountains watershed have been ongoing since the late 1980s, with the inception of the Pu'u Kukui Watershed Management Area, the West Maui Natural Area Reserve, and later, the Kapunakea Preserve. Thus, the proposed management actions in this plan are based on a preexisting foundation of management programs.

This plan presents the consensus interests and goals of the 13 Partners of WMMWP. The WMMWP Partners contributed to this updated plan by participating in discussions and meetings with their fellow Partners to identify priority watershed management actions and develop a budget to support those goals. The update combines the basic information and rationale of previous watershed planning efforts with additional programs that have arisen with years of WMMWP discussions and experience. Current watershed management programs and activities are described, and future programs in each of eight areas of management priorities are outlined.

It should be noted that this plan recommends key actions for each program, but does not set priorities among or within the programs nor identify specific funding responsibilities or sources among the Partners. Priorities and values differ among the Partners, depending on individual levels of watershed management and regional differences in resources, threats, and management needs. Priorities and funding will be ongoing issues for discussion in the Partnership. Moving forward, the focus is on consensus values of common good to the Partners, as committed to jointly by the Partnership.

## II. PROFILE OF THE WEST MAUI MOUNTAINS WATERSHED

### A. Rare Species, Vegetation Communities and Ecosystems

The West Maui Watershed is home to thousands of species of native plants, birds, snails, insects and other invertebrates. All native Hawaiian species are relatively rare in the world, and there are at least 18 plant species that are endemic to West Maui in particular, making them especially extraordinary (the rarest of which are listed in Appendix A and mapped in Figure 2, below). The watershed encompasses an array of vegetation communities that are arranged across climatic and elevation zones. Studies in the West Maui Watershed have already contributed to an improved understanding of evolution, unique genetic information transfer and other central biological concepts. The broad range of native communities and rare species in the West Maui Watershed are shown in Figure 2.



*Ki'owaiokihawahine, Violet Lake, near the summit of Pu'u Kukui. Photo credit: [www.kahea.org/nars/ecosystems.html](http://www.kahea.org/nars/ecosystems.html)*

Near the Pu'u Kukui summit at 5,788 feet, the landscape is dominated by montane bogs, and wet, windswept shrublands which extend downward to more mesic forests and shrublands.

Ki'owaiokihawahine (Violet Lake) represents a little-known ecosystem found only on Maui and Hawai'i. This example of a Hawaiian Montane Lake is approximately 10 feet by 20 feet in size and is found within the Pu'u Kukui Watershed Preserve in the northwestern region of the West Maui watershed. Notable rare species that grow in this unique environment include 'ōhi'a (*Metrosideros polymorpha*), *Viola mauiensis*, *Lobelia gloriamontis*, Hawaiian damselflies (*Megalagrion spp.*), and others.

Other unusual ecosystems include Mauna 'Eke, a magmatic dome formed during the later years of the West Maui volcano. This plateau-like region is pocketed with deep sinkholes, bogs of standing water, and stunted yet pristine vegetation. These unique species include the 'Eke Silversword (*Argyroxiphium caliginis*), Hinihina (*Geranium humile*), and Ko'oko'olau (*Bidens conjuncta*), as well as miniaturized giants like 'Ōhi'a.

Moving down the mountain slopes, other vegetation communities include Koa (*Acacia koa*) forest, Lama (*Diospyros sandwicensis*) forest, diverse mesic forest with several dominant native tree species, and a variety of native shrubland types. Uluhe (*Dicranopteris linearis*) ferns are common in these areas, and shrubs like Pūkiawe (*Leptecophylla tameiameiae*) and Kanawao (*Broussaisia arguta*) are frequently



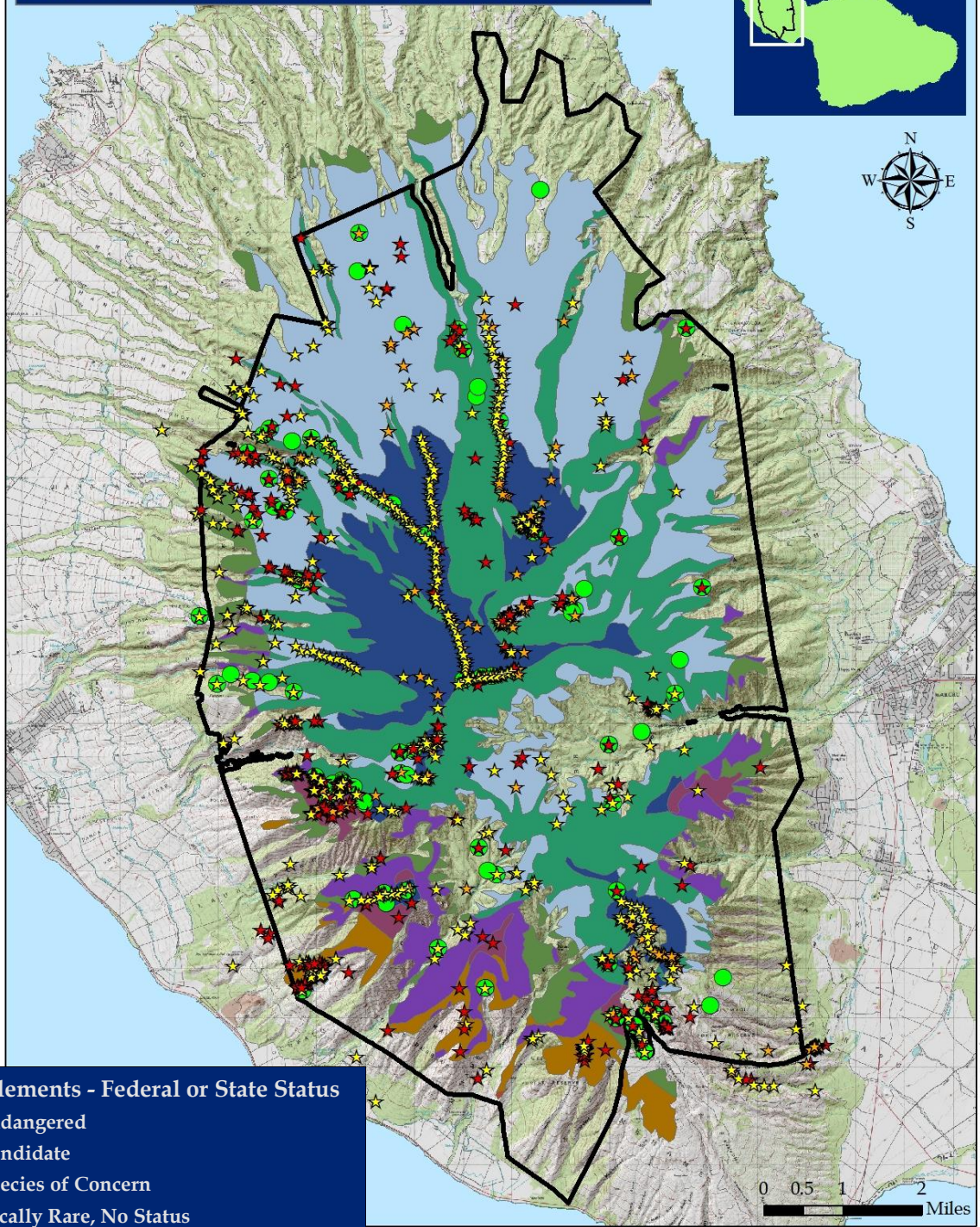
*Mauna 'Eke plateau, as seen from across montane bogs containing native sedges, green swords, lobelias, and other rare species. Photo credit: The Nature Conservancy of Hawai'i*

seen as well.

Below 3,000 feet elevation, there begins a transition from native-dominated into more alien-dominated vegetation types, with non-native trees and shrubs such as Strawberry Guava (*Psidium cattleianum*), Ironwood (*Casuarina* sp.), Koster's Curse (*Clidemia hirta*), *Macaranga tanarius*, and others that grow increasingly prominent in a mixed native and alien canopy. Below 2,000 feet, naturalized alien vegetation dominates, including varieties of guava forest (*Psidium guajava* and *P. cattleianum*) and Java plum (*Syzygium cumini*), with the exception of small and sometime rare assemblages of native forest and shrubland stands such as Wiliwili (*Erythrina sandwicensis*) and Naio (*Myoporum sandwicense*). At the bottom edge of the watershed, plantings of introduced trees such as *Eucalyptus* sp., Cook and Norfolk Pines (*Araucaria* spp.), Silky Oak (*Grevillea robusta*), and naturalized alien vegetation occupy the lowest slopes.



# Rare Elements in West Maui Watersheds



**Rare Elements - Federal or State Status**

- ★ Endangered
- ★ Candidate
- ★ Species of Concern
- Locally Rare, No Status

**Native Vegetation Communities 2005**

- Montane Wet Forest & Shrubland
- Montane Mesic Forest & Shrubland
- Lowland Wet Forest & Shrubland
- Lowland Mesic Forest & Shrubland
- Lowland Dry Forest & Shrubland
- Lowland Dry Shrubland & Grassland
- Wet Cliff
- Dry Cliff

MAP BY: S. MCCLANE AND J. LABRAGA, WMAWMP, 2013

*Figure 2. Map of rare species and native vegetation communities across the West Maui watersheds. The windward, northern regions host montane and lowland wet forests and shrublands while the leeward, southern regions are home to montane and lowland dry and mesic forests and shrublands. Arrays of rare species are found throughout the watersheds in varying environments.*

## **B. Services and Resources of the Forested Watershed**

Living on an island, in a closed system, we all rely on the resources and services that are provided by our watersheds. Our watersheds recharge the streams and aquifers that provide fresh, clean water to residents, communities, farmers, and businesses. The forests function as slow, vegetated water filters that inhibit erosion and runoff, thereby protecting streams, reefs and oceans for swimming, fishing, and other marine activities. By trapping moisture, healthy watersheds also prevent destructive wildfires. The forests provide habitat for Hawai'i's unique native species of plants and animals that are found nowhere else in the world. These culturally significant plants and animals continue to be utilized in traditional practices such as hula, storytelling, and medicine. We all enjoy our watersheds recreationally, whether through hiking, biking, hunting, bringing keiki to play in the streams, or just gazing at the verdant slopes from a distance. Watersheds offer an informative and interactive classroom setting for learning about our native forests and plants and the significance in taking care of our 'āina. For these reasons, effective management and protection of our watersheds is of the utmost importance.

### **1. RAINFALL, STREAMFLOW, AND GROUNDWATER RECHARGE**

Water is the primary resource of concern that drives the creation of this management plan. The water resources that support our population and livelihoods depend on intact, vegetated watersheds for reliable production and storage. The relationship of these forested uplands to a dependable supply of clean water was recognized as early as 1880, and a report from 1902 stated:

*Forest protection means not only increasing the rainfall, but -- more important still -- conserving the water supply. The future welfare and agricultural prosperity of the Hawaiian Islands depends on the preservation of the forest, particularly where water is taken from a stream whose headwaters lie within the forest belt, which is the case with most streams on the islands.*

*U.S. Forester E. M. Griffith 1902 (Ching 2001)*

On the summit and upper slopes of West Maui, cool air saturated with moisture sweeps across native forest and shrubland thickly clothed with foliage and epiphytic mosses. Even without rainfall, forest vegetation pulls moisture directly out of clouds and fog, and the condensed moisture falls to a thick ground cover of native ferns and shrubs. Studies have shown that a native Hawaiian forest can intercept fog drip to increase precipitation by as much as 30 percent, and as much as 10 to 15 percent of the recharge to our aquifers is thought to be from this fog drip alone (DLNR, 2011). West Maui's forests have a large area known as the "Fog Zone" (see the area outlined in yellow in Figure 3) where this type of condensation is a large part of the hydrologic cycle in our windward units. These areas are priority recharge areas for our aquifers, where healthy foliage and leaf litter buffer the release of stored water, delivering a more consistent and dependable source of water for eventual use, long after the rain has ceased falling. A study on Haleakala showed that over 118 inches of precipitation in a year was collected as fog being intercepted by lush forests, significantly adding to the sustainability of our water source (Giambelluca *et al.*, 2011).



# West Maui Forested Watersheds Provide Water For These Maui Communities

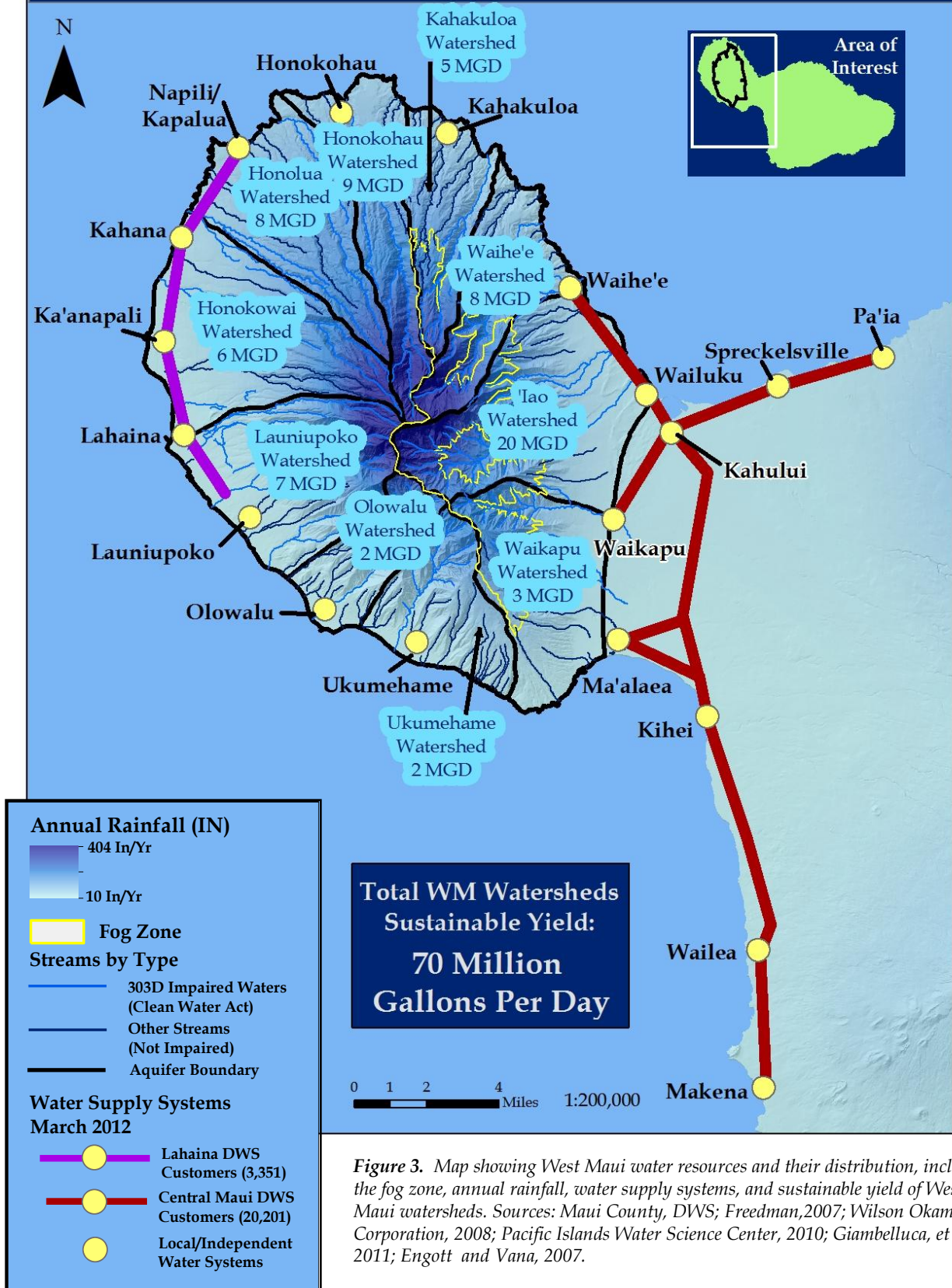
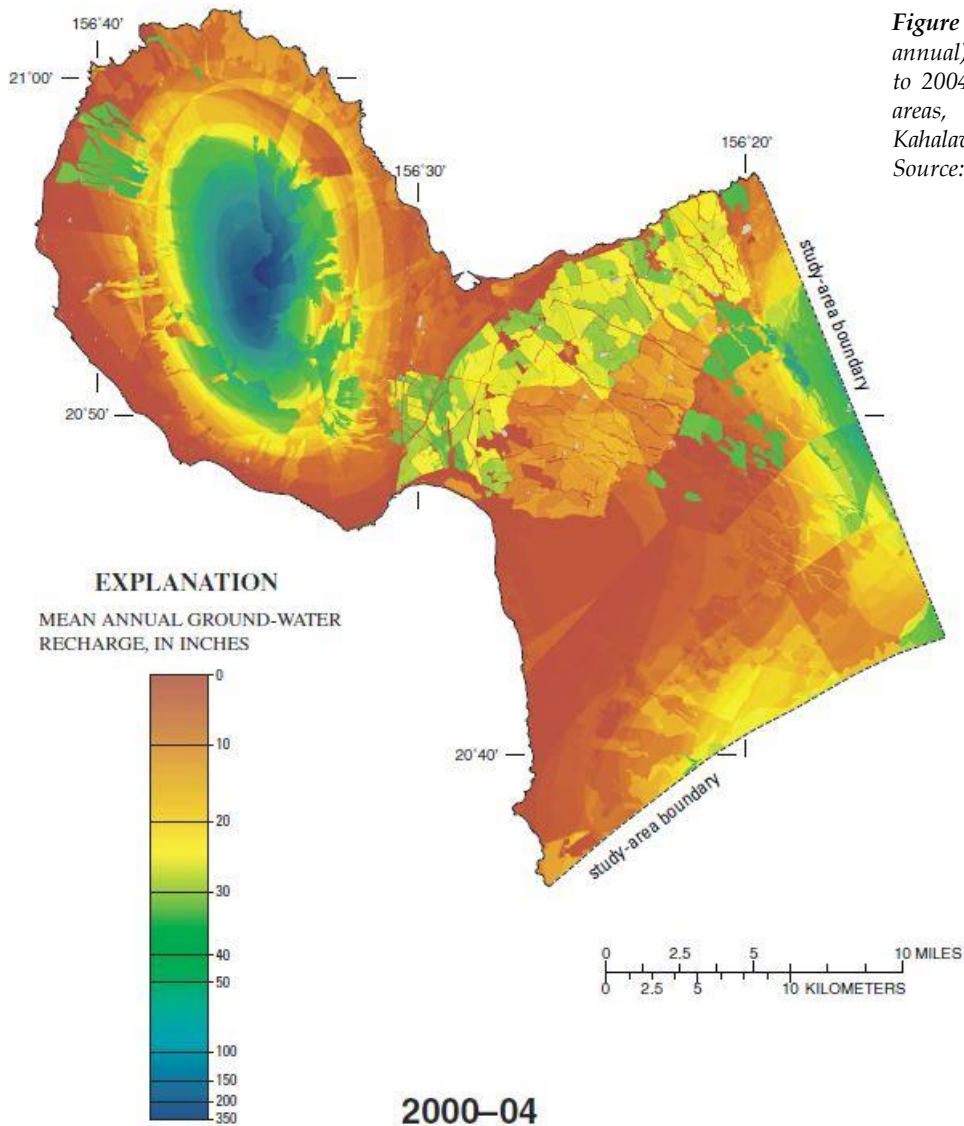


Figure 3. Map showing West Maui water resources and their distribution, including the fog zone, annual rainfall, water supply systems, and sustainable yield of West Maui watersheds. Sources: Maui County, DWS; Freedman, 2007; Wilson Okamoto Corporation, 2008; Pacific Islands Water Science Center, 2010; Giambelluca, et al., 2011; Engott and Vana, 2007.

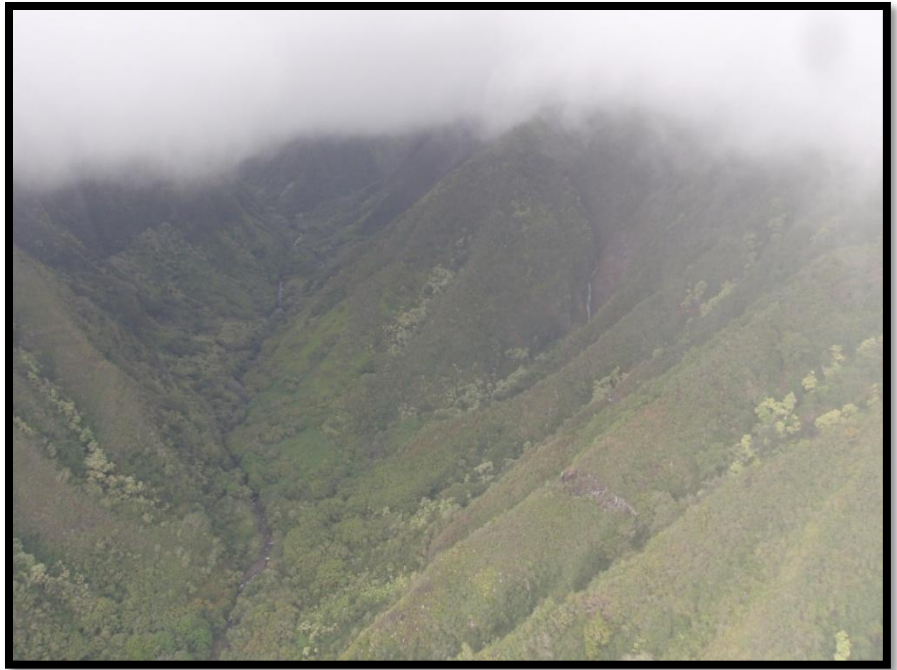


**Figure 4.** Groundwater recharge (average annual) in Central and West Maui from 2000 to 2004. As indicated by the blue and green areas, the core watershed area of Mauna Kahalawai is a key groundwater recharge area. Source: Engott and Vana, 2007.

The summit of Mauna Kahalawai experiences an average annual rainfall of 364 inches, making it one of the wettest places on the planet (Pacific Islands Water Science Center, 2010). This rainfall contributes to 69 stream channels that originate from the watershed. Sixteen of these channels have sections that are continuous-perennial (flowing year-round) and the rest have reaches of intermittent and non-perennial flow (flowing year-round at upper elevations only, and intermittently at lower elevations) (Division of Aquatic Resources, 2012). An estimated 25.55 billion gallons of freshwater can be provided each year by the West Maui Watershed. This water is funneled to the communities of West Maui, Wailuku, Kahului, Pā'ia and Kīhei-Makena, providing water to approximately 77 percent of DWS customers on Maui, in addition to many others on private systems (Figure 3) (Freedman, 2007).

Forested watersheds act as sponges, soaking up fog drip and precipitation that will recharge both streams and aquifers. Native Hawaiian vegetation in particular has been shown to be

more efficient at absorbing and collecting precipitation than a non-native forest, with almost twice the canopy water storage capacity of an invaded site (Takahashi, *et al.*, 2011). Indeed, the pristine core of the West Maui watershed is a key groundwater recharge area, as indicated by the blue area in Figure 4, above. Native forests are multi-layer complexes of canopy trees, understory plants, shrubs, ferns and mosses that absorb the kinetic energy of falling rain, reducing the rain's erosive capacity and increasing the infiltration of the rainwater into the ground. During photosynthesis, plants release water vapor into the



*Waihe'e Valley, with streams, waterfalls, knife ridges, rocky cliffs, and a meandering river valley. Each geographical feature provides habitat for a distinct vegetation community. Photo credit: WMMWFP.*

atmosphere through evaporation and transpiration, a process called evapotranspiration. Evapotranspiration is increased in warm and sunny conditions. Open grasslands lose far more water to evapotranspiration than closed forest or shrubland. The cool ground-level shade provided by a healthy, multi-layered forest will protect the water-holding layers from wind and harsh sunlight and suppress evapotranspirative loss of water. This allows much of the rainfall and condensed fog drip to percolate through the soil and collect in aquifers and streams as clean water.

As the island population increases, demand for fresh water resources will increase as well. It is projected that total domestic water use in the DWS Central Maui and Lahaina systems will increase from 27.5 million gallons per day (mgd) (approximately 10 billion gallons per year) in 2010 to 33.62 mgd (approximately 12.3 billion gallons per year) by the year 2020 (Freedman, 2007). By comparison, the total sustainable yield for the West Maui Watershed was recently documented at 70 mgd (25.55 billion gallons per year) (Wilson Okamoto, 2008). Maintaining a healthy watershed, therefore, will be the key to ensuring a reliable and sustainable water supply for our island.

## **2. NATIVE SPECIES AND ECOSYSTEMS – BIOLOGICAL VALUE**

Perhaps the greatest value of the thousands of native species in the West Maui watershed is the function they perform together as parts of a complex, natural ecosystem. The landscape of the West Maui Mountains is highly variegated, containing knife ridges, steep valleys, boggy plateaus, and cascading waterfalls that spill into meandering streams. Winds, rains, clouds and sunshine hit each feature differently, such that every nook contains a unique microclimate that provides habitat for a distinct array of native species. Over the millennia, a plethora of native



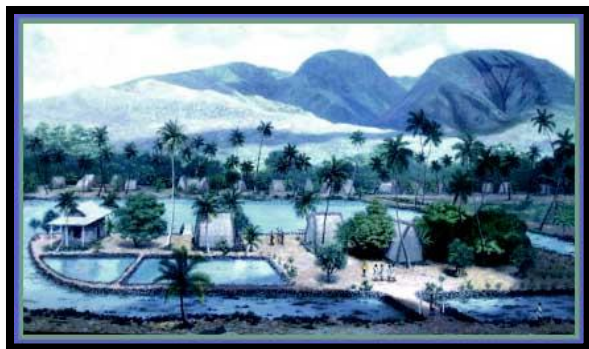
species have formed symbiotic relationships that enable entire ecosystems to flourish, and for this reason, many of them grow best when surrounded by their counterparts.

Even when crammed into thickets or clinging to sharp inclines, native species have evolved into a stable, symbiotic coexistence. For instance, Koa is a nitrogen-fixer that brings nitrogen into the soil which in turn provides nutrition for germinating plants. In addition, the tree's sickle-shaped leaves filter sunlight, allowing rays to penetrate to the understory to shine gently upon the supple leaves of delicate herbs and young saplings. Lichens, mosses, and even ferns grow along the trunks and branches of Koa, 'Ōhi'a, and other forest trees, and 'Ōhi'a are often seen growing up intertwined with another tree like 'Alani (*Melicope* sp.) or 'Ōlapa (*Cheirodendron gaudichaudii*). Native insects, snails, and spiders nestle into mossy beds and hide under leaves, providing food for foraging native forest birds, and providing numerous ecosystem functions through their complex food web interactions. Forest birds serve as pollinators, seed dispersers, and are often early indicators of ecosystem stability and resilience. Montane-nesting seabird species, which have become rare since historic times, can influence soil composition and nutrient cycling. Together, the layers of tree branches, leafy shrubs, billowing ferns and mosses trap fog and collect rain water, ensuring that all forest plants have enough moisture to thrive while still releasing clean water downstream. In this way, the native Hawaiian forest composes a complex, multi-layered ecosystem that provides critical habitat for a wide array of endemic and indigenous species.

Native species and intact, interconnected ecosystems provide the best chance for a stable, functioning, and beautiful watershed. By contrast, invasive weeds tend to form monotypic stands that displace native species and diminish the biodiversity that makes native ecosystems so successful at sharing nutrients and gathering water. Once a native ecosystem is colonized by invasive alien species, restoration of the native habitat is a costly, labor intensive, and strategically challenging undertaking. Thus, protection of the native ecosystems from invasions of alien species is critical to the health and vitality of the watershed.

### **3. CULTURAL SIGNIFICANCE**

The Hawaiian name for the West Maui Mountains is Mauna Kahalawai, House of Water. *Wai*, meaning water in Hawaiian, is the 'staff of life' and is protected by the *Mo'o Akua*, lizard gods. The ancient Hawaiians recognized the significance of the forest as the main source of water and perpetuated this knowledge in a proverb: *Hahai no ka ua i ka ululā`au* - the rain follows the forest. *Wai* was synonymous with wealth, such that the areas that contained the most water were prized above all others. Thus, Mauna Kahalawai, with its steady rainfall, misty cloud cover, and bountiful streams, was highly regarded. Near the summit of 'Eke Crater and Pu'u Kukui is Ki'owaiokihawahine (Violet Lake), a Hawaiian montane lake that formed in the highland bogs. This small lake is an extremely rare gem, part of the larger *kapu* (forbidden) area of the summit, where heaven and earth were believed to meet. Mauna Kahalawai was also referred to as Hale Mahina, House of the Moon, named so for Hina, goddess of the moon, who resided in 'Iao Valley.



Illustrative depiction of Moku'ula with Mauna Kahalawai standing in the background. Photo courtesy of the County of Maui.

Many prominent Hawaiian royals made their homes in Lahaina, on the western slopes of Mauna Kahalawai, and the fertile lands in this region supported a vibrant population. On the coastal lowlands, Kamehameha III made his home on an island in the fishpond called Moku'ula which was fed by springs charged by mountain rain. Many of the lands to the south of Lahaina, in the *ahupua'as* of Launiupoko,

Olowalu and Ukumehame, contain remnants of ancient Hawaiian villages, agricultural terraces, petroglyphs and heiau sites, as well as many post-contact sites along the Lahaina Pali Trail. To the north of Lahaina are the six Hono-a-Pi'ilani, the bays of King Pi'ilani, (from South to North) Honokōwai (bay drawing fresh water), Honokeana (cave bay), Honokahua (sites bay,) Honolua (two bays), Honokōhau (bay drawing dew) and Hononana (animated bay), all whose upper wet valleys contain vestiges of historic taro cultivation and many important sites, including heiau, examples of historic agriculture and unknown burial sites.

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In Central Maui, on the eastern slopes of Mauna Kahalawai, 'Īao Valley was considered one of the island's centers of civilization. Similar to Lahaina, prominent *ali'i*, or chiefs, resided in this lush area, below which fertile soils and plentiful water supported a large resident population. 'Īao Stream is one of the *Na Wai 'Eha*, The Four Waters, which also included Waihe'e, Waiehu, and Waikapū Streams. With its abundance of fresh water, 'Īao Valley was a sacred place reserved for high chiefs, and for hundreds of years *ali'i* were laid to rest in secret burial sites along the valley's steep walls. The practice of burying *ali'i* in the Valley began in the eighth century and continued until 1736, with the burial of King Kekaulike (Tsutsumi, 2006). Commoners were not permitted into 'Īao, except during the annual Makahiki festival which was held on the grassy plateau above 'Īao Needle. According to legend, Maui the demigod and Hina the goddess of the moon raised their daughter 'Īao in the valley. 'Īao became the lover of a half-man, half-fish god. This angered her father, who turned the man-fish into a pillar of stone that is now known as 'Īao Needle.



Photo: 'Īao Needle. Photo credit: Randall Sherman

Shrouding the mountain slopes, the native forest itself is of great cultural significance. Ancient Hawaiians believed they were direct kin of the plants and animals that shared their world and those beings with great *mana*, spiritual power, could take on the form of other plants and animals. The upland forests were the sacred home of Ku, the god of war, governance, and leadership. The forests were also the realm of Laka, goddess of hula and guardian of forest plants. In such a world, a person could talk directly to the winds and rains and expect a response, and animals like the 'Io, (*Buteo solitarius*) or Hawaiian hawk, could stand as a family's

ancestral guardian (The Nature Conservancy, 2011). Indeed, Elspeth Sterling's book *Sites of Maui* (1998) alludes many times to the cultural significance of the West Maui Mountains and its cloud-shrouded uplands. The upland forest was *wao akua*, where entry required a strict protocol, including an offering and a statement of identity and purpose. If the purpose was to collect trees, only a single tree or species could be collected at a time. For example, the taking of a large 'Ōhi'a was regarded as a sacred act, requiring a human sacrifice in return for the removal of the tree (The Nature Conservancy, 2011).

These ancient relationships between the people, the gods, and the land led early Hawaiians to gain an especially detailed knowledge of the differing physical characteristics and uses of native species found in the upland forests. Trees such as the endemic Lama and indigenous Naio were often chosen for house building, while endemic hardwoods such as Kauila, Olopua, and Koa were used to fashion spears, daggers, and clubs. Wiliwili, an endemic dryland forest tree, was known for its buoyancy and used for making fishing floats and surfboards, while Koa was used in making canoes, containers, and tools (The Nature Conservancy, 2011). Many Hawaiian forest species were collected for medicinal purposes. For example, the bark of the 'Ōlapa (*Cheirodendron gaudichaudii*) tree was used to treat asthma, the flowers of Māmane (*Sophora chrysophylla*) were used as an astringent, and the meat within the trunk of the native Hapu'u fern (*Cibotium splendens*) was used to stimulate appetite and purify the blood (Nagata, 1970). The native trees, ferns and shrubs of the upland forests comprise a shared resource that is crucial to the continuation of traditional Hawaiian cultural practices such as woodworking, weaving, cordage, herbal medicine, featherwork, fishing, canoe paddling, lei making, hula and other customs. Similarly, fresh water yielded by the watersheds was a shared resource that enabled traditional cultivation of Hawaiian *kalo* and other downstream uses. Beyond their material value, the upland forests are sacred places of prayer that remain important to the descendants of the original residents of the West Maui *ahupua'a*. Inasmuch as the resources of the watersheds were the lifeblood of all residents, the stewardship of these resources was a shared responsibility that was carried out with the utmost honor and respect.

With respect to land and resource management, the ancient Hawaiians developed the *ahupua'a* system, a complex and sophisticated system that governed land stewardship from mountain summits to the outer reef. Here, natural land divisions like ridges and streambeds divided each island into numerous pie-shaped *ahupua'a* that spanned mauka to makai, from the uplands to the ocean. Although they varied greatly in size, each *ahupua'a* provided all resources necessary to sustain life: lush native rainforests, abundant fresh water, fertile agricultural lands, and bountiful nearshore waters. Importantly, it was understood that in exchange for these gifts, inhabitants were charged with the responsibility of maintaining these resources to ensure their bounty would endure in perpetuity for the betterment of future generations. Thus, pristine environments were seldom visited, plants were gathered sparingly, and fish and game were left untouched during breeding seasons – all measures to ensure that populations of flora and fauna would have ample time to regenerate each year. Furthermore, with the understanding that all life in the lowlands of the *ahupua'a* were sustained by freshwater borne in the uplands, the forests were regarded with great care. It is on this foundation that WMMWP approaches watershed management in West Maui.



#### 4. EROSION PREVENTION

Another major function of a forested watershed is that of a soil anchor. The roots of trees, shrubs and associated understory plants grip the steep mountain slopes tenaciously, holding soils in place. In this way, forest trees and vegetation prevent erosion and maintain clear, clean water in streams that flow out to nearshore reefs and coastal waters. A healthy watershed will prevent muddy, sediment-choked reefs and marine life such as those seen in the photos below.



*Photos of Honolua Stream flash flood on December 12, 2011: torrents of muddy water wash out into the Honolua/ Mokuleia Marine Life Conservation District.  
Photo credits: Save Honolua Coalition*

Denuded and invaded watersheds altered by destructive foraging of feral ungulates, human impacts, fire and forest disease are subject to mudslides and flash floods. Many invasive plants either lack deep roots that hold soil in place or they colonize monotypic stands that inhibit percolation and speed runoff. Without adequate forest growth and ground cover, muddy water and debris rush into streams during periods of heavy rainfall. Sediment levels recorded in a South Moloka'i reef during two heavy storms in 2004 were 10 times higher than during non-storm events (Bothner, *et al.*, 2006). Perpetuating the cycle, eroded areas then dry quickly, hampering native re-growth and rendering them prone to further erosion and runoff.

While it is widely theorized and accepted that native vegetative cover improves water quality and ungulate activity and a denuded watershed leads to diminished water quality, solid data exhibiting this has yet to be compiled and published. In West Maui, WMMWP is conducting water quality and watershed monitoring to collect data in support of a study into the relationship between ungulate activity, soil erosion, and vegetative cover. As the watershed is fenced off and cleared of feral ungulates, it is anticipated that the data gathered by WMMWP will demonstrate this relationship between a healthy watershed and high water quality.

#### 5. AESTHETIC AND ECONOMIC VALUE

Beyond the ecological functions of watersheds, the forested landscape possesses both aesthetic and economic values. Scenic views of the lush, green mountain landscape improve our quality of life, and trips into the backcountry contribute to individual well-being. Meanwhile, numerous non-profit organizations and for-profit businesses find their livelihoods in the

resources of the forested watershed. Jobs in watershed management and conservation fields provide direct economic benefits, and eco-tourism operations rely on our healthy forests for their continued success. Moreover, as discussed above, the coastal areas of West Maui feature miles of sandy beaches and coral reefs that support the active, outdoor lifestyle of local residents and visitors alike. The vibrancy of these coastal resources is directly reliant upon healthy upland watersheds to maintain high water quality and pristine nearshore waters. One University of Hawai'i study examined the various services provided by O'ahu's Ko'olau forests. These services included water recharge, water quality, climate control, and biodiversity, along with cultural, aesthetic, recreational, and commercial values. The study concluded that these services together have a net present value of between \$7.4 and \$14 billion (Roumasset, *et al.*, 1997).

To be considered alongside the economic benefits of a healthy watershed are the costs of repairing a damaged watershed. It has been calculated that the State, Federal, and private entities that manage Hawai'i's native forests spend approximately 75 percent of their resources on preventing the spread of alien species and repairing the damage they cause – a significant expense (The Nature Conservancy, 2011). Investment in proactive measures that inhibit the introduction of alien species would go far in averting costly expenditures on reactive measures like damage reversal and habitat rehabilitation. In order to realize the full economic benefit of our native watersheds, it is essential to invest in their health and protection.

## **6. HUNTING OPPORTUNITIES**

While ungulate hunting is a contemporary recreational activity and a source of food for some, hunting (pig hunting in particular) is not a traditional Hawaiian practice. In the West Maui Mountains, hunting has not been a long-held tradition. Pig hunting has only been pursued for a few decades, and opportunities for deer hunting have only recently arisen. Due to the steep slopes and variegated terrain in West Maui, good hunting grounds are limited, leaving little prospect for hunters to control feral animal populations. In general, only ridge-top trails and the more accessible valley bottoms provide opportunities for hunters. Some hunting occurs along the lower slopes of the mountain, in designated hunting areas such as the State of Hawai'i Game Management Areas at Kahakuloa. Some private landowners such as Maui Land & Pineapple Co., Inc. offer hunting programs with availability and access granted on an individual basis and only in designated areas of Honokōhau, Honolua, Mailepai, Kahana and Mahinahina.

Hunted land mammals such as pigs, goats, and deer were introduced to the islands at various points in time. Reviews of firsthand testimonies in more than 60,000 native Hawaiian land documents dating from 1846 to 1910 revealed many references to pigs, but nearly every reference was in the context of them being near-home and cared for – domesticated, not hunted (Maly and Maly, 2004). Feral pigs were not present in any significant number in the West Maui Mountains until the 1950s, and several remote sections remain free of any evidence of pigs. Goats, on the other hand, were a problem in the early 1900s, and were largely eradicated from the West Maui Mountains by the 1960s. Their impacts were severe however, and are still visible in the form of eroded scars on the slopes of Lihau and Helu on the mountains' southwestern slopes. More recently, Axis deer have arisen as a desirable hunting target and a major threat to

native ecosystems. This species was introduced to the islands in 1959, and herds have proliferated rapidly (Hess, 2008). According to anecdotal reports, Axis deer have been observed in the surrounding lowlands of all major WMMWP management units. At present, sightings have been reported in within the Northeast (Kahakuloa), Southeast (Waikapū and Hanaula), and Southwest (Ukumehame) Units. In the interest of protecting the native forests from destruction and degradation by ungulates, hunting and animal control are critical aspects of watershed management.

## **7. HIKING, OUTDOOR RECREATION, AND EDUCATION**

For enthusiasts of all ability levels, hiking is a popular activity in the West Maui watershed. The Division of Forestry and Wildlife (DOFAW) regulates hiking and outdoor recreation in watershed areas and has developed trails in West Maui via its Nā Ala Hele program. In addition, well established State Parks like ʻĪao offer recreational and educational opportunities. Maui Land & Pineapple Co., Inc. (ML&P) leads limited authorized research trips into the Puʻu Kukui Watershed Preserve, and as part of ML&P's educational outreach efforts, it has established a Forestry Stewardship project just below the Preserve for the community to take part in native ecosystem restoration, watershed improvement and protection, and native wildlife habitat enhancement in Honolua. With water resources being a primary concern, development of additional recreational uses of the watershed must proceed slowly and prudently.

Alongside hiking, other popular recreational activities in the West Maui Mountains include mountain biking and dirt biking. These contemporary pastimes have risen in popularity, with most riders frequenting trails that have been blazed illegally into forested lands. To date there are no legal locations to ride within conservation lands in West Maui. Problematically, dirt bikes in particular cause massive and severe erosion on these ridges, and some trail blazers have chopped into stands of native vegetation to carve new paths. Education on the fragility and importance of native watersheds will be crucial in order to mitigate destruction of the native forest environment caused by dirt bike riding, while still allowing for recreational enjoyment.

The West Maui Watershed is an important resource for education on environmental processes and native ecosystems. The watershed can serve as an outdoor classroom ideally suited to express both the biological and the cultural values of West Maui to students and other audiences at accessible educational sites. About once per quarter, WMMWP staff lead volunteer stewardship experiences and interpretive hikes within the Maunalei Arboretum (above Kapalua) and on the Waiheʻe Ridge Trail, both of which are easily accessible and provide high educational value. In their feedback to WMMWP, participants marvel at their new insights into the complexities of our native forests and the significant role of the watershed. They express great appreciation for their experiences.

### C. Primary Threats to the Watershed

Thanks in part to extremely rugged terrain, the West Maui Mountains have enjoyed, until relatively recently, a history largely free of many of the effects that destroyed or displaced native watershed forests on other islands. There are still many areas near the summit of the West Maui Mountains that are entirely free of feral animals, and some of these untouched native forests, shrublands and bogs are as pristine as any other location in the state. Unfortunately, feral animals and invasive plant species have begun to invade the West Maui Mountains and threaten to colonize native ecosystems and destroy the integrity of the watersheds.

One of the greatest threats to the watersheds of West Maui is the destructive effects of non-native animals, particularly feral ungulates such as pigs, goats, cattle and deer. These non-native animals damage the watershed structure, introduce diseases and open the way for plant pests via groundcover disturbance. Feral pigs or their sign (trails, wallows and rooting) have been observed on over 62 percent of the watershed, typically below 3,500 feet in elevation, and other animals such as feral cattle, goats and Axis deer are invading on the lower periphery. Native forests are challenged to withstand the effects of large land mammals whose browsing, rooting and trampling destroy native vegetation. Consequences of this destruction include accelerated erosion, the creation of disturbed areas in which invasive plants can establish and spread, and pollution of the water supply with silt, feces, and disease.



While much of the West Maui Mountains are still blanketed by native forest, some invasive plants have completely crowded out native plants in portions of the watershed. Native vegetation dominates approximately 70 percent of the WMMWP land area, but of this, less than 20 percent is without invasive plant problems (The Nature Conservancy, 2005). As seen in the photos to the left and right, invasive species like strawberry guava (*Psidium cattleianum*) have the potential to aggressively colonize and alter substantial tracts of native forest.

*Photos of lush, native forest complex (left) in contrast to monotypic strawberry guava (*Psidium cattleianum*) understory (right). Photos courtesy of Forest and Kim Starr.*

Lately, there has been an increase in human disturbances which compromise the health of the watershed and native forests. Harmful disturbances include trespassing on watershed lands and subsequent damage to WMMWP fences, supplies and equipment. Uncontrolled dirtbike riding, illicit cultivation of marijuana, and unauthorized blazing of hiking trails deep into the watershed have resulted in soil erosion and introductions of invasive species, among other problems.



In addition, fire continues to be a threat to watershed lands in West Maui. Wildfires leave in their wake vast expanses of bare soils that erode into streams and reefs

and lay prone to swift invasions of non-native, fire-resistant grasses that choke out slower growing native species.

The management programs conducted by WMMWP are designed to contain and suppress the myriad of threats to the watershed to ensure the long-term protection and preservation of native species and ecosystems. The following chapters expound the existing and proposed management programs established by WMMWP to combat these threats, along with a synopsis of WMMWP's programmatic accomplishments to date.

### **III. EXISTING MANAGEMENT PROGRAMS**

#### **A. Current WMMWP Initiatives**

Ahead of the inception of WMMWP, several parcels of land in the West Maui Watershed were designated for watershed and/or native ecosystem protection. In particular, these lands were enveloped by the State Conservation District and Forest Reserve System, and the allowable uses of these lands were defined by State statutes. At that time, management programs were devoted to promoting the health of the native ecosystems, primarily by abating known threats. Examples of Partnership lands that were designated for watershed protection by multiple State and private mandates included the following: Pu'u Kukui Watershed Management Area of Maui Land & Pineapple Co., Inc.; the four sections of the West Maui Natural Area Reserve (NAR) System; and The Kapunakea Preserve, managed by The Nature Conservancy of Hawai'i.

Once the Partnership formed in 1998, new landowning partners quickly mobilized to volunteer more lands in West Maui for watershed protection. On the windward side of the West Maui Mountains, focus was given to the Hanaula Region on what is now Wailuku Water Company (WWC) land, where feral pigs and cattle numbering in the hundreds had been devastating the upper wet forest. Similarly, efforts were expanded to create fenced management units in and across WWC lands in Waikapū Valley, Kapilau Ridge, Waiehu and Waihe'e. Also in Waihe'e, Department of Water Supply lands are nearly fenced entirely and ungulate free. In Kahakuloa, the State's Natural Area Reserve lies protected and mauka of a fence which has separated it from game management areas which offer public hunting opportunities on the makai side. On the leeward side of the West Maui Mountains, WMMWP is currently helping to manage lands from Panaewa NAR to Kapunakea Preserve that are owned by Kamehameha Schools, Kahoma Land Company, General Finance Group and the State of Hawai'i. Alongside the attention given to newly designated lands, further assistance was given to existing management areas to solidify long-standing efforts.

As a whole, the major activities that have been conducted in WMMWP lands include:

- Baseline watershed forest health and threat assessments
- Establishment of forest health monitoring transects
- Fencing to control movement of feral animals, especially pigs and deer
- Staff control to remove pest animals from upper watershed
- Pest plant control, particularly of priority weed species such as *Psidium cattleianum*

In concert with these field activities, WMMWP strives to educate the community and build awareness of the importance of watersheds and native forests. In terms of education, WMMWP crew periodically lead interpretive hikes to the Maunalei Arboretum and Waihe'e Ridge. These locations exhibit layers of both native and non-native ecosystems, thereby serving as outdoor classrooms that demonstrate the functional and cultural value of native forests. Meanwhile, organized volunteer trips to fieldwork sites give residents and visitors hands-on opportunities to actively participate in watershed management activities. Beyond these outings, WMMWP crew host educational booths at annual community events such as the Maui County Ag Festival, Arbor Day, Earth Day, and Whale Day, providing outreach materials and expertise to the general public to promote watershed ideals on a daily basis.



## **B. Broad-Based Support and Collaboration**

Outside the umbrella of WMMWP and its supporting organizations, watershed management activities in West Maui are also advanced by multiple levels of government and other non-profit entities. Preceding the inception of WMMWP, organized management of the watersheds of the West Maui Mountains has been ongoing since the 1980s. In 1989, the four units of the State's West Maui Natural Area Reserve were inventoried and their status documented with regard to invading alien plants and animals. Soon after, the Pu'u Kukui Watershed Management Area was established by Maui Land & Pineapple Company, Inc., following a biological inventory and subsequent management recommendations for watershed protection. Biological inventories of additional ML&P lands and former Amfac/JMB lands were also undertaken, and the Kapunakea Preserve was established in 1991 through a partnership with The Nature Conservancy. Today, botanical inventories continue with expert assistance and collaborations with organizations like the Plant Extinction Prevention Program (PEPP) and National Tropical Botanical Garden (NTBG). Moreover, in late 2011, the State of Hawai'i, Department of Land and Natural Resources inaugurated a statewide initiative for the protection of key watersheds across the Hawaiian Islands. Notably, the priorities of the State's initiative align with those of WMMWP.

### **1. STATE OF HAWAI'I - RAIN FOLLOWS THE FOREST INITIATIVE**

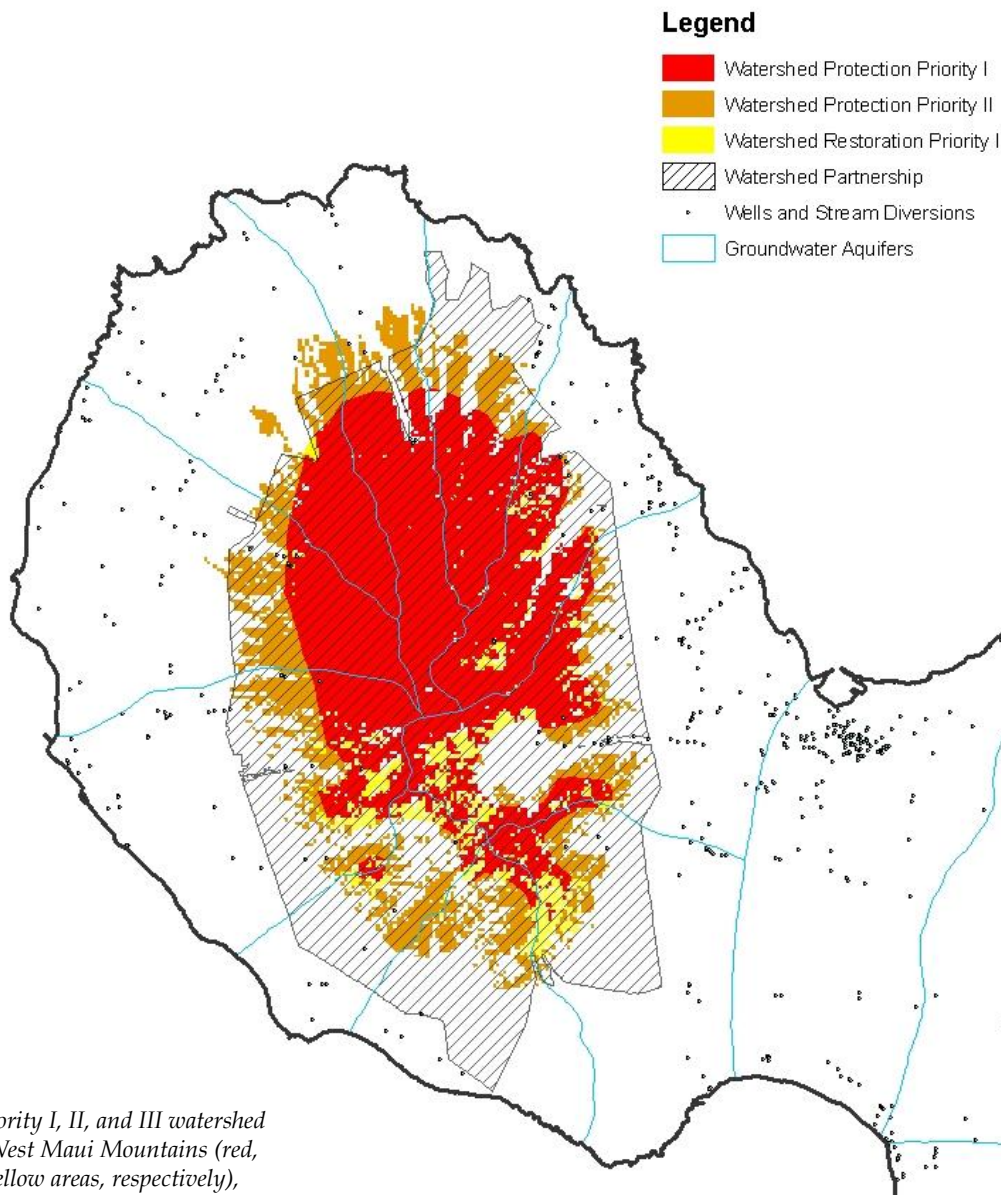


The State of Hawai'i, Department of Land and Natural Resources (DLNR) launched the "Rain Follows the Forest" or *Hahai no ka ua i ka ululā'au* Plan in November 2011. The purpose of this plan is to replenish Hawai'i's sources of water and to secure funding to protect more acres of crucial source water forests. The Rain Follows the Forest Plan recognizes that immediate action is needed to secure our islands' water supply and that the most efficient way to do this is through forest protection measures. Priority actions of the plan include managing invasive plant and animal species, restoring native species, increasing Hawai'i's ability to withstand impacts from climate change, educating and building awareness among the public, and restoring capabilities of the DLNR by finding additional sources of funding. In turn, DLNR is tasked to ensure mauka watersheds are fully functioning so fresh water resources can be utilized and enjoyed by the people of Hawai'i in perpetuity.

In determining appropriate management approaches and objectives for each region, the Rain Follows the Forest Initiative identifies three types of priority watershed areas that are defined by climatic conditions, vegetation, and land types (Figure 5). Priority I areas encompass native wet forests, and Priority II areas are comprised of mesic forest landscapes. Both areas, being covered largely by native vegetation, are high water recharge and fog capture areas that are under threat of conversion to alien landscapes without proper management. Meanwhile, Priority III areas contain non-native forest and grasslands wherein reforestation with native species would yield greater groundwater recharge. Notably, the WMMWP boundaries almost fully envelop the Rain Follows the Forest priority areas in West Maui.

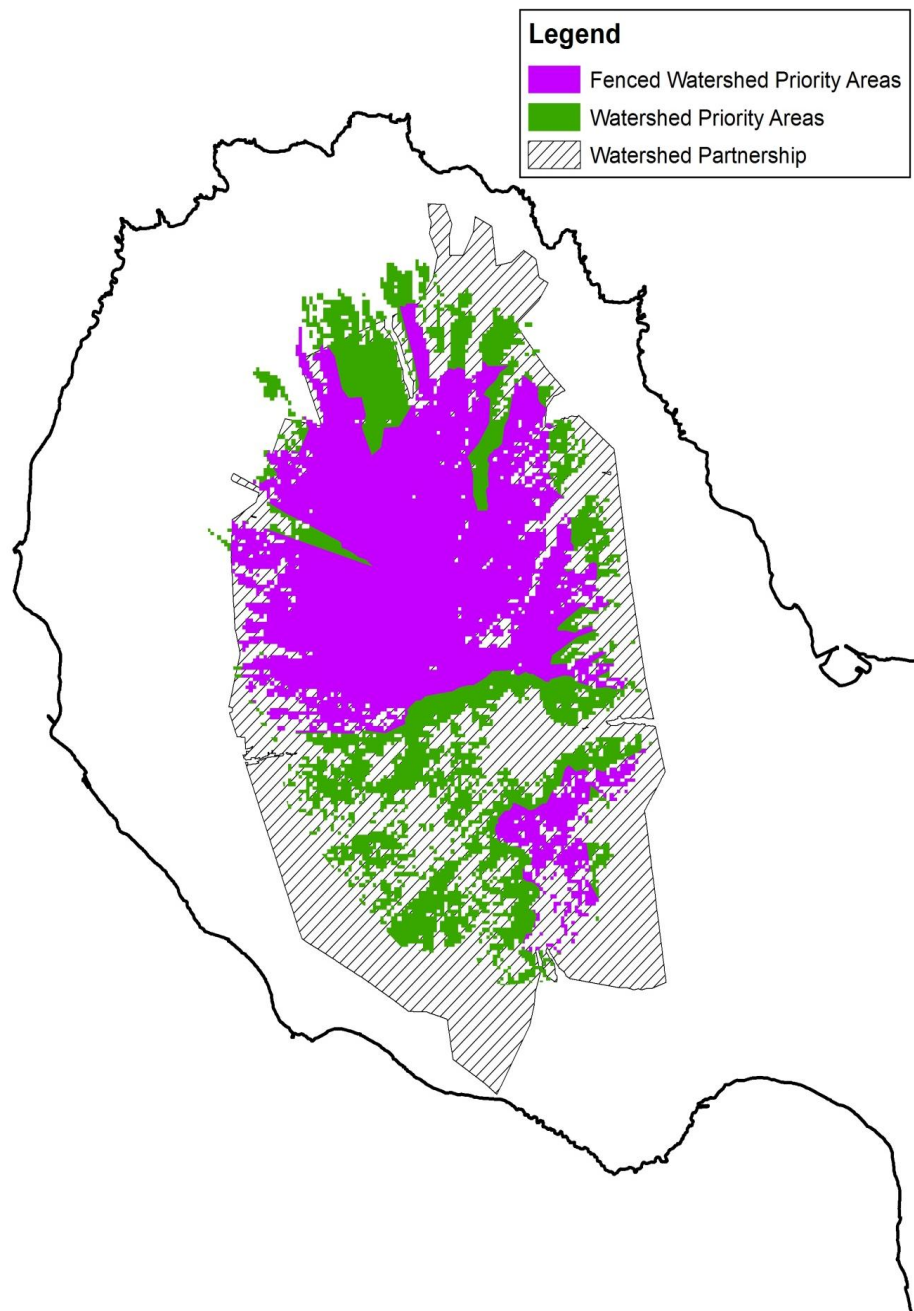


# Priority Watershed Areas



*Figure 5. Priority I, II, and III watershed areas in the West Maui Mountains (red, orange and yellow areas, respectively), shown in relation to the WMMWP project area (crosshatched grey), as well as wells, stream diversions, and groundwater aquifers. The WMMWP lands almost fully encompass the Rain Follows the Forest priority watershed areas and provide fresh water for thousands of residents and businesses.*





*Figure 6. Fenced and unfenced watershed priority areas (purple and green areas, respectively) within the WMMWP lands (crosshatched grey). Over the next five to ten years, WMMWP and its Partners plan to construct additional strategic and boundary fences to protect all watershed priority areas.*

Towards advancing the goals of the Rain Follows the Forest, the WMMWP management plan and its priorities coincide with several of the Rain Follows the Forest action items. Mutual priorities include animal control, weed control, wildfire management, outreach and education, and monitoring and coordination. In this regard, WMMWP has already made considerable progress in the Priority I and II areas in West Maui, mainly through protecting water recharge areas behind fences. Additional fencing projects planned for the next five to ten years will further secure native forest and water resources in priority areas (Figure 6). Invasive species control will be sustained in all priority areas within fences to truly safeguard the sustainability of the watershed. Similarly, wildfire management, outreach, and monitoring programs will undergo further development over the coming years to achieve the stated program goals.

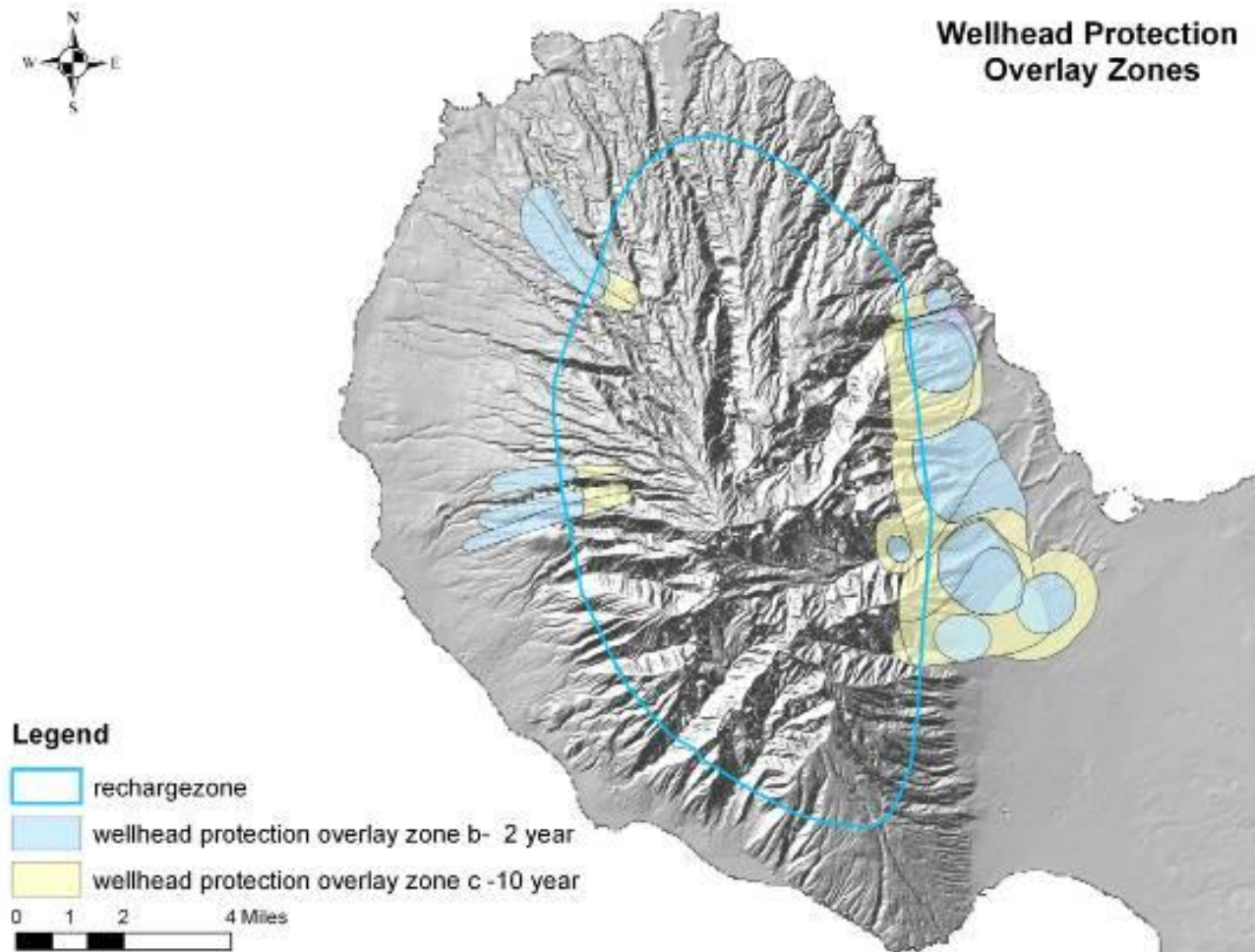
## 2. COUNTY OF MAUI

The County of Maui and its Department of Water Supply (DWS) have been instrumental in the support of watershed protection across Maui Nui. Since the inception of the Partnership in 1998, the County and DWS have not only helped to found WMMWP, but they have also



maintained their roles in leadership and financial support for WMMWP's programs. As explained on the DWS website, the DWS Grant Program for Watershed Partnerships endeavors "to ensure upland watersheds are fully functioning so fresh water resources can be utilized and enjoyed by the people of Hawai'i in perpetuity... Since 1995, the DWS has provided \$7.07 million dollars of funding to a total number of 54 partners." Further support has also been lent

by the Mayor's Office via the County Environmental Coordinator, and the County Council has passed resolutions in support of watershed protection and the use of safe biological controls to combat Maui's worst invasive weed species.



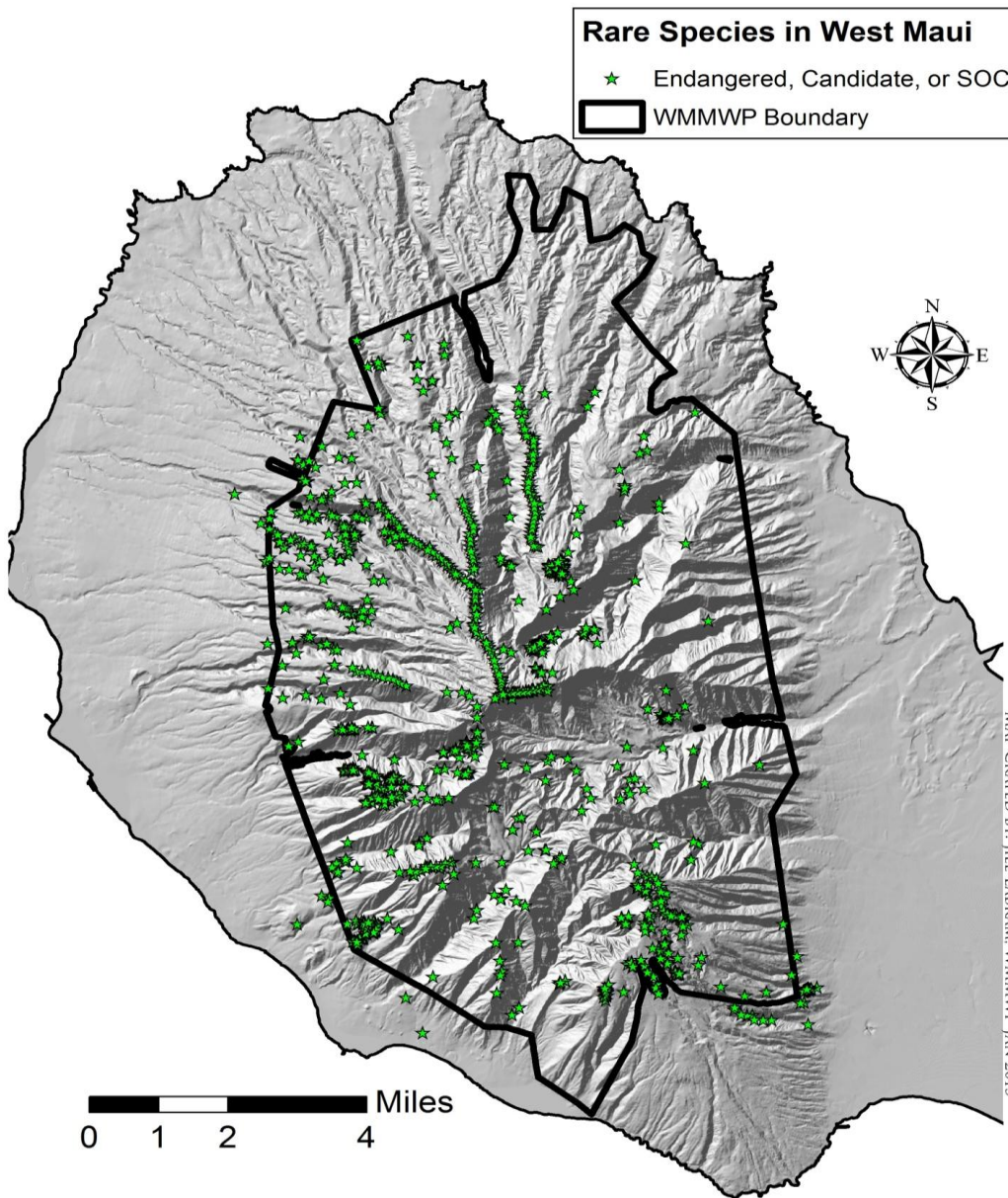
*Figure 7. The Department of Water Supply Well Head Protection program zones. In addition to general watershed protection efforts, the County is also concerned about the integrity of well water which originates within Mauna Kahalawai. Collaborating to protect forested land will help to ensure the quality and quantity of water available to well systems.*

### 3. U.S. FISH & WILDLIFE SERVICE

The United States Fish & Wildlife Service's mission is "to conserve, protect, and enhance wildlife and their habitats for the continuing benefit of the American people." With 30 endangered species and an estimated total of 146 rare species and vegetative communities inhabiting WMMWP lands alone, a collaboration to achieve the mutual goal of species



protection is naturally formed. With the issuance of program grants, USFWS has supported WMMWP's management efforts to protect landscapes through fencing and invasive species control. Several funding initiatives such as the Partners for Fish and Wildlife Program have advanced WMMWP's goals considerably, especially on privately owned lands.



*Figure 8. Map of endangered, candidate, and species of concern in the WMMWP project area. Although fences protect many species from feral ungulates, ongoing fencing projects and implementation of other invasive species controls are necessary to protect critical habitats.*

MAP CREATED BY: JILL LABRAM, WMMWP | JAN 2013



#### 4. DOH, EPA, NOAA, & USACE

In order to achieve the goals of WMMWP, it is sometimes necessary to look beyond traditional collaborations to further both internal goals and the overall mission. Working with many agencies and groups that have been expanding their efforts in watershed protection has become increasingly necessary and fruitful. Two parallel efforts include the “The West Maui Watershed Project” led by the U.S. Army Corps of Engineers (USACE) and the “West Maui Ridge to Reef Initiative.” Both projects have spawned new collaborations and programs. Participating agencies include the National Oceanographic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA) via the Hawai’i State Department of Health (DOH), the U.S. Army Corps of Engineers and the State Department of Land and Natural Resources (DLNR). Importantly, these projects integrate mauka forest management with mauka-to-makai solutions, and in doing so, they enlist the support of many community stakeholders. Through this collaboration, these agencies have enabled WMMWP to play an active role in solutions for protecting water resources in our stream and reef ecosystems.

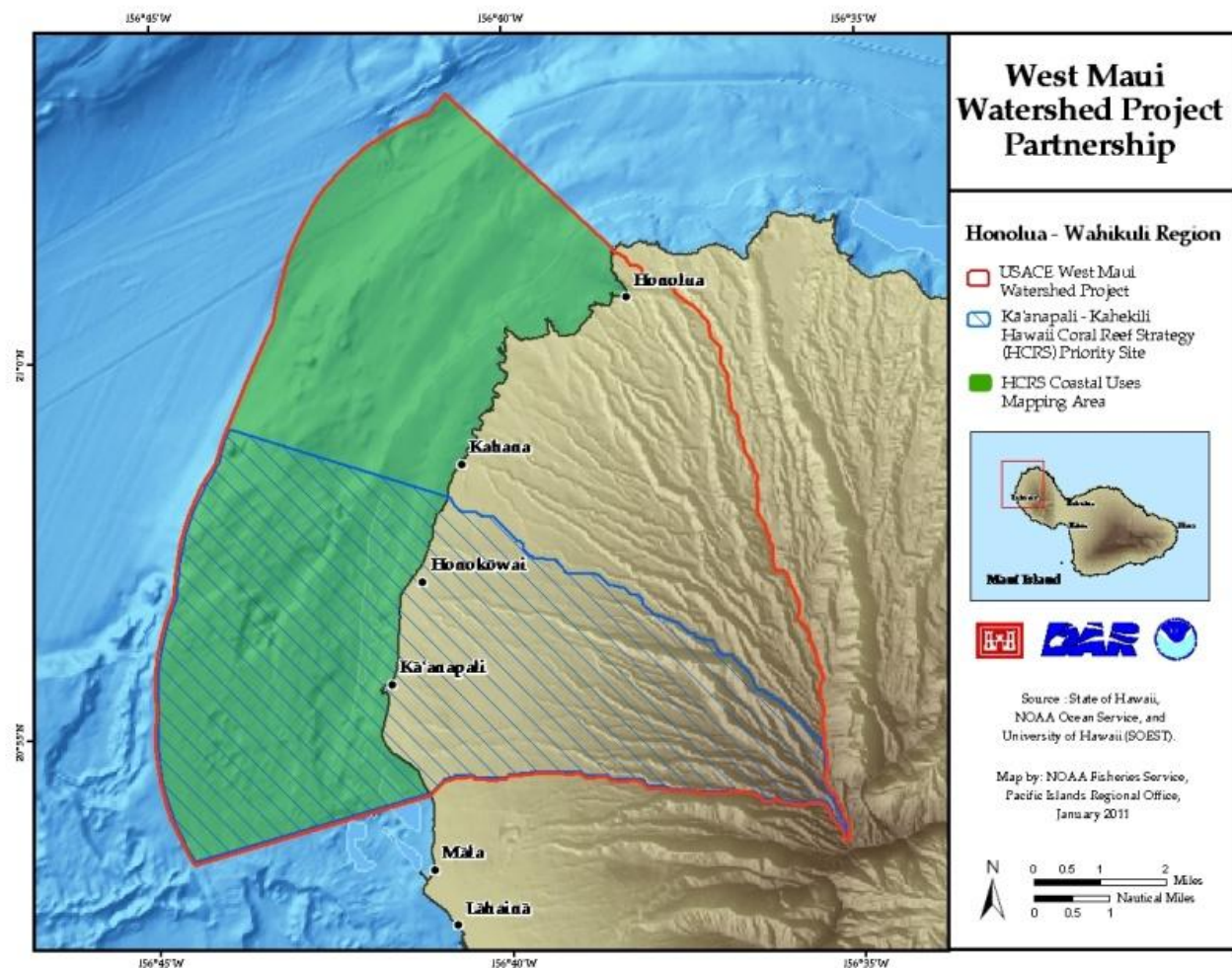


Figure 9. West Maui Watershed Project Partnership area, stretching from the watershed core out to the edge of the nearshore coral reef. This area includes portions of the northwest and west units of the WMMWP project area.

## 5. THE NATURE CONSERVANCY

Both the Hawai'i Chapter and the local Maui-based office of The Nature Conservancy (TNC) have played major roles in the support of watershed and invasive species protection on Maui and throughout the State. Contributions of conservation management based knowledge, advocacy, research, and development of new technologies has been integral to bolstering the success of WMMWP and other watershed partnerships. The Nature Conservancy played a significant role in the formation of WMMWP, and TNC received initial funding from the DOH to enable the development of WMMWP's original management plan. Since then, WMMWP staff have benefited from a direct collaboration with TNC through a sub-contract to manage TNC's Kapunakea Preserve. Funding provided to complete this mission has enabled knowledge to be gained across a full spectrum of objectives necessary to protect watershed resources, and this knowledge has been further amplified across the watershed.



## 6. MAUI FIRE DEPARTMENT

On the local level, WMMWP has been working since 2011 with the Maui Fire Department, local agencies, and area landowners in the West Maui Fire Task Force. As a founding member, WMMWP is an active participant in its mission "to prepare a proactive plan updated regularly, in dealing with wild land fires, placing priority on educating first responders as well as community partners with a specific focus on increased awareness and preservation of life, natural & cultural resources, and infrastructure."



## 7. MAUI CONSERVATION ALLIANCE

WMMWP is an active and founding participant in the Maui Conservation Alliance (MCA), a cooperative partnership of government, private and non-profit organizations striving for the long-term protection of Maui's ecosystems. Since its inception in 2008, the MCA has focused on key priorities including supporting the use of biological controls, watershed protection, and inter-island biological security issues.



## 8. THE MAUI INVASIVE SPECIES COMMITTEE

The Maui Invasive Species Committee (MISC) was created to address very serious threats to native ecosystems posed by invasive alien species of plants and animals. The activities of MISC have included public education, providing information to the Hawai'i legislature and Maui County, as well as planning, coordinating, and facilitating cooperative chemical, mechanical, and biological control programs. Several MISC targets have serious potential to invade WMMWP lands. Ivy gourd (*Coccinia grandis*) in the West Maui lowlands and fountain grass (*Cenchrus setaceus*) found in Waiehu are now under control thanks



to MISC efforts. Pampas grass (*Cortaderia sp.*) is currently the only MISC target species within WMMWP lands. This species is wind dispersed and has managed to find its way into the most remote and sheer terrain, making the work difficult and largely dependent upon helicopter spray operations. It is strategically important for the WMMWP to work closely with MISC in their approach to controlling and eradicating invasive plants in West Maui.

## 9. THE HAWAI'I ASSOCIATION OF WATERSHED PARTNERSHIPS (HAWP)



HAWP's mission is "to increase the effective management and protection of mauka (upper elevation) watershed areas by raising the capacity of Watershed Partnerships, facilitating sharing of watershed management expertise, building public support for protecting watershed values, and developing sustainable funding sources." HAWP is comprised of eleven island-based Watershed Partnerships across the State that work collaboratively with more than 71 public and private partners on six islands. Together, these Watershed Partnerships protect over 2.2 million acres of vital forested watershed lands in Hawai'i. The WMMWP played an instrumental role in the formation of HAWP through its initial statewide conferences and advocacy for a statewide consortium of watershed partnerships. Today, WMMWP works within HAWP to advance watershed protection on Maui and make a critical difference for the protection of forested watersheds in our state.

### C. Summary of Major WMMWP Accomplishments

Over the years, WMMWP has made significant gains in animal control, weed control, watershed monitoring, and other programs in West Maui since finalizing the original Watershed Management Plan in 1999. Increases in funding have enabled WMMWP to amass a larger crew, broaden its reach across the West Maui Mountains, and develop new initiatives in wildfire management and rare species protection. Yet, while the lands of WMMWP encompass a total of 47,319 acres, only 21,804 acres (roughly 46%) are currently under active management by WMMWP staff and Partners. However, with the implementation of the updated Watershed Management Plan, WMMWP plans to further expand its program scope to actively manage the majority of the 47,319 acres of Partnership landholdings. In this context, the following tables provide a summary of WMMWP accomplishments in watershed management to date:

*Table 1. Summary of WMMWP accomplishments to date in invasive animal management and control.*

INVASIVE ANIMAL MANAGEMENT AND CONTROL		
Program	Initiative	Accomplishments
Fence Building	Ungulate ingress routes around WMMWP boundary fenced off	- 19.44 miles built to date
		- 7.33 miles built by WMMWP staff
		- 4.73 miles built by WMMWP staff and Partners
		- 7.38 miles jointly built by WMMWP Partners
		- 14.91 total miles of pig fence (4-foot fence)
		- 4.43 total miles of pig and deer fence (8-foot fence)
		- 6.4 miles of fence managed by WMMWP staff in 2012
		- 29.7 miles of fence inspected by WMMWP staff in 2012 (certain fences checked multiple times each year)
		- 1.4 miles of fence maintained (e.g. repaired or brushed) by WMMWP staff in 2012
		- 16.9 miles of fence proposed for installation
	- 10.9 miles of fence proposed for retro-fit	
	Maximize acres of WMMWP lands protected behind fences	- 21,084 acres protected behind fences as of 2012
		- 11,722 acres protected by WMMWP-built fences
		- 7,567 acres protected by Partner-built fences
- 1,795 acres protected by joint-built fences		
- 18,802 acres of pig exclusion area		
		- 2,282 acres of deer and pig exclusion area
Ungulate Control	Remove known ungulates from WMMWP lands	- 385 ungulates removed by WMMWP staff since database established in 2005
		- 2,567 ungulates removed collectively by Partners since 1992
		- 1,500 ungulates dispatched by DLNR aerial shoots
		- 485 pig captures by PKW since 1998
	Entire acreage of WMMWP lands ungulate-free (including 937 acres of PKW land protected behind fence outside of WMMWP boundary)	- 30,088 acres exhibiting zero known ungulate activity
		- 62.4 percent of WMMWP lands
		- 8,281 acres exhibiting light ungulate activity
		- 17.1 percent of WMMWP lands
		- 9,887 acres exhibiting moderate to heavy ungulate activity
		- 20.5 percent of WMMWP lands

**Table 2.** Number of ungulates within the WMMWP lands dispatched each year by WMMWP and its Partners. A total of 18,053 acres of WMMWP lands are under active animal control and additional acreages will be managed with the completion of new strategic and boundary fences. Shown in the far right column is the growth in WMMWP acreage under active animal control.

**Ungulates Dispatched by Year, WMMWP Wide**

Year	Management Unit													Total Ungulates	Total Unit Acres
	Hanaula	Hahakea/Wahikuli	Kapunakea	Panaewa	Mauna Alani	Waihe'e	Eke	Kapilau	Waikapu	Honokowai	Waiehu	Helu	Ukume hame		
*1992-2000	77	-	170	-	-	-	-	-	-	-	-	-	-	247	3,925
2001	47	41	-	-	-	-	-	-	-	-	-	-	-	88	3,894
2002	18	43	11	1	0	0	-	-	-	-	-	-	-	73	10,764
2003	14	50	36	0	2	1	-	-	-	-	-	-	-	103	10,764
2004	4	61	5	1	0	0	-	-	-	-	-	-	-	71	10,764
2005	4	15	4	0	0	0	-	-	-	-	-	-	-	23	10,764
2006	5	51	15	0	1	0	0	-	-	-	-	-	-	72	11,683
2007	1	68	10	0	0	0	1	2	-	-	-	-	-	82	12,117
2008	0	26	7	0	4	0	0	8	0	0	-	-	-	45	15,459
2009	0	8	16	0	4	0	0	21	0	0	4	-	-	53	17,060
2010	0	20	10	0	0	0	0	5	0	3	5	0	-	43	18,053
2011	5	4	4	6	0	0	0	7	0	2	2	1	-	31	18,053
2012	1	0	5	22	0	0	0	6	0	-	2	0	-	36	16,485
<b>Totals</b>	<b>176</b>	<b>387</b>	<b>293</b>	<b>30</b>	<b>11</b>	<b>1</b>	<b>1</b>	<b>49</b>	<b>0</b>	<b>5</b>	<b>13</b>	<b>1</b>	<b>1500**</b>	<b>2467</b>	
<b>Acres per Unit</b>	2,652	1,242	1,273	1,773	587	3,237	919	434	1,774	1,568	1,601	993		<b>Total Acres</b>	18,053

\*Hanaula data 1996-2000. Kapunakea data 1992-2000.

\*\*Aerial shoot-DLNR



**Table 3.** Summary of WMMWP accomplishments to date in the area of invasive plant control.

INVASIVE PLANT CONTROL		
Program	Initiative	Accomplishments
Target Species Control	Control all Priority 1 species	- 1,407 <i>Clidemia hirta</i> individuals treated
		- 87.26 acres swept for <i>C. hirta</i>
		- 84 <i>Cortaderia sp.</i> individuals treated
		- 0.06 acres swept for <i>Cortaderia sp.</i>
		- 1 <i>Macaranga tanarius</i> individual treated
		- 6.7 acres swept for <i>M. tanarius</i>
		- 5,965 <i>Psidium cattleianum</i> individuals treated
		- 100.84 acres swept for <i>P. cattleianum</i>
		- 119 <i>Rubus argutus</i> individuals treated
		- 21.22 acres swept for <i>R. argutus</i>
		- 2 <i>Sphaeropteris cooperi</i> individuals treated
		- 8.14 acres swept for <i>S. cooperi</i>
		- 166 <i>Tibouchina herbacea</i> individuals treated
		- 7.35 acres swept for <i>T. herbacea</i>
Target Species Control	Control all Priority 2 species	- 32 <i>Acacia mearnsii</i> individuals treated
		- 10.55 acres swept for <i>A. mearnsii</i>
Prevention	Prevent establishment of incipient populations	- In 2011, <i>Cinchona pubescens</i> eradicated in West Unit
		- 7 <i>C. pubescens</i> individuals treated
		- 6.19 acres swept for <i>C. pubescens</i>
Technological Methods	Incorporate the use of new technologies	- In 2012, established Herbicide Ballistics Technology (HBT) Standard Operating Procedures (SOP)
		- In late 2012, trial implementation of HBT began
		- From 2010 to 2012, assessed use of high-resolution imagery with Resource Mapping Hawai'i

**Table 4.** Summary of WMMWP accomplishments to date in the area of wildfire management.

WILDFIRE PROGRAM		
Program	Initiative	Accomplishments
West Maui Fire Task Force	Active participation and contribution by WMMWP Partners and Staff	- In 2011, WMMWP served as founding member of WMFTF, and WMMWP continues to serve as an active member
		- Community Wildfire Protection Plan currently in progress
		- Ongoing fire infrastructure mapping with WMFTF members

Table 5. Summary of WMMWP accomplishments to date in the area of human activities management.

HUMAN ACTIVITIES MANAGEMENT		
Program	Initiative	Accomplishments
Deter Harmful Activities	Measure impacts	- From 2011 to 2012, WMMWP conducted a survey of Waiehu Region erosion rates resulting from dirtbike activity
	Address trespass	- In 2009, WMMWP convened the Dirtbike Working Group comprised of local landowners
		- In 2008, WMMWP created "Malama Aina" signs to promote respect for the native forests and watersheds - 20 signs posted at entry points around WMMWP boundary

Table 6. Summary of WMMWP accomplishments to date in the area of public education and awareness.

PUBLIC EDUCATION AND AWARENESS		
Program	Initiative	Accomplishments
Volunteer Engagement	Hosting Americorps interns	- Six interns since 2006, each serving a one-year term - 9,350 total hours contributed by Americorps interns
		Stewardship outings
	- Volunteers assist with <i>Psidium cattleianum</i> control on Waihee Ridge - 28 volunteer hours clocked - Volunteer trips to Kahoma for fence maintenance, weed control, and animal control - 29 people; 600 volunteer hours clocked	
	Community Education	
Interpretive hikes	- From 2009 to 2012, WMMWP staff led 17 hikes to Waihee Ridge trail and Maunalei Arboretum - 204 people served	
	Participation in outreach events	- WMMWP staff host a booth in at least six events per year, including Whale Day, Earth Day, Maui County Ag Festival, Arbor Day, and others - 1,110 people served in total since beginning of outreach program efforts in 2009
	Publication of informative materials	- In 2006, WMMWP website established to provide educational information about watershed functions, invasive species, and the importance of native forest protection, along with staff biographies and information on upcoming events - In 2006, updated in 2010, WMMWP staff published an informational brochure which provides an overview of watershed functions along with WMMWP's mission and objectives

Table 7. Summary of WMMWP accomplishments to date in the area of rare species protection.

RARE SPECIES PROTECTION		
Program	Initiative	Accomplishments
Assessment	Record species present in WMMWP lands along with status of each	- 146 known rare species in WMMWP lands
		- 48 endangered species
		- 1 threatened species
		- 13 candidate species
		- 84 species of concern
Habitat Protection	Known rare species and critical habitats within WMMWP lands protected behind fences	- 95 rare species protected behind WMMWP fences, based on known GPS points
		- 38 rare species remain outside WMMWP fences, based on known GPS points
		- 18,942 acres of native vegetation communities protected behind fences
		- 8,878 acres of critical habitat protected behind fences
Other	Assist PEPP with out-planting as opportunities arise	- 95 <i>Stenogyne kauaulaensis</i> individuals planted
		- 84 <i>Cyanea kauaulaensis</i> individuals planted
		- 12 <i>Plantago princeps</i> individuals planted
		- 4 <i>Cyanea magnicalyx</i> individuals planted
	Populate and maintain GIS database	- Information on 133 rare species in WMMWP lands included in GIS database

*Table 8. Summary of WMMWP accomplishments to date in the area of water and watershed monitoring.*

<b>WATER AND WATERSHED MONITORING</b>		
Program	Initiative	Accomplishments
Transects	Establish monitoring transects across all WMMWP lands	- 22 monitoring transects established to date (including 4 PKW transects)
		- 1,675 total transect stations
		- 103.5 acres covered by transects
Water Quality	Establish water quality monitoring stations in streams	- One monitoring station in Honolua Stream, checked monthly for stream water quality and rainfall
Erosion Rates	Establish erosion bridges to monitor erosion rates	- 10 erosion bridges established in 2012, checked annually

*Table 9. Summary of WMMWP accomplishments to date in the area of management coordination.*

<b>MANAGEMENT COORDINATION</b>		
Program	Initiative	Accomplishments
Staffing	Maintain current staff; expand as necessary	- 10 full-time staff as of December 2012
		- Watershed Coordinator
		- Field Crew Supervisor
		- Field Crew Leader
		- Natural Resource and GIS Technician
		- Program and Data Assistant
		- Field and Data Assistant
- Field Assistants (4)		
Partner Coordination	Conduct regular WMMWP Partnership meetings	- Quarterly meetings held with WMMWP Partners to discuss, evaluate, and identify program goals and objectives

## **IV. WMMWP WATERSHED MANAGEMENT PLAN**

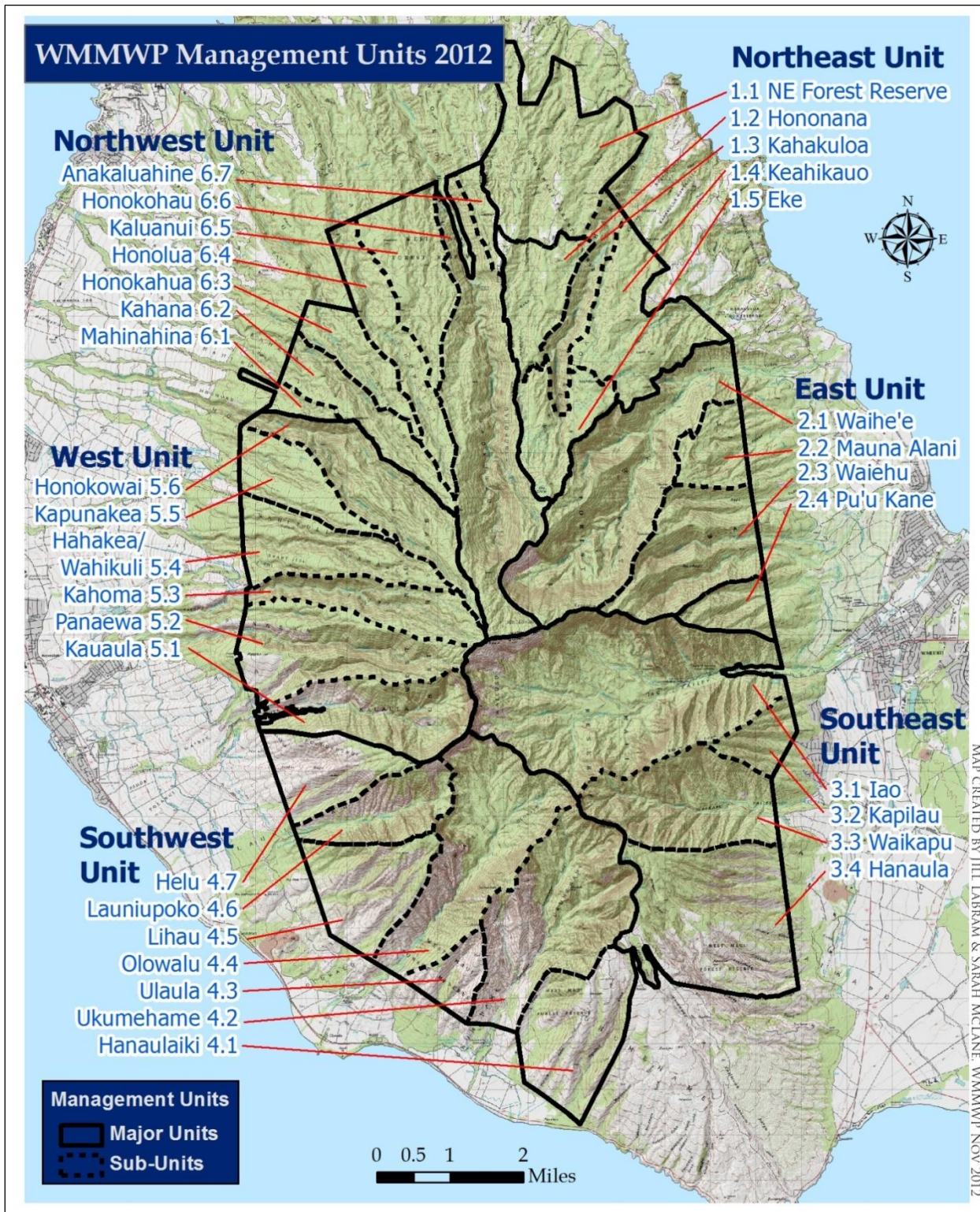
### **A. A Cooperative, Integrated Management Approach**

In consideration of the variegated landscape and unique ecology of the West Maui Mountains, cooperative management arises as the most practical approach to protecting the watershed for several reasons:

1. The management challenges threatening the health of the watershed are regional in scope, not restricted to particular landowners, but a shared concern of all ahupua'a that converge on the West Maui summit region.
2. The successful maintenance of the health and quality of the entire watershed requires the protection and involvement of all major landowners. Each part of the watershed is affected by the health of the neighboring parcels. We cannot afford to lose any significant part of this forest if we expect to rely on its resources far into the future.
3. Even when combined, the resources of the Partners are limited in relation to what is needed to protect the entire watershed. These limited resources must be carefully weighed, levied and managed in order to address the threats to the watershed. A combined effort will take advantage of economies of scale for large strategic fencing projects and other infrastructure needs.
4. To achieve the most effective management of the watershed, we must apply best practices and take advantage of breakthroughs of the most experienced partners. The partnership approach promotes sharing of technical expertise to make all partners more effective
5. Expertise needs to be sought from outside the partners. In recent years watershed protection initiatives have expanded at the state and global levels. Lessons learned elsewhere are vital to success here in West Maui. Outside collaborations should be sought as necessary to meet our goals.

To organize the deployment of watershed management strategies, WMMWP subdivides the West Maui Mountains into six distinct geographic units for which specific priority actions are identified and implemented (Figure 10). Priority management actions in the six units vary with such factors as the magnitude of ungulate activity, the type and extent of invasive species populations and the number of planned or completed fences. While animal control may take precedence in one unit and weed control in another, all WMMWP management activities are conducted in varying degrees across all six units. The following section outlines the WMMWP management plan which sets forth management programs for the coming years to address perceived threats to the watershed and continuously improve WMMWP's reach and capabilities.





**Figure 10.** Map of the six major WMMWP management units and the multiple sub-units within each. In general, each sub-unit encapsulates a distinct watershed defined by natural features like ridge lines or by fence lines and natural barriers that impede ungulate movement.



## B. WMMWP Goals, Management Methods, and Objectives

Many of the management priorities of WMMWP are long-standing necessities established through a history of watershed and forest management on the part of Partners such as DOFAW/NARS, Maui Land & Pineapple Company, Inc., and The Nature Conservancy. During Partnership discussions on this updated plan, eight major actions emerged as priorities for watershed management in West Maui. These are:

- Invasive animal management and control
- Invasive plant control
- Human activities management
- Water and watershed monitoring
- Wildfire management
- Protection of rare species and habitat
- Public education and awareness of watershed management
- Watershed management coordination

### 1. INVASIVE ANIMAL MANAGEMENT AND CONTROL



*From left to right: feral cow, wild goat, wild boar, and Axis deer (Photo credits (from left to right): WMMWP, HAWP, Courtesy of Billy Ray Hanes, and WMMWP.*

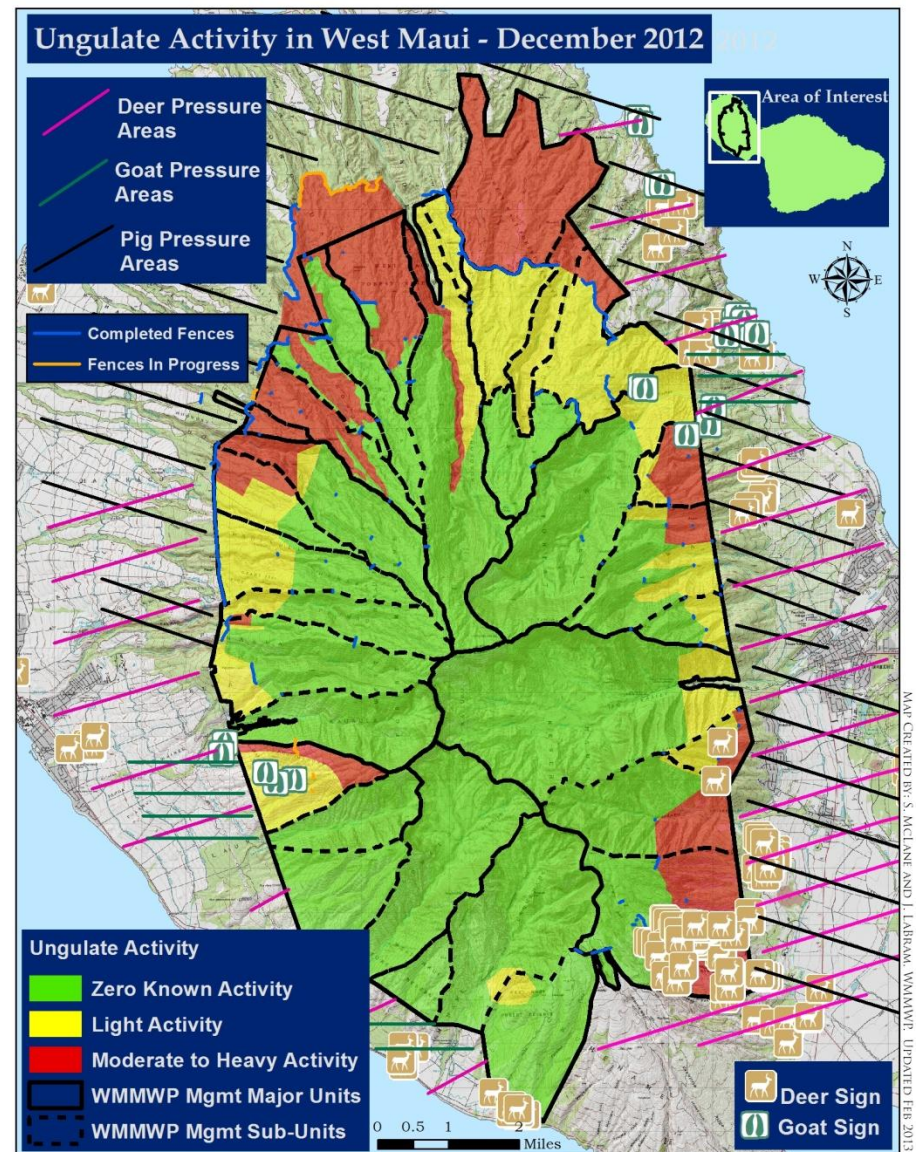
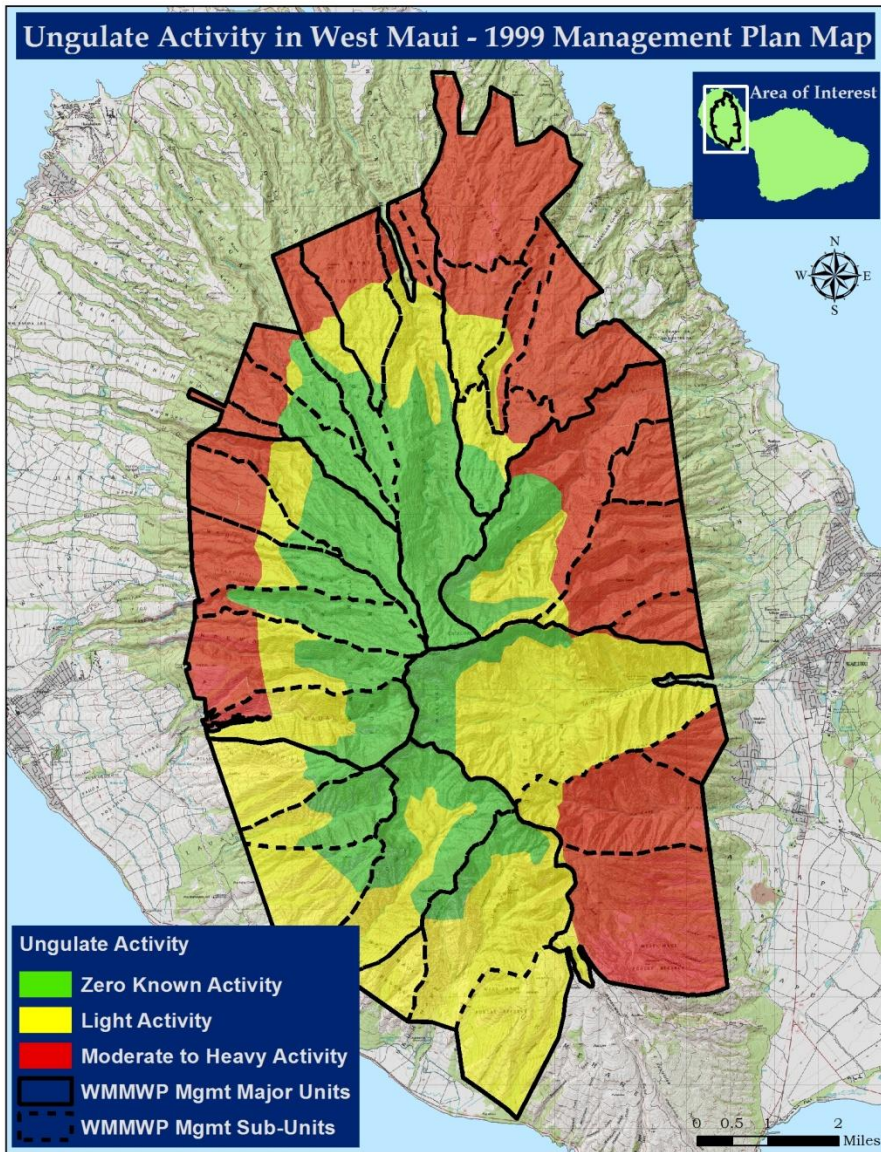
Feral animals are one of the most conspicuous threats to the West Maui Watershed. There were no large land mammals in Hawai'i before human beings arrived. Absent of large native land animals, the native vegetation evolved for thousands of years without the need to defend against grazing or trampling by such animals and subsequently shed defenses such as thorns and poisons. Pigs and goats were introduced to Hawai'i by Captain James Cook in 1778 and cattle by Captain George Vancouver in 1793 (Info Grafik, 2013). Within decades feral animals had destroyed much of the lowlands and were threatening mauka watershed forests, prompting the establishment of the first forest reserves in Hawai'i. Stories reported feral goats to have roamed the hills from Lahaina to Ukumehame in the thousands, and cattle were released into the forest during times of drought to fend for themselves.

Today, in remote sections of the watershed where hunters seldom venture, serious damage by pigs and goats continues to occur, and Axis deer have made their way into West Maui as well. Pigs are still the most widespread animal in the watershed, and feral pig control efforts

cannot be understated. Goats seem to be in limited number at present, known to consist of three small populations in the Southwest and Eastern Units. Over fifty cattle had caused forest canopy destruction near the intact summit of Hanaula until 2006 when the last known cow was removed. Axis deer were once limited on Kahalawai but are now another serious threat, spreading at an alarming rate in the lowlands around the watershed and as high as 3,000 feet elevation in Waikapū (Figure 11 and Figure 12). With abundant food supplies and no natural predators, feral animals proliferate rapidly in the wild and destroy large areas of forest. Today the skeletal remains of 'Ōhi'a trees clearly visible during helicopter assessments of this area serve as a potent reminder of their forest converting power. Although 69 percent of the watershed maintains native vegetation cover (refer to Figure 2), over 70 percent of that area has been at least somewhat impacted over the past few decades, and degradation of the native forest cover is still a constant threat. Moreover, aside from their destruction of the forest, feral ungulates are also vectors of water-borne diseases such as *Leptospirosis* and *Giardia* that contribute to the degradation of surface water quality.

In the lower, more accessible elevations of the watershed, ungulate populations persist, and public hunting remains a helpful form of active animal control. Public hunting is supported within State managed hunting units in Kahakuloa, and ML&P allows hunting on their lands in West Maui via their volunteer hunting program. These programs serve to limit the harmful impacts of ungulates while providing hunters with an important resource. Much of the watershed, however, lies outside the permitted hunting areas, beyond the reach of hunters and outside fenced and managed areas. Thus, feral pigs range across well over one-third of the watershed, where they are capable of rapidly reproducing and pressuring managed sections.





**Figure 11 and Figure 12.** Historic vs. Current Ungulate Range Maps: The map at left shows historic ungulate ranges known at the inception of the Partnership in 1999, while the map at right shows the current ungulate distribution as of December 2012. Although pigs and goats have been exterminated from most of the watershed (as evidenced by areas in green), goats persist in certain areas and populations of Axis deer are on the rise. Pressure on existing fences is increasing as deer migrate across the central valley and begin to establish herds in West Maui. More and taller 8-foot-high fences are now required to keep deer and other ungulates out of the watershed core.



Smaller animals are also emergent pests in the West Maui watershed. Rodents, feral cats and dogs, mongoose, and certain non-native birds are established in the West Maui Mountains and are known to harm or compete with native species. Some small alien mammals are also vectors of water-borne diseases such as *Leptospirosis* and *Giardia* that contribute to the degradation of surface water quality. Potential small animal threats include Jackson's chameleons (*Trioceros jacksonii*) which have been observed at mid elevations of the watershed, as well as coqui frogs which have been reported in Kapalua. Fortunately, the coqui have been controlled with success in West Maui by extinguishing incipient populations on the periphery of the watershed. Pests like coqui have been introduced to Maui in imports of nursery plants from off-island which are distributed throughout West Maui. Caution must be exercised to guard against infestations like those in Maliko Gulch in East Maui and in Puna and Hilo on the Big Island. It is strategically important for WMMWP to work closely with MISC to develop and implement approaches to controlling incipient animal pests in West Maui.



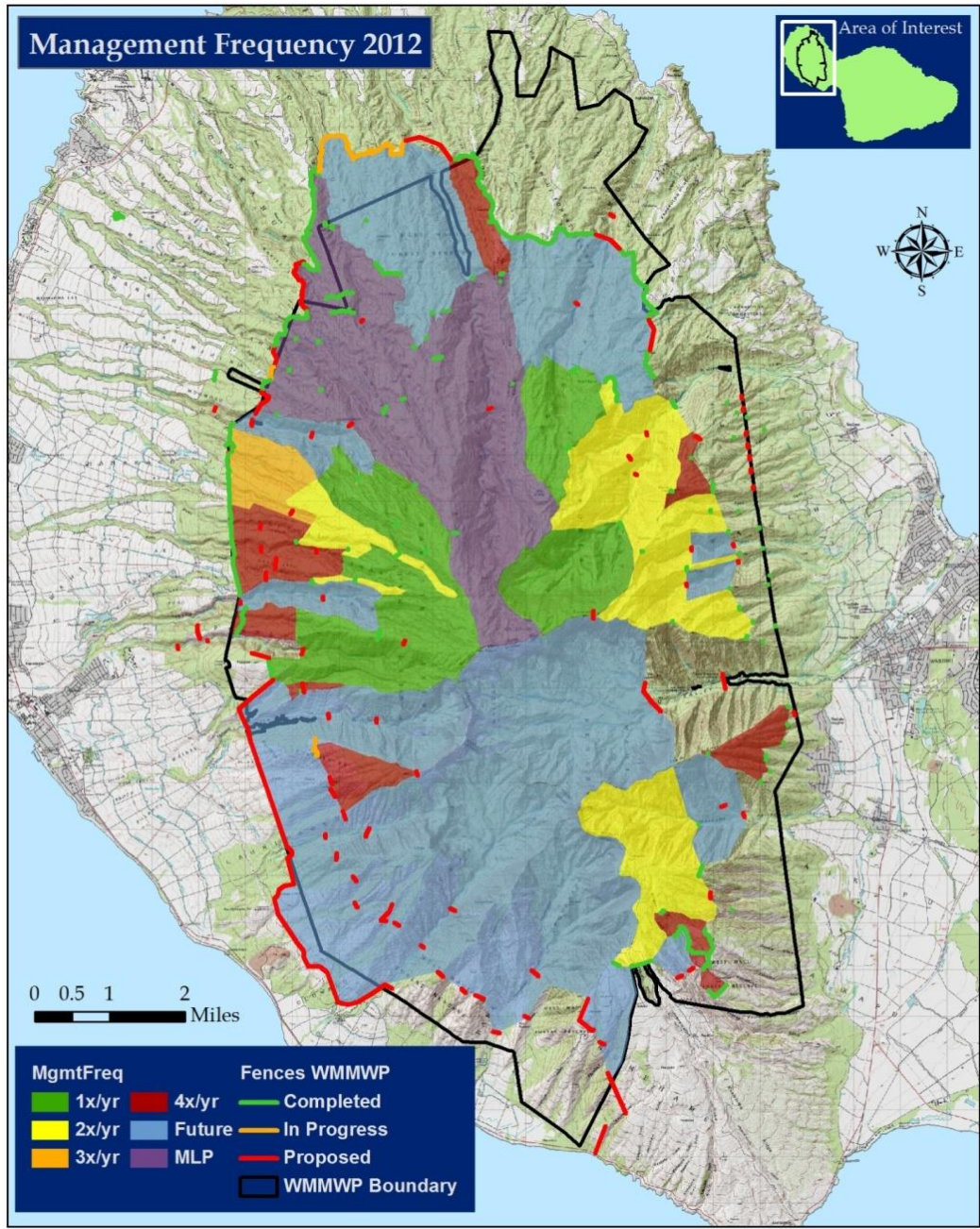
*Jackson's chameleon (Trioceros jacksonii), an introduced species found in WMMWP lands. Photo credit: WMMWP.*

### **Management Methods:**

Management methods to address invasive animal issues need to be adaptive and integrated with many parallel efforts. Fencing is typically the first effort to protect an area from ungulate invasion and disturbance. Even as far back as 1876, foresters recognized that the construction of fences and barriers to prevent hooved animals from trespassing into forests would be crucial to the protection of watersheds and water resources (DLNR, 2011). Fences prevent ungulates from becoming established in sensitive areas and inhibit ungulates from reestablishing themselves once removed. Fence maintenance and regular inspections are critical to this end; thus, fences must be improved and expanded to the extent practical.

While strategic fences integrated into natural topographic barriers have been effective in cutting off corridors, full boundary fencing is necessary to ensure greater protective integrity for the watershed as a whole (Figure 13). Fences must be built to a height adequate to prevent ungulates like Axis deer from bounding over the top. To address this, four-foot-tall fences designed to exclude pigs and goats are being retrofitted with another four feet of material to increase the protective height to eight feet. New eight-foot-tall fences will also be constructed, especially along watershed boundaries, to address expanding deer populations. Ongoing research and experimentation in fencing continuously refines fencing methods to be most effective in preventing ingress by Axis deer and other feral mammals. Through continuous research, WMMWP stays abreast of these developments and modifies practices accordingly.





*Figure 13. Map showing frequency of animal management and control activities across fenced regions of the WMMWP project area. Depending on the magnitude of ungulate infestations, managed areas are monitored and maintained between one time (green areas) and four times (red areas) per year. Areas in blue have yet to be protected behind strategic boundary fences that are either proposed (red lines) or in progress (orange lines). Active animal management in these areas will commence once the fences are completed. Animal control in the purple area is managed separately by the Pu'u Kukui Watershed Preserve team of ML&P.*

Ungulate removal practices including hunting, trapping and aerial shooting are employed in areas where they are deemed appropriate to remove ungulates from within fences or to reduce the exterior pressure on our fences by roaming animals below. Many times, a multi-tactic approach is necessary and is dependent on factors like vegetative cover, accessibility, resources, and safety. Ungulates can become wise to one method, so a diversity of methods may be needed to reach removal goals.

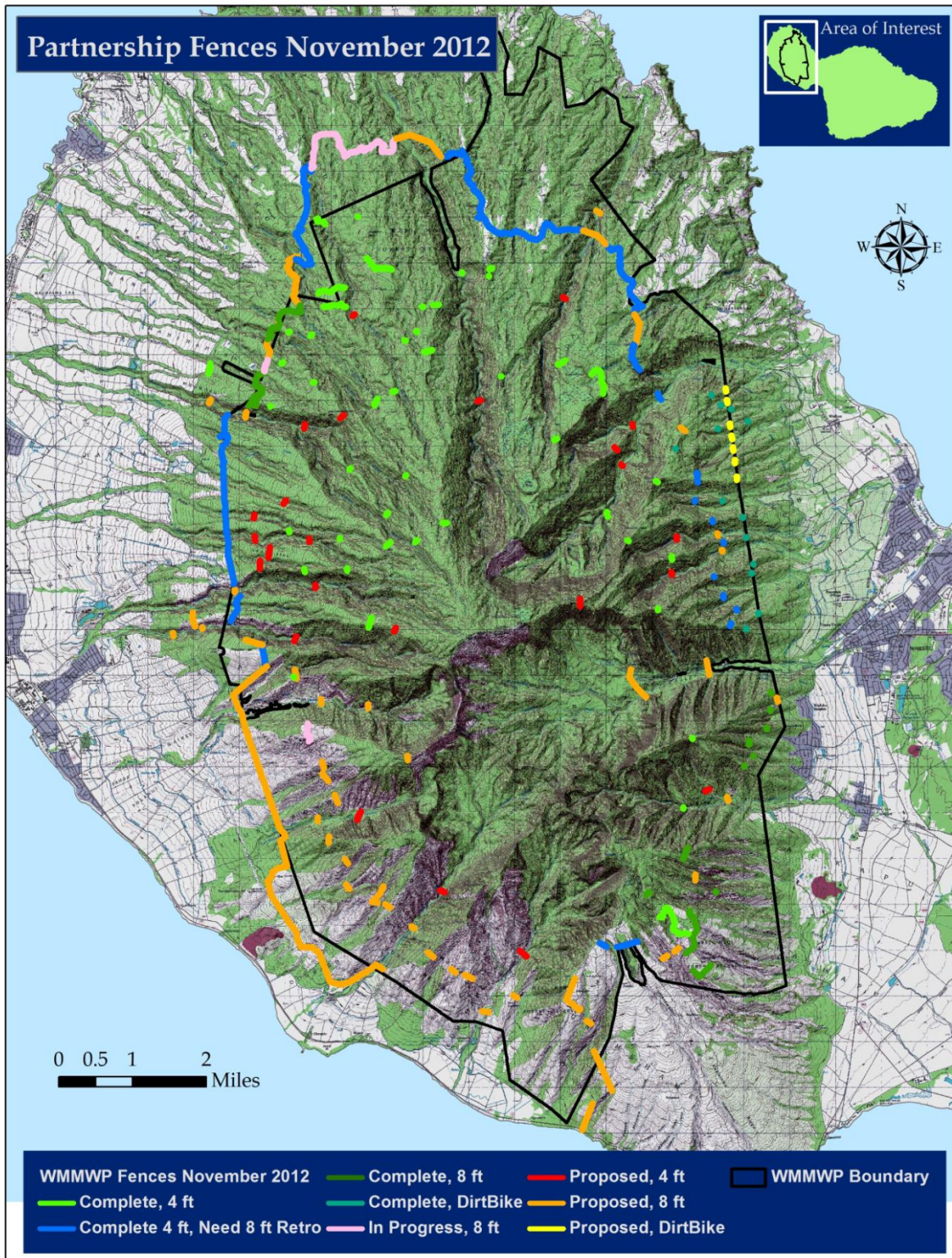
### **Invasive Animal Management and Control Program Goals:**

- Implement zero tolerance management of ungulates and reduce populations and/or impacts from other alien pest animals
- Minimize loss of vegetative cover, loss of rare species habitat, and watershed soil erosion resulting from animal activity
- Minimize human health risks and decreases in water quality associated with animal-borne diseases

### **Invasive Animal Management and Control Program Objectives:**

- 1) Inspect and maintain all Partnership ungulate management areas.
  - a. Ensure the continued absence of ungulates in approximately 12,565 acres within fenced units with annual management checks
  - b. Achieve a level of zero ungulates within an additional approximately 19,525 acres via quarterly or more frequent management checks
  - c. Establish aggressive ungulate control in newly fenced units, implementing zero tolerance management methods
  - d. Scout all remaining ungulate free areas at least annually for the purposes of early detection and rapid response
- 2) Inspect and maintain all fences biannually or more as specified by managers and warranted by vandalism, ungulate pressure and known natural hazards to fences. A comprehensive table of all WMMWP fences is compiled in Appendix B.
- 3) Construct and maintain additional strategic fences along key ungulate ingress routes sufficient to protect the watershed. Priorities include:
  - a. Complete strategic fences in southwest unit remaining from 1999 Management Plan
  - b. Construct strategic valley fences where appropriate to protect perennial streams, basins, and fragile riparian habitats
  - c. Retrofit 10.9 miles of boundary fence as necessary to increase fence heights to exclude expanding deer populations (Figure 14)
  - d. Construct additional forest boundary fencing as resources permit:
    - i. Pu'u Kukui Watershed Preserve
    - ii. Kanaha through Launiupoko
    - iii. Lihau NAR through Olowalu
    - iv. Papalaua and Hanaula'iki





*Figure 14. Map of existing and proposed WMMWP fences, as of November 2012. Work is ongoing to enclose the entire WMMWP area in 8-foot-tall fences designed to exclude deer, pig, and goats. Together, these fences will protect the entirety of the core watershed area.*

- 4) Support State aerial shoot program and utilize as a strategic tool to remove ungulates.
  - a. Establish permits and protocols to control specific populations such as goats in Waihe'e and Helu, Axis deer watershed-wide, and new ungulate populations as they arise
  - b. Support State-led efforts to maintain the Ukumehame goat population at zero
- 5) Explore new ungulate management alternatives to increase control efficacy such as staff hunting with dogs, new live trapping methods, and contract hunting.
- 6) Maintain and enhance existing public hunting programs in Kahakuloa GMA and ML&P land makai of the Pu'u Kukui Watershed Preserve and encourage management of populations on adjacent lands.
- 7) Provide testimony to support State and County wide efforts to limit the distribution of new vertebrate and invertebrate threats from outside the state and from inter-island transport (e.g. Mouflon Sheep, fire ants, etc.).
- 8) Work with County and State to find solutions to the increasing Axis deer population issue.
  - a. Work through the Maui Conservation Alliance (MCA) to specify County-wide objectives for controlling deer threats to watershed areas
  - b. Create a zero tolerance zone within WMMWP conservation areas
- 9) Follow and support efforts to control other vertebrates that threaten watershed health and function.
  - a. Support Maui Invasive Species Committee (MISC) programs that target pest animals in West Maui
  - b. Assist in rapid response to potential future outbreaks of pests such as snakes, coqui frogs, veiled chameleons, fire ants and others that pose a threat to WMMWP
  - c. Support through testimony statewide efforts to administer safe rodenticides
- 10) Maintain monitoring data sufficient to measure success, inform adaptive management, funders, and policy makers.

Table 10. Objectives and Costs for Invasive Animal Management and Control Program.

Management Strategy: Invasive Animal Management & Control							
Objectives	Cost Per Unit / Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost
1) Inspect and maintain all Partnership ungulate management areas .							
a. Ensure and maintain the absence of ungulates in ~12,565 acres within fenced units with annual management checks ( Does not include 6,423 in current ungulate management by PKW)	\$9.09 / Acre plus 3%/yr.	\$ 114,216.00	\$ 117,642.48	\$ 121,171.75	\$ 124,806.91	\$ 128,551.11	\$ 606,388.26
b. Achieve a level of zero ungulates within an additional ~19,525 acres via quarterly or more frequent management checks	\$9.09 / Acre Adding 3,905/ yr.	\$ 35,496.00	\$ 70,992.00	\$ 106,488.00	\$ 141,984.00	\$ 177,480.00	\$ 532,440.00
c. Establish aggressive ungulate control in units as they are fenced, implementing zero tolerance management methods	Included in above	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
d. Scout all remaining ungulate free areas at least annually for the purposes of early detection and rapid response.	Decreases as land is managed in above	\$ 20,000.00	\$ 17,500.00	\$ 15,000.00	\$ 12,500.00	\$ 10,000.00	\$ 75,000.00
		<b>\$ 169,712.00</b>	<b>\$ 206,134.48</b>	<b>\$ 242,659.75</b>	<b>\$ 279,290.91</b>	<b>\$ 316,031.11</b>	<b>\$ 1,213,828.26</b>
2) Inspect and maintain all fences biannually or more as specified by managers and warranted by vandalism, ungulate pressure and known natural hazards to fences.	\$8.63 / meter of fence						
a. Current Fences (All complete/partial fences in Partnership - including NARS and MLP fences) = 31,703 meters of fence (19.7 miles)	WMMWP only =11,567 m or 7.4 miles plus 3%/yr.	\$ 99,823.00	\$ 102,817.69	\$ 105,902.22	\$ 109,079.29	\$ 112,351.67	\$ 529,973.86
b. New Fences - Per Year Added							
- 4 Foot Fences	2,456m total 491 m/yr	\$ 4,239.00	\$ 8,478.00	\$ 12,717.00	\$ 16,956.00	\$ 21,195.00	\$ 63,585.00
- 4 Foot Retro to 8 Foot Fences	17,528 m total - 3,505 m/yr	\$ 28,078.57	\$ 58,326.72	\$ 88,574.87	\$ 118,823.02	\$ 149,071.17	\$ 442,874.34
- 8 Foot Fences	16,543m total - 3308 m/yr	\$ 28,548.04	\$ 57,096.08	\$ 85,644.12	\$ 114,192.16	\$ 142,740.20	\$ 428,220.60
- Dirt bike Barricades	505m total - 101 m/yr	\$ 872.49	\$ 1,744.99	\$ 2,617.48	\$ 3,489.97	\$ 4,362.47	\$ 13,087.40
		<b>\$ 161,561.10</b>	<b>\$ 228,463.47</b>	<b>\$ 295,455.69</b>	<b>\$ 362,540.44</b>	<b>\$ 429,720.50</b>	<b>\$ 1,477,741.20</b>
3) Construct and maintain additional strategic fences along key ungulate ingress routes sufficient to protect the watershed. Priorities include:							
a. Complete strategic fences in Southwest Unit remaining from 1999 Plan. Currently Funded	Lihau = 1061m (.64 miles) Ula'ula = 579m (.36 miles)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
b. Construct strategic valley fences to protect perennial streams, basins and fragile riparian habitats and ridge top fences to protect uplands. 30 Estimated	7676m (4.77miles) 1535m/ yr. @ \$ 82/m	\$ 125,870.00	\$ 125,870.00	\$ 125,870.00	\$ 125,870.00	\$ 125,870.00	\$ 629,350.00
c. Retrofit boundary fence as necessary to increase fence heights to exclude expanding deer populations.	17,528m (10.9 miles) 3,505/yr. @ \$55/m	\$ 192,775.00	\$ 192,775.00	\$ 192,775.00	\$ 192,775.00	\$ 192,775.00	\$ 963,875.00
d. Construct additional forest boundary fencing as resources permit such as:	All Below @ \$ 82/m						
i. Pu'u Kukui Preserve Boundary -	3,956m (2.46miles)	\$ 162,196.00	\$ 162,196.00	\$ -	\$ -	\$ -	\$ 324,392.00
ii. Kanaha thru Launiupoko Boundary -	4,593m (2.85 miles)	\$ -	\$ 188,313.00	\$ 188,313.00	\$ -	\$ -	\$ 376,626.00
iii. Lihau NAR thru Olowalu Boundary -	5,428m (3.37 miles)	\$ -	\$ -	\$ 222,548.00	\$ 222,548.00	\$ -	\$ 445,096.00
iv. Papalaua/Hanaula'iki Segments :	2,566m (1.59 miles)	\$ -	\$ -	\$ -	\$ 105,206.00	\$ 105,206.00	\$ 210,412.00
		<b>\$ 480,841.00</b>	<b>\$ 669,154.00</b>	<b>\$ 729,506.00</b>	<b>\$ 646,399.00</b>	<b>\$ 423,851.00</b>	<b>\$ 2,949,751.00</b>



Table 10. (Continued)

Management Strategy: Invasive Animal Management & Control Continued								
Objectives	Cost Per Unit/ Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
4) Support State aerial shoot program and utilize as a strategic tool to remove ungulates								
a. Establish permits to control specific populations such as goats in Waihe'e, and Helu, deer watershed wide and new ungulate populations as they arise.	In Coordination / State Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
b. Support State lead efforts to maintain the Ukumehame goat population at zero and reduce deer and other ungulates watershed wide	Helicopter Time	\$ 16,000.00	\$ 16,000.00	\$ 16,000.00	\$ 16,000.00	\$ 16,000.00	\$ 80,000.00	
5) Explore new ungulate management alternatives to increase control efficacy such as staff hunting with dogs, new live trapping methods and contract hunting.	In Coordination/Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
6) Maintain and enhance existing public hunting programs in Kahakuloa GMA and MLP land makai of the Pu'u Kukui Preserve and encourage management of populations on adjacent lands.	Included in Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
7) Provide testimony to support State and County wide efforts to limit the distribution of new vertebrate and invertebrate threats from outside the state and from inter-island transport (i.e. Mouflon Sheep, fire ants, etc.).	In Coordination / Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
8) Work with County and State to find solutions to the increasing Axis Deer population issue.								
a. Work through the Maui Conservation Alliance (MCA) to specify County wide objectives for controlling deer threats to watershed areas	In Coordination / Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
b. Create a zero tolerance zone within WMMWP conservation areas	In Coordination / Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
9) Follow and support efforts to control other vertebrates which threaten watershed health and function								
a. Support the Maui Invasive Species Committee (MISC) programs that target West Maui pest animals.	In Coordination / Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
b. Assist in rapid response to potential future outbreaks of pests such as snakes, Coqui frogs, Veiled Chameleons, fire ants etc. which pose a threat to WMMWP.	Redirect funds/Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
c. Support Statewide efforts to administer safe rodenticides through testimony.	Included in Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
10) Maintain monitoring data sufficient to measure success, inform adaptive management, funders, and policy makers.	Included in Monitoring Budget	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
		Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
<b>INVASIVE ANIMAL MANAGEMENT &amp; CONTROL TOTAL</b>		<b>\$ 828,114.10</b>	<b>\$ 1,119,751.95</b>	<b>\$ 1,283,621.44</b>	<b>\$ 1,304,230.34</b>	<b>\$ 1,185,602.61</b>	<b>\$ 5,721,320.45</b>	

## 2. INVASIVE PLANT CONTROL



From left to right: Australian Tree Fern (*Sphaeropteris cooperi*) on a hillside; close-up of Koster's Curse (*Clidemia hirta*); thicket of *Macaranga tanarius* saplings; patch of *Tibouchina herbacea*. Photos courtesy of Forest and Kim Starr.

Although many non-native plants of great benefit have been introduced to Hawai'i, a number of serious invasive plants have invaded native watersheds and threaten to permanently alter their stability. Invasive plants are a serious problem because they aggressively displace native plants, diminish habitat for native animals, and reduce the structural complexity of the watershed. These losses significantly undermine the efficacy of the watershed and have far-reaching, negative impacts on our island's economy and quality of life. In East Hawai'i for example, invasive plants have reduced groundwater recharge by an estimated 85 million gallons per day (DLNR 2011). Invasive species displace economically or culturally important plants, convert scenic landscapes of pristine native forests into thorny tangles, and even promote wildfire. Many invasive plants gain a foothold in the forest by sprouting in areas opened up by feral animals; other invasive plants are spread by birds, wind, hikers, and vehicles that enter the forest carrying mud and seeds from other areas. With numerous vectors for introduction into the watershed, invasive plants must be met with strong and innovative methods of eradication and management.

In lowland areas and along most roads, vegetation is largely non-native, and in some cases, non-native trees were purposely planted in an effort to recreate forests lost historically by uncontrolled feral cattle. Oftentimes, non-native species planted in lowland areas spread upland, into the watershed, carried by vectors like wind, birds, and hikers. Most recently, Pampas Grass (*Cortaderia spp.*), a wind-dispersed species, has infiltrated the most remote and sheer terrain, making eradication difficult and largely dependent upon helicopter spray operations. For these invasions, it is strategically important for WMMWP to work closely with MISC in their efforts to control incipient populations. As WMMWP gains experience and collective knowledge from collaborations with MISC and other organizations, the great task of combating invasive species becomes more feasible to accomplish.



Photo: Pampas grass (*Cortaderia sp.*) plumes amid 'ohi'a (*Metrosideros polymorpha*) and other native vegetation. Photo credits: WMMWP.



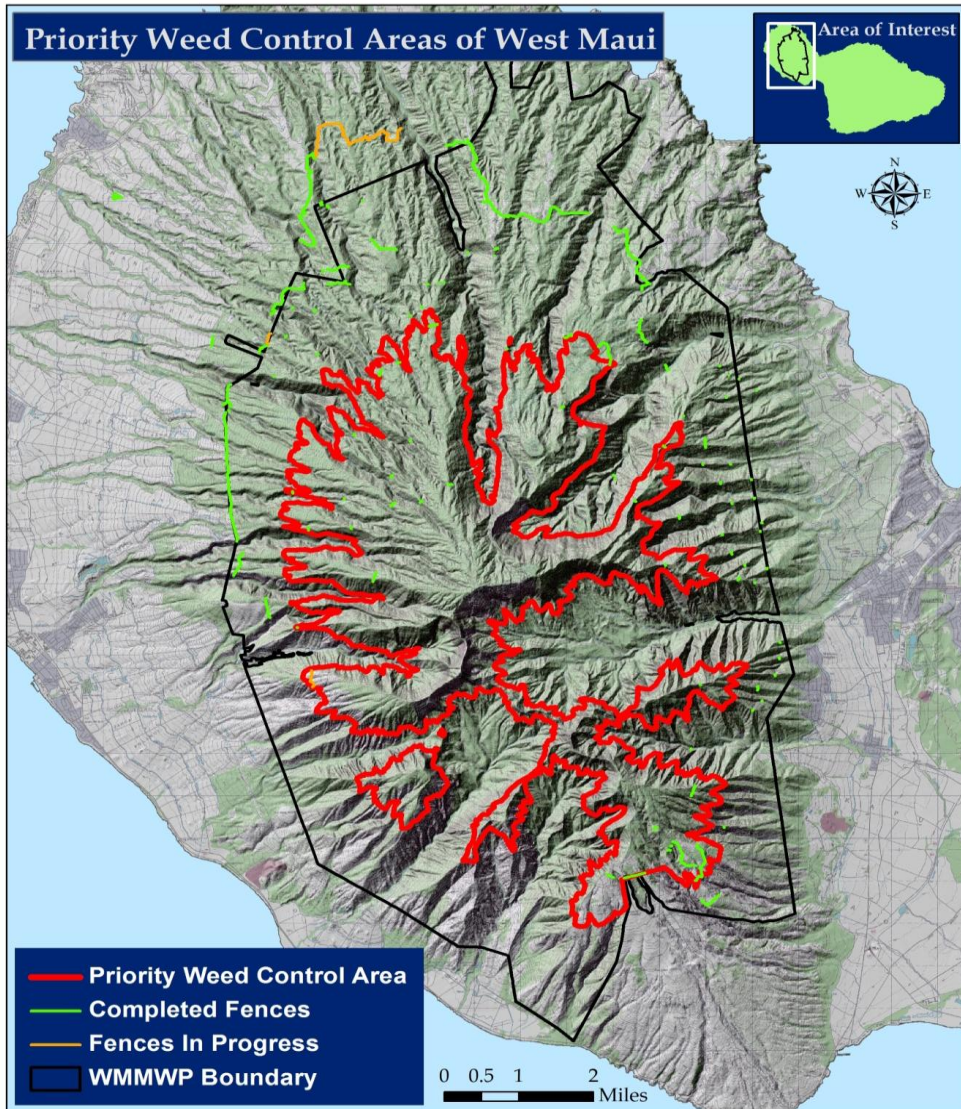
## Management Methods:

The central management principle is to remove the most severely invasive plants from the relatively pristine core of the watershed found above 2,800 feet. WMMWP follows a “top-down” approach to invasive plant control. The overriding goal is to push invasive plant populations makai, back below 2,800 feet in elevation, toward core lowland infestation areas, and inhibit species from expanding their ranges to alter more native forest (Figure 15). Beyond the top-down approach, a specific assessment of species abundance and threat level is made to set feasible management goals for each priority species. Prevention from invasion is the most

ideal, but once alien species are established within the watershed, elimination of incipient populations becomes the next best level to attain. Suppression then focuses available resources on controlling outliers and satellite populations, while containment methods are instituted to keep core concentrations of invasive species from expanding.

The presence and extent of invasive species across the watershed is determined through a combination of aerial and ground surveys along transects. Together, these survey methods locate both core populations and outliers throughout the watershed (Figure

16). Monitoring for invasions may also involve remotely sensed and high resolution aerial imagery. As these technologies develop, WMMWP will take full advantage of their ability to locate invasive plant



**Figure 15.** WMMWP priority weed control areas (outlined in red) above the 2,800-foot elevation line. Note that in the vicinity of the Kaheawa Windfarm in the south unit, the 2,800-foot line was amended to exclude the Windfarm area, as this area is located outside WMMWP boundaries and is managed by other entities.



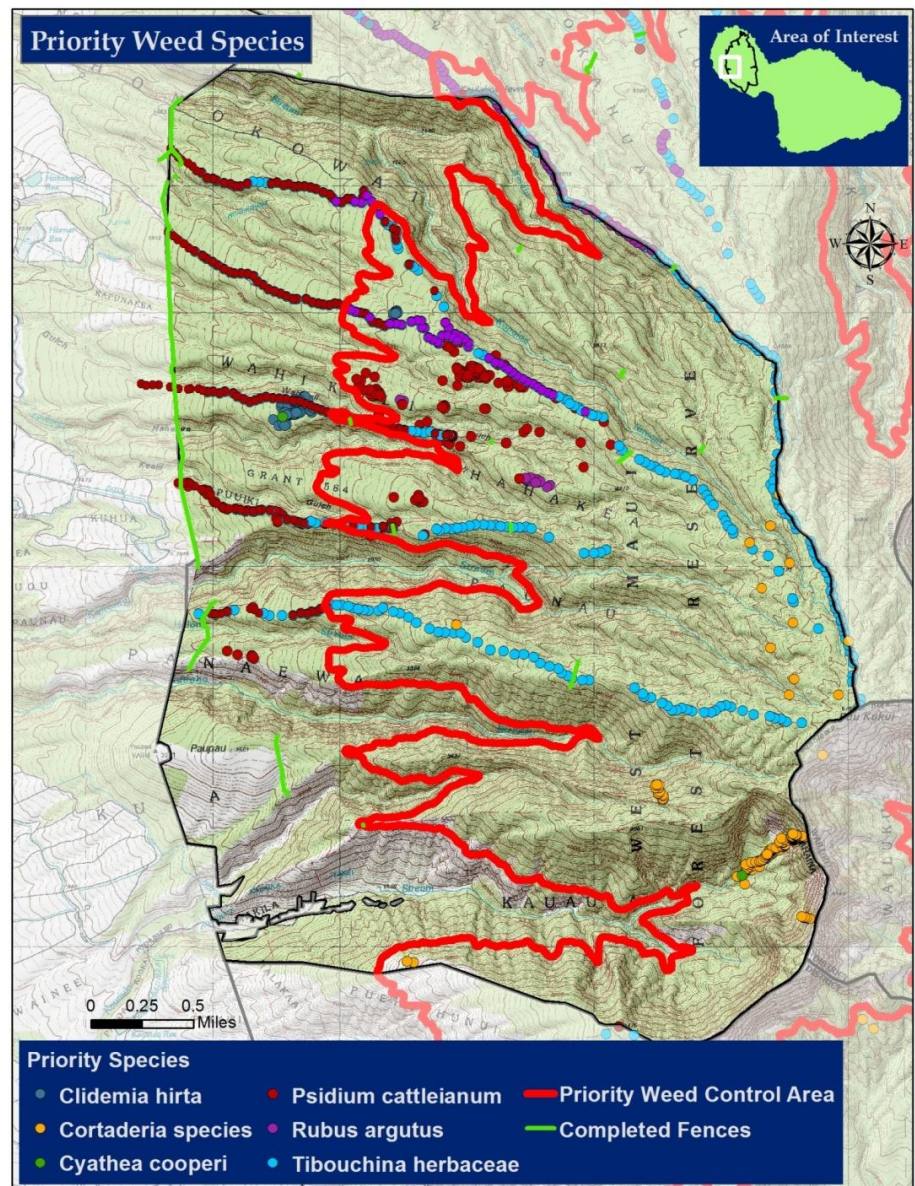
targets, map their ranges and develop appropriate management responses. In a landscape that is as challenging as West Maui, the ability to view species remotely seems to have great potential and utility. Current efforts by Resource Mapping Hawai'i can provide one centimeter resolution imagery in good conditions that can be ortho-rectified and fully mosaiced – put simply, the aerial photographs are stitched together and layered over a map in the exact locations at which they exist in reality. More in-depth Satellite based imagery analysis, like the work of Greg Asner with the Carnegie Airborne Observatory, can locate plants based on unique chemical signatures. It is anticipated that these remote sensing methods will be the future of invasive plant identifications in 10 to 20 years.

**Figure 16.** Map of Priority 1 weed species in the WMMWP West Unit, based on data collected during ground transects and aerial surveys. Data regarding Priority 1 and Priority 2 weed species in all six WMMWP management units are graphically recorded in this manner. For reference, the 2,800-foot elevation line is drawn in red.

As shown, a population of pampas grass (*Cortaderia* sp.) has become established deep in Kauaula Valley to the south, and *Tibouchina herbacea* is prevalent across the mountainside. In this unit, strawberry guava (*Psidium cattleianum*) is well established below the 2,800-foot line and is advancing further upslope.

Once inventoried, invasive plants are prioritized based on their level of threat to the ecosystem. Current priority targets for WMMWP include several habitat modifying species, each requiring a particular approach depending on its susceptibility to various

control techniques, mode of dispersal, our ability to detect and access the plant, and its level of infestation. Table 11 and Table 12, shown below, respectively list the Priority 1 and Priority 2 species identified by WMMWP, along with the prevalence and control methods of each. Species ranked under Priority 1 are already established within the watershed core, while species ranked under Priority 2 threaten to encroach upon the pristine core above 2,800 feet.



**Table 11.** Inventory of Priority 1 weed species that have infiltrated the core watershed area above 2,800 feet. General control and biological control strategies – if any exist – are listed for each species.

Species Name	Common Name	WRA Rank	Units Present	Highest Known Elevation	Highest Known Elevation WMMWP	General Control Strategy	Biological Control
<i>Psidium cattleianum</i>	Strawberry guava	18	All	4,265 ft	4,800 ft	Cut-stump/frill treatments of undiluted triclopyr amine	<i>Tectococcus ovatus</i> – approved but not dispersed in WM
<i>Tibouchina herbacea</i>	Cane Tibouchina	24	All	5,249 ft	5,788 ft	Pulling – limited to SEAs	<i>Syphraea uberabensis</i> approved but not dispersed in WM
<i>Clidemia hirta</i>	Koster’s curse	27	W, NW, NE, E, SE	4,340 ft	3,500 ft	A 50% triclopyr amine application to cut stump	<i>Liothrips urichi</i> – but needs more research. A nematode is in development which is promising.
<i>Cortaderia Species</i>	Pampas grass	24 & 26	All	11,154 ft	5,700ft	Glyphosate applied to foliage	None
<i>Macaranga tanarius</i>	Parasol leaf tree	12	E, SE, SW	4,400 ft	4,400 ft	None verified	None
<i>Sphaeropteris cooperi</i>	Australian tree fern	8	W, NW	4,593 ft	3,120 ft	Removal of growing tip; fronds removed and sprayed with imazapyr directly on the stem terminals	None
<i>Rubus argutus</i>	Prickly Florida blackberry	21.5	W, NW, SE	8,292 ft	4,000 ft	0.5% triclopyr amine applied to wet foliage; glyphosate; cut stump and Garlon 3A	None successful
<i>Toona ciliata</i>	Indian mahogany	12	E, SE, SW	4,921 ft	3,700 ft	Cut-stump treatments of triclopyr ester	Unknown

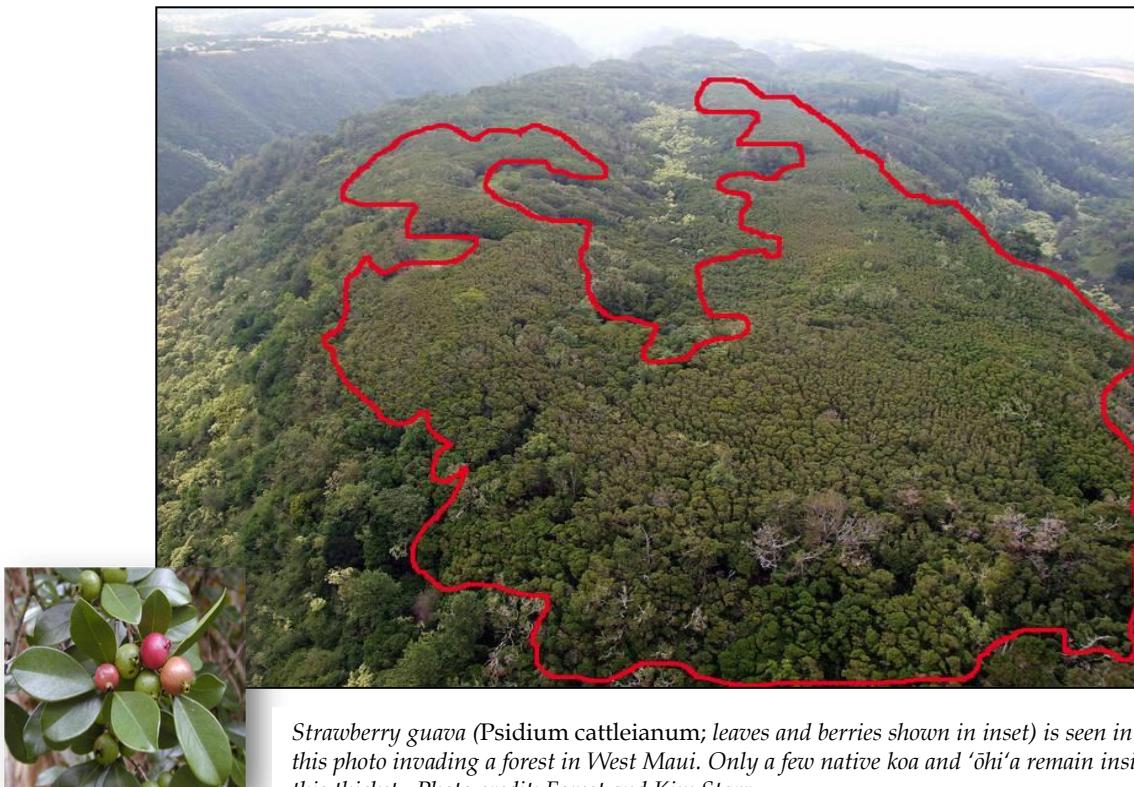
WRA Ranking is taken from the Hawaii-Pacific Weed Risk Assessment. More information can be found at <https://sites.google.com/site/weedriskassessment/home>



**Table 12.** Inventory of Priority 2 weed species threatening to enter the core watershed area above 2,800 feet. General control strategies have been developed, yet biological control strategies have yet to be identified for these species.

Species Name	Common Name	WRA Rank	Units Present	Highest Known Elevation	Highest Known Elevation WMMWP	General Control Strategy	Biological Control
<i>Acacia mearnsii</i>	Black wattle	15	W, SW	5,577 ft	2,500 ft	Cut stump or Triclopyr ester dripped into drilled holes	None
<i>Alpinia zerumbet</i>	Shell ginger	10	W	2,788 ft	unknown	None documented - may be able to mimic for other gingers	None
<i>Angiopteris evecta</i>	Mule's foot fern	8	E	4,895 ft	1,300 ft	Cut, remove black stipules off site	Unknown
<i>Ardisia elliptica</i>	Inkberry, Shoebutton Ardisia	11	NW, E	1,804 ft	2,045 ft	Glyphosate foliar and triclopyr basal bark and cut stump applications	Unknown
<i>Casuarina equisetifolia</i>	Ironwood	21	All	5,000 ft	3,500 ft	Shoots and saplings - foliar application of triclopyr amine. Larger trees - cut-surface applications of glyphosate, dicamba, and picloram	None
<i>Cenchrus setaceus</i>	Fountain grass	26	None	8,530 m	unknown	Glyphosate applied by spraying or drizzle or by hexazinone at 10-20% of liquid concentrate applied to wet the green foliage	None
<i>Cestrum nocturnum</i>	Night blooming jasmine	17	E	2,952 ft	3,300 ft	Triclopyr ester at 20% in crop oil applied via basal bark	None
<i>Cinchona sp.</i>	Quinine	9	W	12,800 ft	2,100 ft	Triclopyr applied to cut stump and basal bark	None
<i>Cinnamomum burmannii</i>	Padang cassia	12	W, NW, NE	2,000 ft	2,435 ft	100% concentration of triclopyr amine after a cut-stump or frill to be effective; injection of Imazypr	None
<i>Falcataria moluccana</i>	Albizia	8	E	2,400 ft	2,550 ft	Aminopyralid injection	None
<i>Melochia umbellata</i>	Melochia	7	SE	1,500 ft	unknown	Pulling saplings and cut stump with 10% triclopyr for larger trees	None
<i>Morella (Myrica) cerifera</i>	Wax myrtle	20	W	1,608 ft	unknown	Cut or frill applications of 100% triclopyr	None
<i>Rubus armeniacus</i>	Himalayan blackberry	24	W, NW	6,300 ft	unknown	Foliar, stem injection, cut stump and basal stem methods of glyphosate or triclopyr products of 10%	None

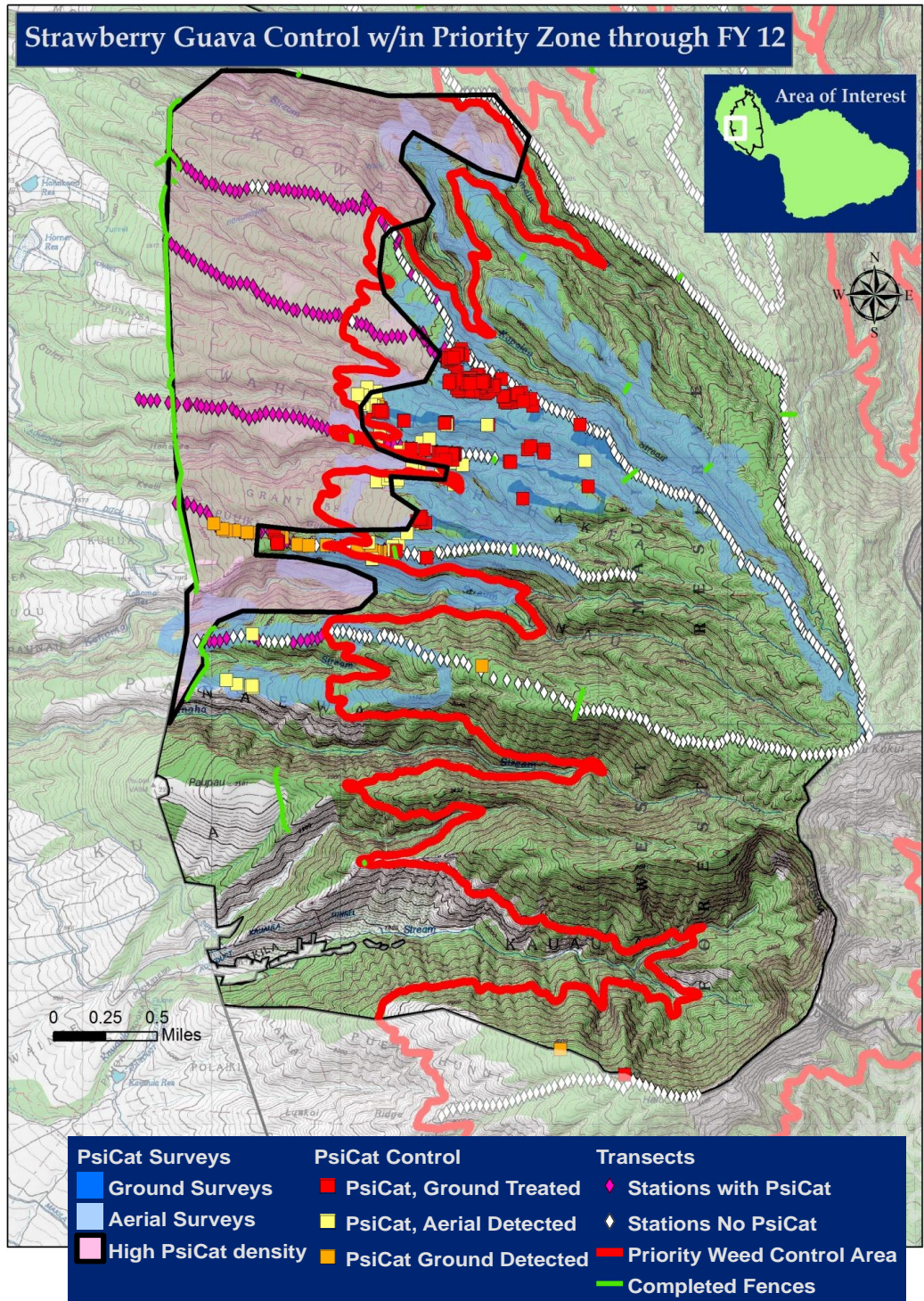
Problematically, however, the core area above 2,800 feet presents some of the most challenging conditions in which to detect, access, and treat invasive species. Unfortunately, invasive plants grow well in cloud laden, windswept, rain saturated, and cliffy terrain – types of places that limit helicopter and ground-based control options. Given these challenges, preventing the establishment or further spread of invasive species is highlighted as a priority. Aggressive approaches must be taken to prevent further introductions of invasive species into the watershed. Strict procedures are followed to ensure that all equipment and clothing utilized in the watershed is inspected and cleaned, and helicopter flights will originate from areas free of aggressive invasive plants. Large infestations will require resources far greater than we can provide. By partnering with other organizations and leveraging available resources to treat invasive plants within one of these levels we can at least keep the invasions from getting worse.



*Strawberry guava (Psidium cattleianum; leaves and berries shown in inset) is seen in this photo invading a forest in West Maui. Only a few native koa and 'ōhi'a remain inside this thicket. Photo credit: Forest and Kim Starr.*

It is important to invest in measures to prevent additional noxious plants from becoming established in the first place, and to support long-term research programs to improve control methods. For several priority species, no effective control method exists for large infestations. Most invasive species are remarkably resilient and must be treated with multiple methods to be completely eradicated depending on their size and location. Limiting forest disturbance by feral animal control is a key starting point for effective invasive plant control. Beyond this, control methods employed by WMMWP include manual pulling, mechanical removal, chemical treatment, and helicopter assisted treatment. Treated plants and searched areas are thoroughly mapped to organize further searching, retreatment and future follow up surveys (Figure 17).





*Figure 17. Map depicting the range of strawberry guava surveyed by WMMWP in the West Unit, including treated and untreated populations. Records of inventory surveys and control treatments for all target species in all management units are kept in this manner.*

Biological controls, the use of insects or diseases that are particularly effective at limiting the spread or setting back the target species, are needed to combat our worst invasive plant species. Typical biocontrols are natural enemies from the native home ranges of introduced invasive plants which are target-specific and unconstrained by terrain, weather, and other human limitations. Support for this tactic is gaining as the public become better educated on its merits.

In March 2009, Maui County passed Resolution 09-35 “Supporting Safe Effective Biological Control for Maui County’s Forest Pests.” A *Tibouchina herbacea* biocontrol has made progress and is hoped to be released on Maui in the next few years thanks in part to early funding for development by the Maui County Department of Water Supply. Strawberry guava also has a promising agent for release and is gaining support. *Clidemia hirta* may have new candidates for release which need to be further tested, supported and utilized when ready. This science is expanding and improving, and although funding is limited, biocontrols may be the most cost effective method in the long run.

Other technologies and application methods should also be considered, and relationships with outside researchers should be fostered to integrate the best methods. One novel example is Herbicide Ballistics Technology (HBT) being developed by Dr. James Leary with the University of Hawai’i College of Tropical Agriculture and Human Resources (CTAHR). This method uses a paint ball gun to shoot encapsulated herbicide in specific doses at invasive plant targets. This tool can be used on the ground and in helicopters to address hard to reach targets like strawberry guava that often grow on cliff faces and inaccessible terrain. More tried and true methods employed by TNC and MISC include helicopter-mounted precision spray applicators which apply precise doses of herbicides to address invasive plant targets like Australian tree fern (*Sphaeropteris cooperi*) and *Miconia*. Volunteer and biological control efforts will be necessary to tackle dense, weedy areas where continuous stands of trees exist and the manpower and rehabilitation efforts would otherwise be cost prohibitive. In time it is hoped that resources and technology will help us regain more land and further optimize the watershed.

As the watershed and its management units are progressively freed of ungulates and protected behind fences, new gaps in the forest cover, in which invasive plants can spread, will diminish. A more stable and robust forest environment enables WMMWP staff to define target areas more clearly and remove the worst habitat-modifying and water consuming invasive species.

The associated WMMWP Weed Management Plan takes into consideration expert opinions from resource managers of several Maui-based conservation organizations. Input was given on the most current and historic understandings of target species, and species were prioritized in terms of their potential threats to the watershed. Moving forward, the Weed Management Plan sets goals to prevent, eliminate, suppress, or contain each species. Here, control objectives that protect the watershed interior are prioritized for each of the six major WMMWP management units. Ultimately, the plan directs control efforts towards priority targets for which lasting and meaningful benefits can be realized and proven successful.

#### **Invasive Plant Control Program Goals:**

- Prevent the introduction of new invasive pests
- Prevent the establishment and spread of the priority watershed-modifying species
- Focus on efforts that protect the 15,000-acre watershed interior above 2,800 feet in elevation
- Expand weed-free interior area outward and makai from the summit

### **Invasive Plant Control Program Objectives:**

- 1) Update the WMMWP Weed Management Plan which identifies priority invasive plant species and specific management control strategies for each as needed.
- 2) Prioritize the approximately 15,000-acre watershed interior (i.e. areas above 2,800 feet elevation) by eliminating habitat modifying invasive plants (Table 11) from within this primary management zone.
- 3) Establish control objectives for controlling priority invasive plant species which pose a high threat to the interior of the watershed (Table 12).
- 4) Expand weed-free zone outward toward the Forest Reserve boundary and from high elevation to low elevation, where feasible, focusing on habitat modifying invasive plants.
- 5) Support the Maui Invasive Species Committee (MISC) programs that target West Maui invasive species such as pampas grass (*Cortaderia sp.*), fountain grass (*Cenchrus setaceus*), and other target species as appropriate.
- 6) Prevent the establishment of *Miconia calvescens* on West Maui.
- 7) Enforce strict procedures for removing invasive plant seeds from vehicles, equipment, and clothing before entering watershed areas.
- 8) Support State and County legislation, outreach, and funding efforts to develop biological controls for our worst invasive plant species (e.g. *Tibouchina herbacea*, *Clidemia hirta* and *Psidium cattleianum*).
- 9) Track novel technological developments in invasive plant identification and control, and implement within the watershed when viable.
  - a. Work with high resolution aerial imaging contractors to map priority invasive plants
  - b. Integrate remotely sensed data for weed detection and interpretation
  - c. Follow developments in herbicide application measures and formulations like University of Hawai'i, CTAHR Herbicide Ballistic Technology
- 10) Further develop spatial data management methods to document invasive plant threats, range changes, weed-free areas, and control strategies.
- 11) Maintain monitoring data sufficient to measure success, inform adaptive management, funders, and policy makers.



Table 13. Objectives and Costs for Invasive Plant Control Program

Management Strategy: Invasive Plant Control							
Objectives	Cost Per Unit/Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost
1) Update the WMMWP Weed Management Plan which identifies priority invasive plant species and specific management control strategies for each as needed .	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
2) Prioritize the ~15,000 acre watershed interior (i.e. areas above the 2,800' elevation) by eliminating habitat modifying invasive plants (refer to Table 4) from within this primary management zone.	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 1,212,500.00
3) Establish control objectives for controlling priority invasive plant species (refer to Table 5) which pose a high threat to the interior of the watershed.	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 242,500.00	\$ 1,212,500.00
4) Expand weed-free zone outward toward the Forest Reserve boundary and from high elevation to low elevation, where feasible, focusing on habitat modifying invasive plants.	Included in item 2	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
5) Support the Maui Invasive Species Committee (MISC) programs that target West Maui invasive species such as Pampas grass ( <i>Cortaderia setacea</i> ), fountain grass ( <i>Pennisetum setaceum</i> ), and other target species as appropriate..	Included in Coordination, 2 & 3	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
6) Prevent the establishment of <i>Miconia calvenscens</i> on West Maui.	Included in Monitoring Section	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
7) Enforce strict procedures for removing invasive plant seeds from vehicles, equipment, and clothing before entering watershed areas.	Included in 2 & 3	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -

Table 13. (Continued)

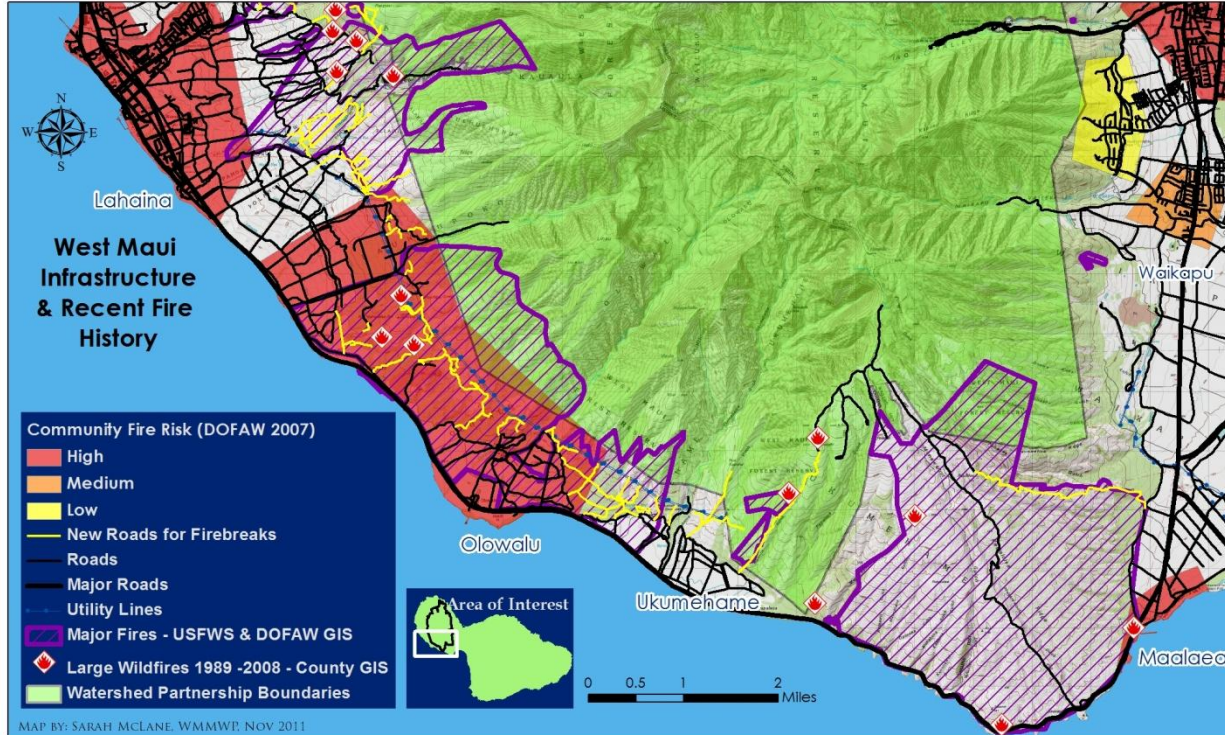
<b>Management Strategy: Invasive Plant Control</b>							
<b>Objectives</b>	<b>Cost Per Unit/Notes</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Total Cost</b>
8) Support State and County legislation, outreach, and funding efforts to develop biological controls for our worst invasive plant species (i.e. Tibouchina, Clidemia and Psidium cattleianum)	For one agent per year	\$ 75,000.00	\$ 75,000.00	\$ 75,000.00	\$ 75,000.00	\$ 75,000.00	\$ 375,000.00
9) Track novel technological developments in invasive plant identification and control, and implement within the watershed when viable.							
a. Work with high resolution aerial imaging contractors to map priority invasive plants	\$150,000/5 yrs.	\$ 150,000.00	\$ -	\$ -	\$ -	\$ -	\$ 150,000.00
b. Integrate remotely sensed data for weed detection and interpretation	Included in 11	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
c. Follow developments in herbicide application measures and formulations University of Hawaii, CTAHR Herbicide Ballistic Technology	yr. 1 includes equipment	\$ 75,000.00	\$ 60,000.00	\$ 60,000.00	\$ 60,000.00	\$ 60,000.00	\$ 315,000.00
		\$ 225,000.00	\$ 60,000.00	\$ 60,000.00	\$ 60,000.00	\$ 60,000.00	\$ 465,000.00
10) Further develop spatial data management to document invasive plant threats, range changes, weed-free areas and control strategies.	Tied to 11	\$ 30,000.00	\$ 30,000.00	\$ 30,000.00	\$ 30,000.00	\$ 30,000.00	\$ 150,000.00
11) Maintain monitoring data sufficient to measure success, inform adaptive management, funders, and policy makers.	Tied to 12	\$ 30,000.00	\$ 30,000.00	\$ 30,000.00	\$ 30,000.00	\$ 30,000.00	\$ 150,000.00
		<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Total Cost</b>
<b>TOTAL FOR INVASIVE PLANT CONTROL</b>		\$ 845,000.00	\$ 680,000.00	\$ 680,000.00	\$ 680,000.00	\$ 680,000.00	\$ 3,565,000.00

### 3. WILDFIRE PROGRAM



Photos, from left to right: Green forest burns along the South Ridge of Kaua'ula Valley; drought prone and fire scorched Pohakea Gulch, mauka of Mā'alaea; Helu māmane and 'a'ali'i shrubland burned to mineral soil; view of 2007 Lahaina fire from the Lanai ferry. Photo credits: WMMWP

Fire is a major threat to the forests and watersheds of the West Maui Mountains, particularly on the dry leeward slopes and surrounding lowlands. The vast majority of destructive fires in West Maui have resulted from human activities in or adjacent to the watershed. Wildfires can be ignited by arching power transmission lines, arson, sparks from dirt bike tail pipes, friction caused by construction tools and equipment, illegal camp fires, catalytic converters, or fireworks. In the last decade, several major wildfires burned thousands of acres in West Maui alone. Several of these fires encroached into watershed lands, impacting ahupua'a from Waikapu in the east to Kahana in the west.



**Figure 18.** The above map shows some of the major fires that have spread across thousands of acres in this view of southern West Maui. Fires not only threaten at risk urban and rural communities (colored polygons) in this arid region but are also a major risk to the sustainability of the watershed. During dry periods, fires have the potential to permanently damage native forest cover. Yellow lines show utility roads which could be improved for fire breaks and emergency access.



Prior to human occupation, fire in Hawai'i happened about once every 700 to 1,000 years (Cuddihy and Stone 1990). Widespread invasion of alien fire-adapted grasses in the early 20<sup>th</sup> century, including fountain grass (*Cenchrus setaceus*), broomsedge (*Andropogon virginicus*), and molasses grass (*Melinis minutiflora*), is primarily responsible for the great increase in wild land fires in the second half of the century (Cuddihy and Stone, 1990). From 1904 through 1939, 205 brush fires in the Territory of Hawai'i burned 14,780 hectares (36,500 acres). Then from 1940-1976, 878 fires burned up to 83,660 hectares (206,650 acres) (Cuddihy and Stone, 1990). The number and intensity of wildfires in West Maui has been increasing, most notably because of the anthropogenic causes discussed above. However, there are also natural reasons for this increased incidence.



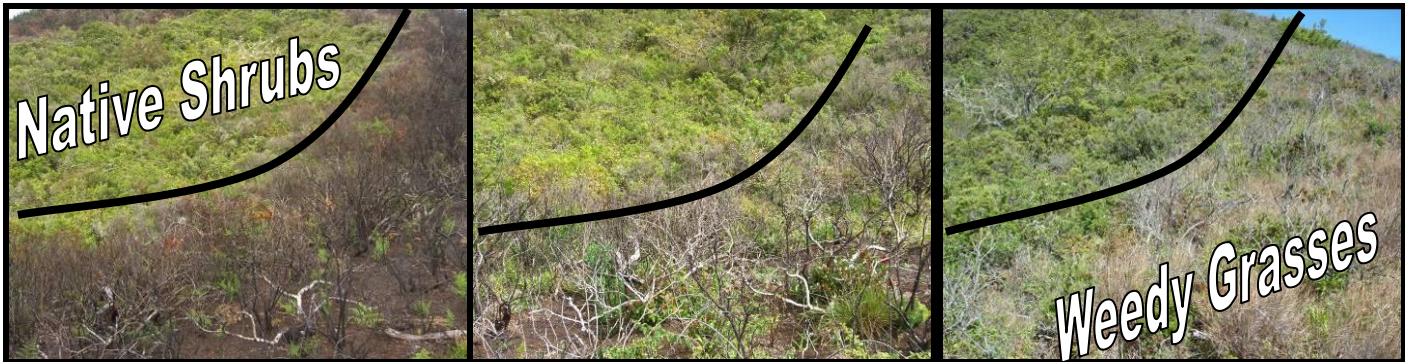
*At left, before picture of intact, pristine shrubland, set in contrast to the fire-burned aftermath at right. This 2007 fire extended from near sea level in Lahaina to an elevation of 3,600 feet. Invasive weeds are now able to establish in burnt gaps and will make this area more prone to fire in the future. Photo credits: WMMWP.*

Climate change in Hawai'i and here in West Maui in the form of reduced rainfall and prolonged drought (See Appendix C) renders the landscape more fire-prone and vulnerable to increased incidents of fire (Cuddihy and Stone 1990). A century-long trend of declining rainfall in Hawai'i has accelerated, with a 12 percent decline in the last 20 years alone (Giambelluca *et al.* 2011). The surrounding landscape below the WMMWP boundary was formerly under irrigated agriculture which stood as a managed and patrolled buffer between fire causing issues and the forest. Now these former agricultural lands are mostly fallow fields blanketed by weedy grasses which burn quickly and widely, providing continuous fuel connectivity between fire ignition sources and the forest. If not left fallow, the fields have been developed, thus increasing the potential for more fires caused by human sources.

Once a fire rolls through a native forest habitat, the area is never the same. Contrary to mainland ecosystems where forests have adapted to natural fire occurrences from lightning, Hawaiian forests have not developed adaptations to resist such destructive forces. After wildfires are extinguished, native species are out-competed by introduced species which can colonize burned land at a faster rate. To make matters worse, fire begets fire. As the forest is



invaded by non-native species, those species make the area more fire prone. The same grasses that allow for fast moving fires in the lowlands reach higher in elevation. The next fire will move up the mountain more quickly and potentially push the impact of fire deeper into the watershed. In times of severe drought, fire can even move into wet forest and further impact the ability of the watershed to sustain water resources. Impacts from fire include a reduction in forest complexity and diversity, decreased water absorption, decreased water infiltration, decreased humidity (which would help a forest to resist fire), and increased erosion and nutrient runoff into streams and coral reefs.



*The progression of photos from left to right shows the conversion of native shrub cover to invasive fire-prone grasses over a four-year period ranging from May 21, 2007 to February 13, 2008 to August 26, 2011 at approximately 3,000 feet elevation in Helu. Invasive grasses render the area more prone to fire, as they are quicker to burn and retain less moisture than layers of native ferns and cloud-laden tree canopies. Photo credits: WMMWP*

Fire prefers dry material to burn; consequently, rare native vegetation communities such as lowland dry shrub land and lowland dry forests are typically the first to burn. In West Maui, this habitat type covers only two percent of its former range, with 1,192.5 acres of this type remaining out of over 60,931.3 acres that existed prior to human settlement in West Maui (TNC, 2005a). Recent fires have consumed 22 percent of the remaining ranges and reduced the range to 927 acres (TNC, 2005a). As the forest type disappears, so do many species unique to that habitat (Figure 19).



*The Kahana Fire extended into typically misty, cloud laden forest of West Maui during droughts in 2011. Photo credit: WMMWP*

**Management Methods:**

Although Maui County and the DLNR currently provide the first line of defense against fires, WMMWP should identify areas where fire is likely to occur and promote and take preventive measures to reduce fire risk. For example, maintaining fire and fuel breaks in high-risk areas could prevent fire from spreading into forested areas. Many former and current field and utility access roads could be improved and maintained to function as both fire breaks and emergency access roads. Currently, this method is being used on Moloka'i with some success; it is being replicated in the Ku'ia area over Lahaina; and it is planned for

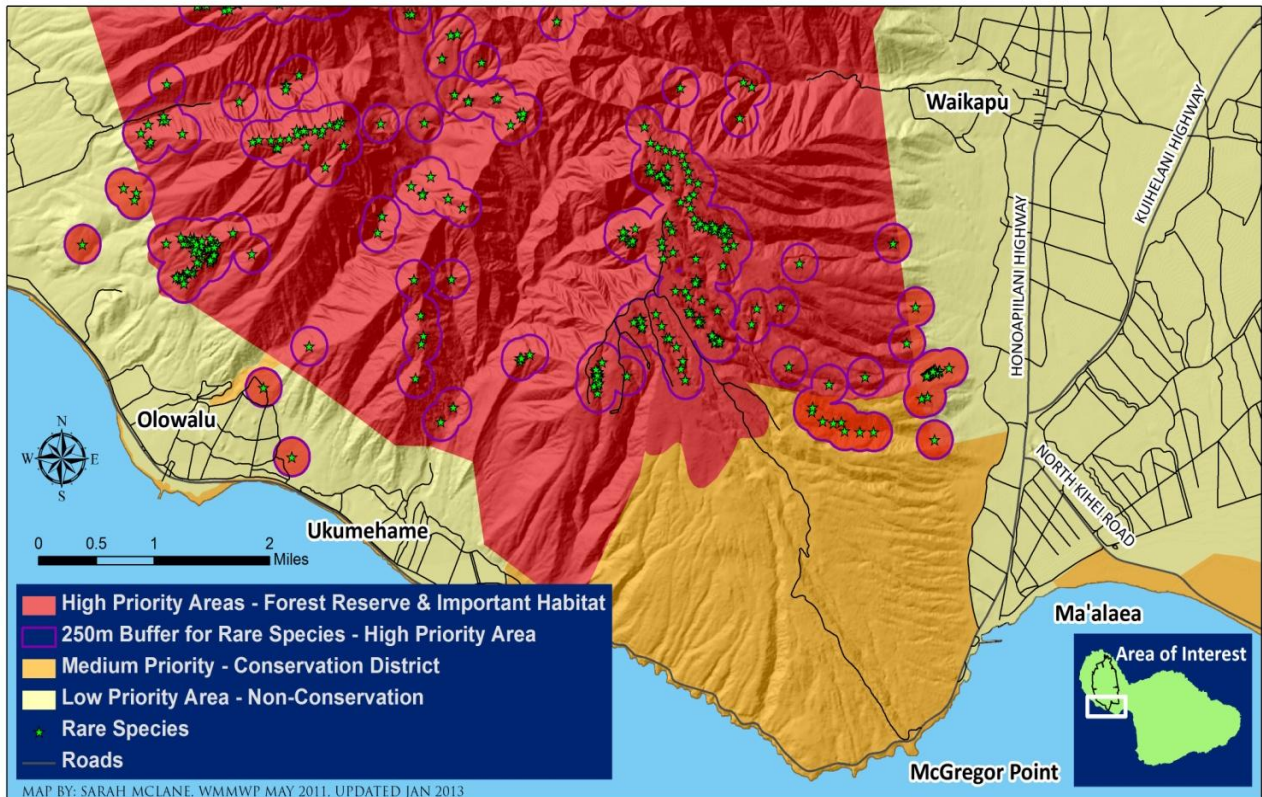
implementation from Launiupoko to Olowalu. Similar plans should be pursued for all remaining fire prone areas with priority on the southern half of the West Maui watershed.

Technicians hired by the Partnership should be trained to the extent possible in basic firefighting techniques to supplement DLNR staff and to aid in self preservation in case of a fire emergency. Other Partnership staff can assist in providing information on access, water locations, hazards, and points of interest should be identified and properly trained as well.



A 2006 wildfire burns across Mā'alaea. Photo credit: Pacific Disasters Center, 2009

Through contributions to the West Maui Fire Task Force, WMMWP is participating in fire planning and the promotion of watershed protection as a priority for fire suppression. Landowner and manager participation in the West Maui Fire Task Force is encouraging the development of pre-suppression strategies. Developing and implementing a Community Wild Fire Protection Plan will also help hone community supported strategies as well as qualify areas



for federal grant assistance in fire prevention.

**Figure 19. High Priority Areas and Rare Species in Fire Zones:** Rare and endangered species, watersheds, and conservation lands are irreplaceable and warrant protection efforts. Fire suppression resources are often used to their maximum abilities in large fires and resources need to be mapped for prioritization. The Maui Fire Department prioritizes life, environment and property in that order.



### **Wildfire Program Goals:**

- Decreased incidence of wildfires within the watershed to reduce impacts to watershed vegetation, water recharge, federally protected rare species, post-fire soil erosion, and invasions of alien species
- Minimized impacts of fire on life, environment, property, infrastructure, and communities

### **Wildfire Program Objectives:**

- 1) Support current efforts by Maui Fire Department and DLNR to prevent, suppress and contain wildfires which threaten the watershed.
- 2) Promote and enhance wildfire preparedness and planning.
  - a. Develop a Community Wildfire Protection Plan for West Maui
  - b. Work with Maui County to integrate Partner knowledge into a pro-active suppression system
- 3) Continue to participate in the multi-entity West Maui Wildfire Task Force.
  - a. Facilitate landowner participation in fire preparedness and response
  - b. Facilitate landowner contributions of current records of key fire infrastructure such as conditions and locations of roads, gates, and water sources
  - c. Provide information on management infrastructure and rare species
- 4) Promote and support the implementation of fire mitigation measures in fire-prone areas surrounding WMMWP lands.
  - a. Maintain and improve firebreaks in the wildland-urban interface to limit spread
  - b. Promote fuel reduction in adjacent lands and along watershed boundaries through methods such as chipping, thinning and grazing of brush
  - c. Promote Firewise developments which integrate fire buffers such as green belts and hardened paths for emergency fire equipment
- 5) Train staff to assist in and survive wildfire outbreaks and emergencies
  - a. Evaluate the training of WMMWP staff in basic firefighting techniques and fire behavior to supplement DLNR and MFD efforts
  - b. Train staff in self preservation techniques, should fire become a threat during fieldwork
  - c. Provide facilitation and informational services during fires relating to access points, water sources and threatened and endangered species locations
- 6) Develop a wildfire emergency protocol with Maui County and the State.

- 7) Evaluate post forest fire impacts and Partnership ability to monitor, mitigate or rehabilitate burned areas to prevent degradation.
- 8) Maintain monitoring data sufficient to measure success, inform adaptive management, funders, and policy makers.
- 9) Where appropriate, deploy volunteer assistance to rehabilitate burned areas and educate on wildfire prevention.



Table 14. Objectives and Costs for Wildfire Program

Management Strategy: Fire							
Objectives	Cost Per Unit/ Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost
1) Support current efforts by Maui Fire Department and DLNR to prevent, suppress and contain wildfires which threaten the watershed including staff time.	Add to Coordination	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 15,000.00
2) Promote and enhance wildfire preparedness and planning.							
a. Develop a Community Wildfire Protection Plan for West Maui (as contractor cost)		\$ 10,000.00	\$ -	\$ -	\$ -	\$ -	\$ 10,000.00
b. Work with Maui County to integrate partner knowledge into a pre-suppression system		\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 7,500.00
		\$ 11,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 17,500.00
3) Participate in multi-entity West Maui Wildfire Task Force.							
a. Facilitate landowner participation in fire preparedness and response		\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00
b. Facilitate landowner contributions of current records of key fire infrastructure such as condition of roads, gates, and water sources		\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00
c. Provide information on management infrastructure and rare species		\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00
		\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 15,000.00
4) Promote and support the implementation of fire mitigation measures in fire-prone areas surrounding WMMWP lands.							
a. Maintain and improve firebreaks in the wildland urban interface to limit spread	Average 9.75K Range from 4.5 to 15K/mile	\$ 9,750.00	\$ 9,750.00	\$ 9,750.00	\$ 9,750.00	\$ 9,750.00	\$ 48,750.00
b. Promote fuel reduction in adjacent lands and along watershed boundaries through methods such as chipping, thinning and grazing of brush	Add to Coordination	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 7,500.00
c. Promote Firewise developments which integrate fire buffers such as green belts and hardened paths for emergency fire equipment	Add to Coordination	\$ 1,800.00	\$ 1,800.00	\$ 1,800.00	\$ 1,800.00	\$ 1,800.00	\$ 9,000.00
		\$ 13,050.00	\$ 13,050.00	\$ 13,050.00	\$ 13,050.00	\$ 13,050.00	\$ 65,250.00

Table 14. (Continued)

Management Strategy: Fire							
Objectives	Cost Per Unit / Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost
5) Acquire training for staff and other entities to assist in a fire emergency and for self preservation.							
a. Evaluate the use of partnership staff in basic firefighting techniques and fire behavior to supplement DLNR and MFD efforts	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
b. Train staff for self preservation purposes if fire becomes a threat during work		\$ 1,200.00	\$ -	\$ 1,200.00	\$ -	\$ 1,200.00	\$ 3,600.00
c. Provide facilitation and informational services during fires related to knowledge in access points, water sources and threatened and endangered species	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
		\$ 1,200.00	\$ -	\$ 1,200.00	\$ -	\$ 1,200.00	\$ 3,600.00
6) Develop a fire emergency protocol with Maui County and the State.	Included in Coordination	\$ 1,000.00	\$ 1,000.00	\$ -	\$ -	\$ -	\$ 2,000.00
7) Evaluate post forest fire impacts and ability to monitor, mitigate or rehabilitate the area to prevent degradation. ( Labor and Helicopter)		\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 15,000.00
8) Maintain monitoring data sufficient to measure success, inform adaptive management, funders, and policy makers.	Included In Monitoring	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
9) Where appropriate, deploy volunteer assistance to rehabilitate burned areas and							
Staff Time	\$ 6,000.00	\$ 6,000.00	\$ 6,000.00	\$ 6,000.00	\$ 6,000.00	\$ 6,000.00	\$ 30,000.00
Volunteer supplies	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00
		\$ 7,000.00	\$ 7,000.00	\$ 7,000.00	\$ 7,000.00	\$ 7,000.00	\$ 35,000.00
		<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Total Cost</b>
<b>TOTAL FOR FIRE</b>		\$ 42,750.00	\$ 31,550.00	\$ 31,750.00	\$ 30,550.00	\$ 31,750.00	\$ 168,350.00

#### 4. HUMAN ACTIVITIES MANAGEMENT

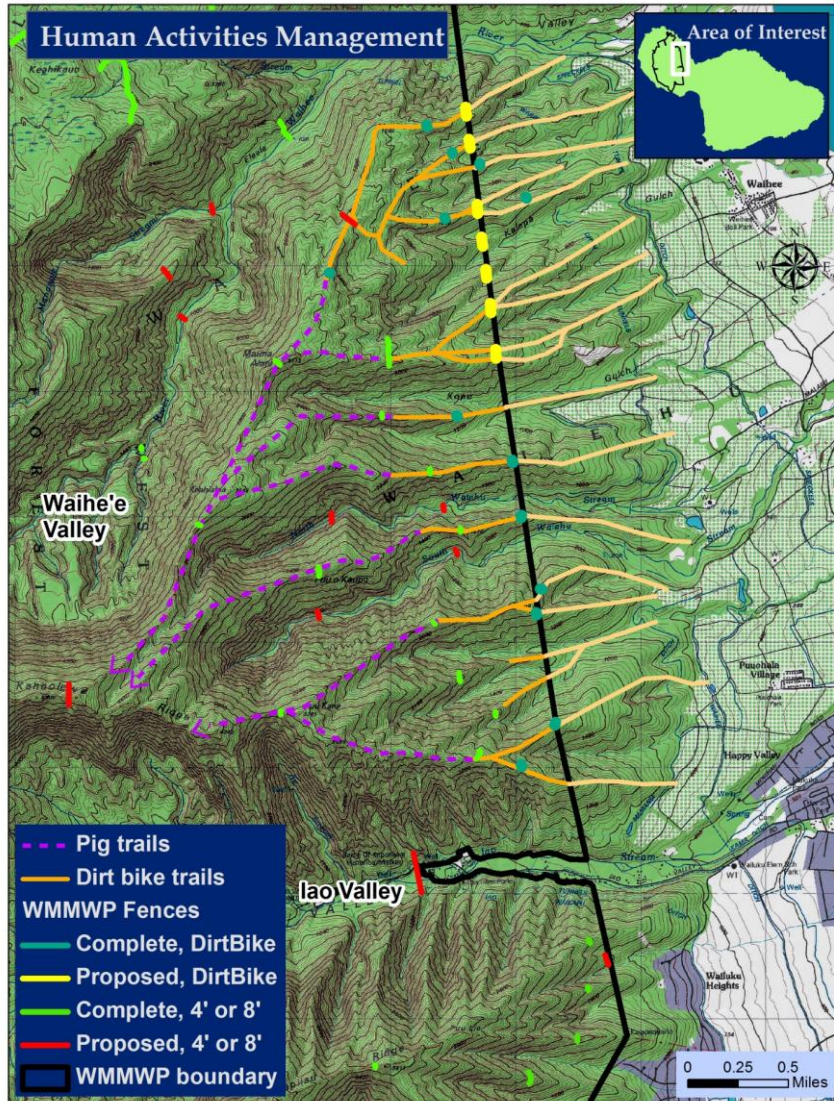


Photos, left to right: Dirt bike trail up ridge into native forest; eroded dirt bike trail; multiple fanning eroded dirt bike trails up ridge; erosion caused by dirt bike trail on ridge. Photo credits: WMMWP

Human activities may not be the most conspicuous threats to the West Maui Watershed, but their effects are nonetheless significant. Hikers, bikers, and landscapers can spread plant and animal pests between and within islands. Such human traffic has been implicated in the spread of major pests such as *Miconia*, *Clidemia*, Jackson's chameleons, and little red fire ants to name a few. Furthermore, human activities can directly damage native vegetation by blazing trails, causing soil erosion, or by sparking wildfires.

Recreational motorized vehicles in the watershed can be a source of significant damage. In West Maui, unauthorized recreational dirt bike riding is causing dramatic damage to native vegetation around the perimeter of the watershed. Its popularity is increasing and so are the illegal trails which are penetrating deeper into the forest, particularly in the East Unit (Figure 20). Acres of accessible ridge tops are covered in overhead-high ruts, crushed vegetation, and deposits of churned mud and dust. The exposed and disturbed substrate is easily colonized by invasive species, such that the incursions of unauthorized vehicles represent significant pathways for invasive plant and feral animal dispersal into the watershed. Dirt bikes are also believed to pressure pigs into new areas, and riders have vandalized fences, thus allowing pig ingress into areas from which they were previously excluded.

Aside from dirt biking, other bands of adventure seekers have begun to probe undisturbed areas of the West Maui Mountains. Problematically, unauthorized trespass and creation of trails into the native forests increases the incidence of introduced plant and animal pests, soil erosion, and damage to rare species and critical habitats. They also represent a significant liability problem, in the event of injury or death, to the landowning Partners. Thus, steps must be taken to avert unauthorized trail-blazing and redirect energies towards official public access trails and authorized points of entry into the watershed.



*Figure 20. Areas of the watershed near Waihe'e Valley are under assault from dirt bikes which continue to expand coverage. Pigs gain deeper and easier access into the watershed on trails and invasive weeds are more easily spread.*

Another human activity destructive to the watershed and hazardous to watershed managers is illicit cultivation of marijuana. This activity has been documented at various locations at lower elevations in the watershed (typically below 2,000 feet elevation), and is primarily conducted in wet and moist areas. Although an infrequent practice, marijuana growers sometimes set anti-personnel devices such as booby traps

of various designs which are intended to protect the valued plants. Growers may interfere with managers in the field and threaten or harm watershed staff or volunteers. The activity may also introduce alien pest and invasive plant species in the plant and soil material that are transported into the forest.

### **Management Methods:**

An outreach and education campaign will be a fundamental approach to righting human behaviors that negatively impact the watershed. It is hoped that by informing the public about the native ecosystems and watershed values they will alter their practices and become advocates for watershed protection. Without the engagement and cooperation of the public, the objectives of this plan will not reach their full potential. Direct appeals can also be made to the public in many forms which will be described in the Public Education and Awareness section of this plan (page 77).



Beyond appealing to the good nature of the community, it may be necessary to take a more aggressive approach to stop impacts and unlawful activities. Coordination with the DLNR Division of Conservation and Resource Enforcement (DOCARE) and Maui Police Department will be necessary to stop chronic behavior such as trespassing tour operators and dirt bike riders. Other methods may include posting signs to deter damage and erecting physical barriers like fences, barricades, or concrete blockades to prevent unlawful motorized access to the watershed. These barriers will also stand as physical reminders to trespassers that watershed management is in effect within the marked area.

While the above actions may be necessary to protect the land, it is understood that access to the forest for traditional practices must be assured. In this regard, it is underlined that access to private lands for cultural gathering will be granted by each landowner upon request.

#### **Human Activities Management Program Goals:**

- Decrease trespassing and destructive intrusions into the watershed
- Decrease the spread of invasive species and new introductions of species into the watershed caused by activities in and nearby the watershed

#### **Human Activities Management Program Objectives:**

- 1) Educate the public on damage to the watershed that can result from activities such as dirt bike riding and hiking and inform communities about the impacts of releasing, planting, and propagating invasive species adjacent to the watershed.
  - a. Use television, radio and printed media to create a series of PSAs
  - b. Conduct outreach sessions with community groups, residents, and home owners associations based nearby the WMMWP protection area
  - c. Post informational signs in interface locations to deter trespassers
- 2) Identify and promote areas where public recreational activities such as hiking and mountain biking can occur with minimal harm to watershed vegetation.
  - a. Assist Off-Highway Vehicle Association and State Nā Ala Hele Program with identifying and publicizing alternative riding locations
- 3) Manage trespassing to deter harmful activities and impacts to the watershed.
  - a. Post interpretive, "Malama 'Aina", and no trespass signs to deter intrusions
  - b. Construct strategic fences, barriers, and concrete blockades at key trespass points
  - c. Work with drug enforcement agencies to eliminate marijuana cultivation in the West Maui Mountains
  - d. Assess the use of private security to dissuade repeat offenders from entry into hot spot areas
  - e. Engage Maui Police Department and DOCARE for enforcement support

- 4) Mitigate and rehabilitate severely degraded areas to minimize erosion and invasive species establishment, potentially using volunteers to assist as well as educate.
- 5) Maintain and enhance existing public hunting programs at Kahakuloa Game Management Area and on other public and private lands along and below the conservation district boundary.
  - a. Assess organized hunting below WMMWP boundary to remove ungulate pressure and implement if appropriate
- 6) Support enhanced enforcement of forest trespass and invasive species regulations, and advocate new regulations and laws protecting watersheds from inappropriate human activities.
  - a. Investigate ways to improve enforcement on laws and fines to protect privately held Forest Reserve lands
- 7) Maintain monitoring data sufficient to measure success, inform adaptive management, funders, and policy makers.

Table 15. Objectives and Costs for Human Activities Management Program

Management Strategy: Human Activities Management								
Objectives	Cost Per Unit / Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
1) Educate the public on damage to the watershed that can result from activities such as dirt bike riding and hiking and inform communities about the impacts of releasing, planting and propagating invasive species adjacent to the watershed.								
a) Use television, radio and printed media to create a series of PSAs	\$ 5,500.00	\$ 5,500.00	\$ 5,500.00	\$ 5,500.00	\$ 5,500.00	\$ 5,500.00	\$ 33,000.00	
b) Conduct outreach sessions with community groups, residents and home owners associations based nearby the WMMWP protection area	Included in Outreach Position	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
		\$ 5,500.00	\$ 5,500.00	\$ 5,500.00	\$ 5,500.00	\$ 5,500.00	\$ 33,000.00	
2) Identify and promote areas where public recreational activities such as hiking, dirt biking, etc. can occur with minimal harm to watershed vegetation.								
a) Assist Off Highway Vehicle Association and State Na Ala Hele Program to find alternative riding locations	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
3) Manage trespassing to deter harmful activities and impacts to the watershed.								
a) Post interpretive, Malama Aina, and trespass signs to deter impacts	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 12,000.00	
b) Construct fences, barriers, concrete blockades at key trespassing points	Included in Fencing	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
c) Work with drug enforcement agencies to eliminate marijuana cultivation in the West Maui Mountains	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
d) Assess the use of private security to deter repeat offenders in hot spot areas	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
e) Engage Maui Police Department and DOCARE for enforcement support	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
		\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 12,000.00	
4) Mitigate and rehabilitate severely impacted areas to minimize erosion and invasive species establishment, potentially use volunteers to assist as well as educate.	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 1,500.00	\$ 7,500.00	
5) Maintain and enhance existing public hunting programs at Kahakuloa and on other public and private lands along and below the conservation district boundary.	Included in Coordination & Partner Costs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
a) Assess additional organized hunting below forest boundary to remove ungulate pressure and implement as appropriate	\$500 Assess \$5000 Implement	\$ 500.00	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 20,500.00	
		\$ 500.00	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 20,500.00	
6) Support enhanced enforcement of forest trespass and invasive species regulations, and advocate new regulations and laws protecting watershed from inappropriate human activities.	Included in Coordination & Partner Costs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
a) Investigate the ways to enhance enforcement on laws and fines to protect privately held forest reserve lands	Included in Coordination & Partner Costs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
7) Maintain monitoring and data gathering sufficient to measure success, inform adaptive management, funders, and policy makers	Helicopter and Data Management 5000	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 5,000.00	\$ 25,000.00	
		Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
<b>TOTAL FOR HUMAN ACTIVITIES MANAGEMENT</b>		\$ 14,500.00	\$ 19,000.00	\$ 19,000.00	\$ 19,000.00	\$ 19,000.00	\$ 90,500.00	

## 5. PUBLIC EDUCATION AND AWARENESS



*WMMWP crew lead interpretive hikes to the Waihee Ridge Trail (left photo) and the Maunalei Arboretum (right) for people of all ages and backgrounds, as well staff outreach booths at community events (middle, HILT annual picnic). Photo credits: WMMWP*

The goal of this program is to build public understanding and support for watershed management within the local community. The Partnership believes that the public should be aware of and support the management of the West Maui Watershed. Education of the public on the watershed, its value, threats, and management, can be conducted via existing media (TV, radio, newspapers, magazines, the internet, etc.) and through special publications aimed at specific audiences. In addition, hikes, outreach booths at community events, service trips, lectures, websites, social networking, and slide shows are excellent forums to communicate with and educate the community. Interpretive signage and carefully crafted curricula can also describe and demonstrate the values of the watershed. Special efforts to engage hunters, dirt bikers, and other key stakeholders will be necessary as WMMWP watershed management programs expand in scope. There may also be opportunities to work with other agencies, 'ohana (families) and groups such as the 'Iao Valley State Park and the Hawai'i Nature Center to enhance public awareness of the West Maui watershed.

Volunteer groups have proven successful in certain watershed area management activities, especially in labor intensive efforts such as invasive species control and trail maintenance in accessible areas (Figure 21, page 80). These groups tend to be extremely motivated, representing a valuable resource for the watershed manager. A community outreach program that gives public presentations, provides informational material, and engages volunteer groups will develop a local constituency that is eager to support watershed management activities. In this respect, the West Maui community and the Native Hawaiian community in particular represent important potential management resources. Stewardship is central to Hawaiian culture and practice, and active participation in resource management is growing among many responsible Hawaiian practitioners. An appreciation for the value of Hawaiian wisdom and traditional resource management and the interdependency between the culture and native ecosystems has also increased. Therefore it is the intention of this plan to maintain the public trust and each landowner has recognized the legitimacy of access to watershed areas under the guidance of access law.



*Volunteer service trip on the Waihee Ridge trail to control strawberry guava. Photo credits: WMMWP*



By educating the public on the importance of native forests and the value of the watershed, WMMWP seeks to revive a sense of individual and community responsibility to protect these areas. Preservation of the native forests and watersheds equates to sustainability in land use and natural resources. By illuminating traditional and modern knowledge of the land's unique treasures and challenges WMMWP can instill a greater sense of appreciation and value for Mauna Kahalawai to empower people to make a difference.

**Public Education and Awareness Program Goals:**

- Build public understanding and support for the management of the watershed
- Develop and implement environmental education programs that impart watershed concepts and protection advocacy
- Establish and maintain a public involvement program to amass a pool of trained volunteers that assists with watershed management projects

**Public Education and Awareness Program Objectives:**

- 1) Make use of traditional and new media to create outreach projects that engage the community.
  - a. Maintain WMMWP website, update WMMWP brochure, create quarterly informational fliers, update outreach booth visuals, and generate quarterly PSAs that inform the community about WMMWP and its current watershed protection efforts
  - b. Generate a list of watershed projects appropriate for newspaper, TV, and radio media to create stories about hot-button issues, and develop a list of media contracts
  - c. Utilize social media forums (e.g. Facebook, Twitter, online blog) to advance outreach goals
- 2) Enhance WMMWP's capacity to integrate and manage volunteer assistance in meaningful, informative, and rewarding resource management projects.
  - a. Continue to integrate AmeriCorps, Hawai'i Youth Conservation Corps, University of Hawai'i, and Kupu volunteer programs with WMMWP projects
  - b. Expand the network of volunteers from the general community, school groups, businesses, "voluntourism" groups, and other civic organizations
  - c. Instill a sense of ownership and provide incentives for volunteer groups such as awards, certificates of recognition, or exclusive access to remote locations
  - d. Account for liability issues and access permission for all volunteer opportunities as well as access protocols for each landowner
- 3) Establish an outreach and education coordination position within WMMWP to direct, organize, and coordinate efforts.
- 4) Identify and train specific Partnership members to conduct hikes, slide shows, and public talks.

- a. Arrange periodic talks and slideshows with community groups such as Rotary Club, Lions Club, Kiwanis Club, and others
- 5) Develop a policy statement for sensitive threat control methods and other water quality concerns.
- 6) Identify key stakeholders of the WMMWP area and include where possible their input on watershed management objectives or issues of concern. As appropriate, create advisory groups to the Partnership to address issues such as wildfire management, dirt biking, and invasive species control.
- 7) Establish relationships with nearby communities and developments to educate and prevent introductions of invasive species, minimize human impacts, and solicit support for watershed values and protection.
- 8) Promote and pursue interagency cooperation and joint educational opportunities.
  - a. Form partnerships with other community groups or agencies that may share values such as Hawai'i Nature Center, 'Īao State Park, Maui Nui Botanical gardens, Hawaii Islands Land Trust (HILT), and Nā Ala Hele Trails System
  - b. Create a watershed educational display for posting at visitor destinations such as the Hawai'i Nature Center, 'Īao State Park, Maui Nui Botanical Gardens, HILT Waihe'e Coastal Dunes Preserve, and Nā Ala Hele Trails
  - c. Partner in educational and volunteer opportunities with West Maui adjacent restoration groups such as ML&P, Maui Cultural Lands, First Wind, Olowalu Cultural Restoration Group, Maui Digital Bus, and local school programs
  - d. Garner input from State and County agencies and cultural organizations which have direct ties to the watershed's resources such as land use, water resources, environmental management, and cultural practices





Table 16. Objectives and Costs for Public Education and Awareness Program

Management Strategy: Outreach & Education							
Objectives	Cost Per Unit / Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost
1) Make use of traditional and new media to create outreach projects that engage the community.							
a) Maintain WMMWP website, update WMMWP brochure, create quarterly informational fliers, update outreach booth visuals and generate quarterly PSAs that inform and the community about WMMWP and its current watershed protection efforts	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 10,000.00
b) Maintain WMMWP staff support of outreach and education efforts	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 37,500.00
c) Generate a list of watershed projects appropriate for newspaper, TV and radio media to visit and create stories about hot-button issues and develop a list of media contracts.	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
c) Utilize social media forums (i.e. Facebook, Twitter, online blog) to advance outreach goals		\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 10,000.00
		\$ 11,500.00	\$ 11,500.00	\$ 11,500.00	\$ 11,500.00	\$ 11,500.00	\$ 57,500.00
2) Establish and maintain a public involvement program to create a pool of trained volunteers to assist with watershed resource management projects.							
a) Continue to integrate AmeriCorps, Hawaii Youth Conservation Corps, University of Hawaii, and Kupu volunteer programs into WMMWP management	\$ 10,000.00	\$ 20,000.00	\$ 20,000.00	\$ 20,000.00	\$ 20,000.00	\$ 20,000.00	\$ 100,000.00
b) Enhance the network of volunteers from the general community, school groups, businesses, "voluntourism" groups and other civic organizations	Included in Outreach Position	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
c) Instill a sense of ownership and provide incentives for volunteer groups such as awards, certificates of recognition, or exclusive access to remote locations		\$ 500.00	\$ 500.00	\$ 500.00	\$ 500.00	\$ 500.00	\$ 2,500.00
d) Account for liability issues and access permission for all volunteer opportunities as well as access protocols for each land owning entity	Included in Coordination	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
e) Maintain WMMWP staff support of involvement programs	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 7,500.00	\$ 37,500.00
		\$ 28,000.00	\$ 28,000.00	\$ 28,000.00	\$ 28,000.00	\$ 28,000.00	\$ 140,000.00
3) 3) Establish an outreach and education coordination position within WMMWP to direct, organize and coordinate efforts to extend our voice and ability to interact.		\$ 52,000.00	\$ 53,000.00	\$ 54,000.00	\$ 55,000.00	\$ 56,000.00	\$ 270,000.00
4) Identify and list specific partnership members who can provide hikes, slide shows, and public talks.							
a) Develop schedule to contact Rotary, Lions, Kiwanis and other community groups to schedule talks and slide shows	Included in Outreach Position	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -





## 6. RARE SPECIES PROTECTION



Photos left to right: *Platanthera holochila*, *Colubrina oppositifolia*, *Cyanea magnicalyx*, *Dubautia plantaginea subsp. humilis*, all Endangered species. Photo credits: Hank Oppenheimer (PEPP)

When performing protection work at a landscape level our aim is not only to protect water resources but to also protect the entire web of life which makes up the native Hawaiian forest ecosystem. Humans and rare species of plants and animals are all dependent on the health of the forest system. This forest not only provides habitat for rare species but these species also make up a considerable portion of its structure and complexity. A total of 23,680 Hawaiian species have been documented, including 18,607 native Hawaiian species (9,151 indigenous species and 9,456 endemic species), and 5,073 human-introduced (non-native) species (Evenhuis and Eldredge, 2002). The West Maui Mountains is home to a current count of approximately 146 rare plants, insects, birds, vegetation communities and one bat (refer to Figure 2, page 13, and Appendix A). As the forest continues to be explored more unique species are found every year.

WMMWP staff collaborates with reputable organizations and groups whose purpose is to aid the recovery of rare species and prevent their extinction. Ultimately this keeps rare species as a viable component of the forest ecosystem and also elevates the need to have them protected under the Endangered Species Act. Presently, the watershed contains 48 endangered species, 1 threatened, 13 candidate and 84 species of concern tracked by state and federal agencies (see Appendix A). As the battle to recover these species progresses we can also evaluate the fragility of the forest through their successful recovery.

Today several efforts are underway to help species recover. The U.S. Fish & Wildlife Service, Hawai'i DLNR, the County of Maui and other agencies have been supporting watershed protection through feral animal control, fencing and invasive plant control projects to protect habitat needed for species protection and recovery as well as biological monitoring and population management through collaborative avian recovery

programs, such as Maui Nui Seabird Recovery Project and the Maui Forest Bird Recovery Project. Botanically, the Plant Extinction Prevention Program (PEPP) has also



WMMWP staff out-planted 95 *Stenogyne kauaulaensis* plants (Species of Concern) with Hank Oppenheimer of PEPP in Unit 5.1. Photo credit: WMMWP

taken root in the last few years. Furthermore, riparian and wetland conservation programs are also growing and may be willing partners in attempts to restore these portions of the watershed for species that are dependent on aquatic ecosystems. These collaborators help illuminate the species richness within the watershed, as well as the challenges that rare species face in survival. Lessons from the investigation of single species efforts can also be applied to landscape scale forest protection issues.

### **Management Methods:**

By sharing information, logistical support and mutual goals we can further each other's programs and reduce costs. If WMMWP protects the habitat, the recovery programs have a place to reintroduce species into safeguarded areas. Threats to the forest from feral animals, disease, fire, and illegal human activities are also a concern to the recovery of rare species. Within this framework we can protect a forest ecosystem in all its complexity so that it can withstand environmental stress and provide a sustainable place for species as well as a source of water.

### **Rare Species Protection Program Goal:**

- Provide landscape level protection of rare species by sustaining the native Hawaiian forested habitat on which they rely
- Contribute to the recovery of rare, and federally listed threatened and endangered species through the protection of habitat and enhancement of populations

### **Rare Species Protection Program Objectives:**

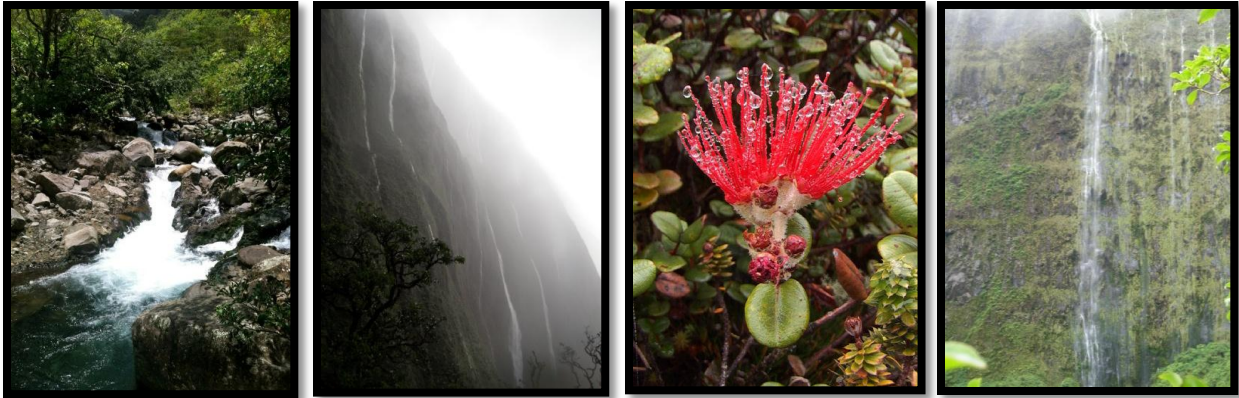
- 1) Facilitate the efforts of the Plant Extinction Prevention Program (PEPP) whose goal is to recover species with 50 or fewer specimens in the wild.
- 2) Assist DLNR and USFWS programs to protect and recover rare species through landscape level habitat protection, watershed threat abatement, surveys, monitoring and facilitation of propagation and reintroduction.
- 3) Document and report rare species findings by WMMWP staff to relevant agencies.
- 4) Develop and maintain a database of rare species location data and maintain reports from all supporting organizations.
- 5) Facilitate the access of credible and fully permitted visiting researchers, biologists and botanists attempting to answer key questions relating to the long term survival and recovery of species (e.g. National Tropical Botanical Gardens, UH researchers, USGS, etc.).

Table 17. Objectives and Costs for Rare Species Protection Program

Management Strategy: Protection of Rare Species							
Objectives	Cost Per Unit/ Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost
1) Facilitate the efforts of the Plant Extinction Prevention Program whose goal is to recover species with 50 or fewer specimens in the wild.	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 10,000.00
2) Assist DLNR and USFWS goals to recover rare species through landscape level habitat protection and watershed threat abatement.	Included In all Programs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
3) Document and report rare species findings by WMMWP staff to agencies.	\$ 500.00	\$ 500.00	\$ 500.00	\$ 500.00	\$ 500.00	\$ 500.00	\$ 2,500.00
4) Develop and maintain a database of rare species location data and maintain reports from all supporting organizations.	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00
5) Facilitate the access of credible and fully permitted visiting researchers, biologists and botanists attempting to answer key questions relating to the long term survival and recovery of species i.e. National Tropical Botanical Gardens, UH researchers, USGS, etc.	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00
		<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Total Cost</b>
<b>TOTAL FOR PROTECTION OF RARE SPECIES</b>		<b>\$ 4,500.00</b>	<b>\$ 4,500.00</b>	<b>\$ 4,500.00</b>	<b>\$ 4,500.00</b>	<b>\$ 4,500.00</b>	<b>\$ 22,500.00</b>



## 7. WATER AND WATERSHED MONITORING



Photos left to right: Waihe'e Stream, Wall of Tears, fog drops on an 'Ōhi'a, Waihe'e Plateau. Photo Credits: WMMWP

Progress in the protection and enhancement of the West Maui Watershed must be measured against baseline conditions. Thus, a baseline survey of the watershed's water and terrestrial resources must be conducted, to establish a clear measure of quality and quantity across the watershed. Measures of forest health and species diversity are also measured as key indicators of watershed conditions and overall health.

### **Water Monitoring**

In terms of water produced by the West Maui watershed, WMMWP relies on the historic and current efforts lead by the U.S. Geological Survey (USGS) and the County Department of Water Supply (DWS) to measure this complex hydrologic system. According to the 1996 report "Evaluation of the Surface-Water Quantity, Surface-Water Quality, and Rainfall Data-collection Programs in Hawai'i" (Fontaine 1996), back in 1994 there were 64 stream gauges within and related to the West Maui watershed, of which only nine were still active as of October 2011. Four of these active gauges have provided continuous flow records, some for over 50 years, on the Honokōhau, Kahakuloa, Waihe'e, and 'Īao Streams. This network of monitoring stations may not be sufficient to provide the picture of water quality or quantity change in response to specific watershed forest management programs.

Trends in the available data from DWS and USGS point to declining rainfall, increased pumpage and a decline in the quantity of available water for wells in West Maui (Figure 22 and Figure 23). Demand for groundwater from the DWS Lahaina System is estimated to increase from about 2.1 mgd in 2007 to 3.5 mgd in 2030. Accounting for groundwater pumped by several private water systems in the area, the total demand for groundwater is expected to increase from 5.8 mgd in 2007 to 11.1 mgd in 2030 (Gingerich and Engott, 2012). At the same time, projections suggest a decline in groundwater recharge rates. Considering rainfall and pumpage trends, updated recharge estimates are lower below the fog zone at roughly 2,000 feet elevation on the leeward side, where forests are assumed by this study to consist of alien species. In the fog zone above 2,000 feet where forests are assumed to consist of native species, updated recharge estimates are higher in all but a few small areas (Gingerich and Engott, 2012). These projections speak to the importance of effective native forest and watershed management

for the benefit of the island’s freshwater resources. In this regard, comprehensive monitoring of water quantity will be integral to setting the direction of watershed management programs.

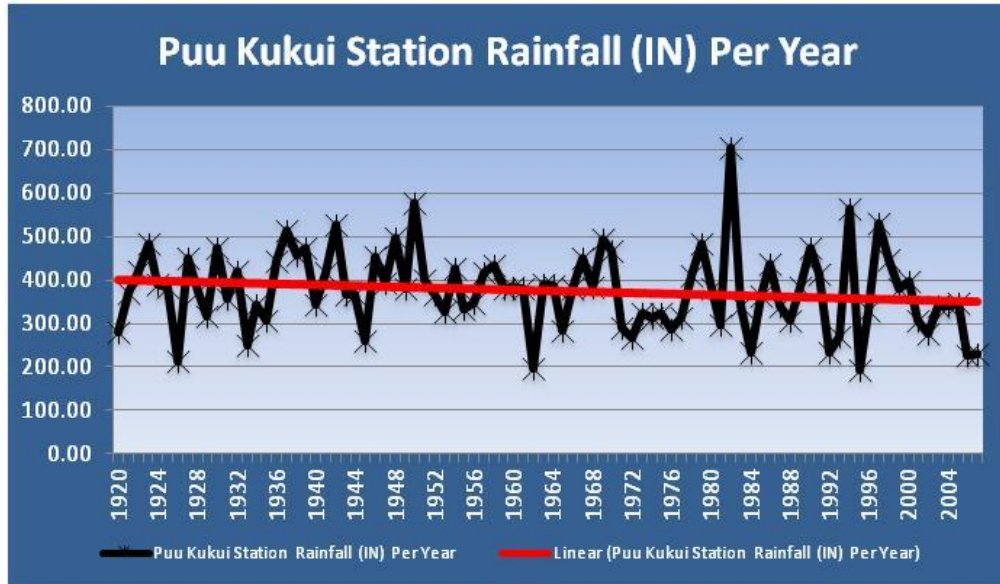


Figure 22 . Puu Kukui Station Rainfall, shown in inches per year, from 1920 to 2008. Source: Data from Pacific Islands Water Science Center, 2012b. Graph produced by WMMWP.

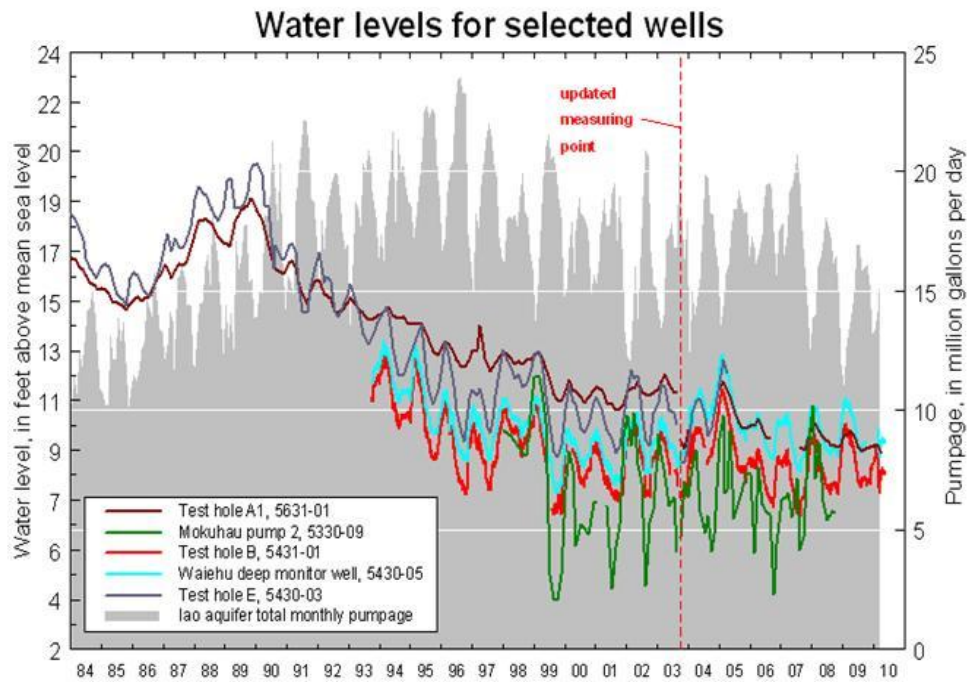


Figure 23. Water levels for selected wells, along with the Iao Aquifer total monthly pumpage, shown in million gallons per day, from 1984 to 2010. Source: Pacific Islands Water Science Center, 2012a.

Recently, various initiatives have arisen to monitor stream water quality to further inform watershed management. Together, the State Division of Aquatic Resources and Bishop Museum compiled existing knowledge into the *Atlas of Hawaiian Watersheds and their Aquatic Resources*. This publication compiles over five decades of data on surveyed streams, ditches, diversions,

and other features found in the Hawaiian Islands. Data includes both physical and biotic features of major streams, species listings, and rankings of the quality of each stream based on the information gathered. The database "provides critical information for monitoring, assessing, managing, and protecting freshwater resources" (Parham *et al.*, 2008). Meanwhile, surface water quality data for streams is beginning to be pursued across the State with new "Mauka to Makai" initiatives. Sponsored by the National Oceanographic and Atmospheric Administration (NOAA), U.S. Geological Survey, U.S. Army Corps of Engineers and DLNR, select places in the State are being studied to identify sources of land based pollution which flow downstream and negatively impact nearshore waters and fragile coral reefs. It is hoped that monitoring methods and lessons learned can be replicated in order to better understand and address pollution that originate from mauka forests.

Land based pollution in the forested watersheds can come from a variety of sources. Of principal concern are those which expose soils and loosen both fine and coarse sediments that



Runoff in Kahakuloa after a heavy December rain.  
© Amit Basu Photography, 21 December, 2010

ultimately runoff into the ocean. Sources of pollution include man-made roads, dirt bike trails, digging and browsing by feral ungulates, defoliation of vegetation by diseases, reduction in vegetative ground cover by invasive plants, devastation by wildfire, and natural background erosion. Denuded forests can contribute increased levels of animal and vegetation based nutrients; for example, nitrogen can be produced by animal waste as well as invasive nitrogen fixing plants.

Feral ungulates are also a source of waterborne diseases such as *Leptospirosis* and *Giardia* that diminish water quality.

Towards addressing the lack of water quality monitoring data, WMMWP is currently experimenting with methods to directly monitor water quality in the mauka watershed portion of Honolulu Valley. Methods under investigation include the use of erosion pins to detect changes in soil levels and automated storm water samplers that capture water during flash rises in stream flow to measure nutrient and turbidity levels. Correlating vegetative cover and ungulate disturbance data with water quality data is a central goal in the effort to measure management accomplishments and prove success in improving water quality through watershed management. Once successful monitoring methods are refined and proven, the intent is to replicate them in additional stream systems as resources permit.

### **Terrestrial and Vegetative Watershed Monitoring**

Since the inception of the Partnership, the scope of WMMWP monitoring programs has grown in concert with expanded land management. Starting with nine monitoring transects in 2000, the number has increased to 22 in 2012 (Figure 24). This transect network is slated to expand as new management areas are added, particularly in the Southwest Unit and in 'Āo Valley in the East Unit. Transects run the entire length of a trail from mauka to makai, and data is collected along continuous stations that measure five meters wide by 50 meters long. Transect data

includes presence and absence of invasive plants as well as percent disturbance caused by feral ungulates.

In concert with transect data, photographic points and vegetation plots have been established to help illustrate quantitative changes in vegetative cover over time. Specific plots have been placed in areas of impacts from dirt bikes, ungulates, fire, and invasive plants. Some show natural, unaided changes in vegetation (see fire photo series on page 66); while others are designed to record changes from pre- to post-management conditions in both disturbed and undisturbed locations.

Monitoring is performed during the course of management to continuously evaluate program effectiveness and adapt accordingly, based on real-time data. Relevant data on all management activities are recorded to document progress in fence maintenance, invasive plant control, ungulate control, and other programs to track success, improve program efficiency, and eventually reduce management costs. Monitoring data is globally positioned with a GPS to aid in identifying relationships with other points of interest. Densities, ranges, and movements of watershed threats can be mapped over time using programs like ESRI's ArcMap. Mapping data points helps us to visualize the full range or scope of problems and transform what we see on the ground into tactical approaches. This process allows us to assess our shortcomings, challenges, and successes topographically, bringing in the three-dimensional reality of controlling threats in these rugged mountains.

New technologies and methods of monitoring are sought to increase our ability to monitor threats across this challenging landscape. High resolution aerial imagery, satellite based imagery, thermal imagers, LiDAR, data transmitted through cellular signals, and unmanned aerial vehicles are just some of the methods currently being considered to increase our knowledge and improve efficiency. Participation in data and information groups (such as the Maui Data Hui and the Maui Conservation Alliance) within and outside of the conservation community is also important in sharing strategies and efforts to streamline our data management. Additional important elements of the biological integrity of the watershed include the biological diversity of indigenous plants and animals. In time, additional metrics or key indicators of watershed health will include the prevalence of invasive plants, general structure and diversity of native plants and animals, measures of vigor of native plants, and incidence of disease or other stressors.

#### **Water and Watershed Monitoring Program Goal:**

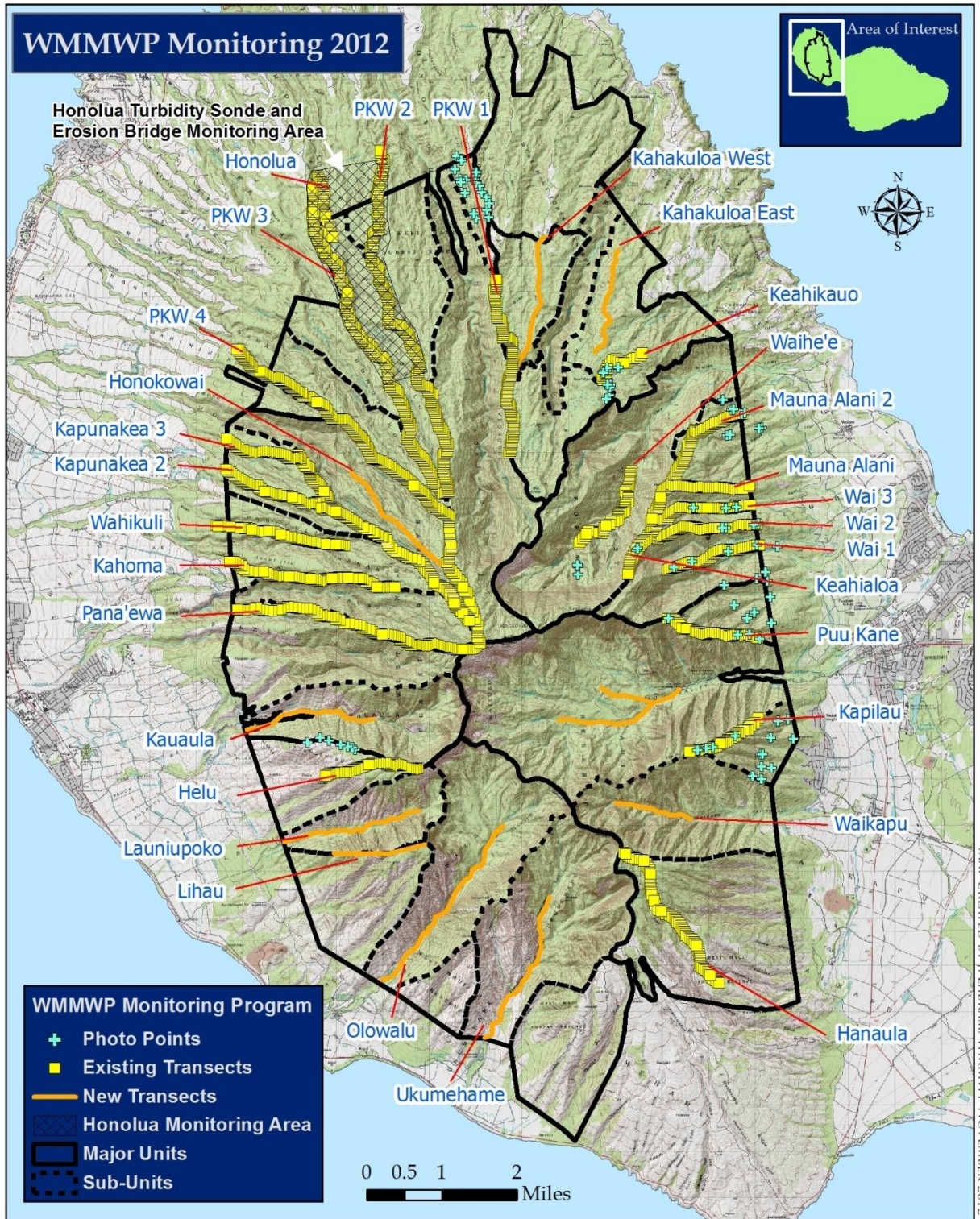
- Monitor the quantity and quality of water resources in West Maui
- Monitor physical and biological resources as well as threats to watershed health
- Determine the effectiveness of watershed management programs to counteract threats to the watershed and maintain and enhance the health of the watershed

#### **Water and Watershed Monitoring Program Objectives:**

- 1) Continue to evaluate water quality monitoring methodologies for simple and cost efficient methods. Replicate and adapt successful monitoring regimes as appropriate.



- 2) Complete the Watershed Monitoring Plan with support from the State of Hawai'i, Department of Health.
  - a. Complete data gathering for Honolulu Stream to measure the reduction in turbidity resulting from effective watershed management
- 3) Continue to support the collection of water quality and quantity data throughout the watershed.
  - a. Support Partner agency efforts to collect stream flow, rainfall, and water quality data from existing stations and support additional water quality and quantity monitoring as needed
- 4) Maintain existing biological and threat monitoring transects (22 total), photo points, vegetation plots, and ungulate removal data sets as indicators of ecosystem and watershed health.
- 5) Conduct annual ground and aerial surveys of unmanaged and newly managed areas for early detection and rapid response to ungulates and other critical watershed threats.
- 6) Assist State and County efforts to monitor threats to forest health such as 'ōhi'a rust, Erythrina gall wasp, and others.
- 7) Assist cooperating agencies, programs, and credible researchers with assessing watershed-related issues such as rare species surveys.
- 8) Coordinate monitoring efforts with lead agencies such as DOH, NOAA, Army Corps of Engineers and EPA to support Mauka to Makai efforts in watershed protection.
- 9) Explore the use of new monitoring technologies as they become available, including analysis of remotely sensed satellite imagery (i.e. World View II), high resolution imagery (i.e. Resource Mapping Hawai'i), remote flying surveillance drones, thermal surveys, and others.
- 10) Further develop and support a database to house data gathered on management plan objectives and maintain technicians to gather and analyze spatial data.
  - a. Integrate data from all Partners to be able to assess watershed-wide issues
  - b. Support development of a statewide database to further watershed protection



**Figure 24. WMMWP Monitoring Map.** Transects are read annually for ungulate sign, and the presence of invasive plants is recorded every other year. Information is recorded in 50-meter intervals. Transects are established to take a baseline inventory when starting work in an area, and then to monitor changes as management activities are implemented. Photo points are preferred by USFWS and are installed to show changes in vegetative cover over time. The hatched marks show the Honolua water quality monitoring area. Ground survey areas are not depicted but are an important aspect, especially in newly monitored areas. Aerial helicopter surveys, also not shown on map, are needed to comb hard to reach places or cover broad areas coarsely.

Table 18. Objectives and Costs for Water and Watershed Monitoring Program

Management Strategy: Water and Watershed Monitoring								
Objectives	Cost Per Unit/Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
1) Continue to evaluate water quality monitoring methodologies for simple and cost efficient methods. Replicate successful monitoring regimes as appropriate.								
Staff Time	\$ 9,600.00	\$ 9,570.20	\$ 19,170.20	\$ 28,770.20	\$ 38,370.20	\$ 47,970.20	\$ 143,851.00	
Supplies	\$ 1,600.00	\$ 1,600.00	\$ 1,600.00	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00	\$ 9,200.00	
Water Quality Monitoring System	\$ 7,000.00	\$ 7,000.00	\$ 7,000.00	\$ 7,000.00	\$ 7,000.00	\$ 7,000.00	\$ 35,000.00	
Water Quality Testing - cost is at \$35 a sample	\$ 1,500.00	\$ 1,500.00	\$ 3,000.00	\$ 4,500.00	\$ 6,000.00	\$ 7,500.00	\$ 22,500.00	
Water Quality Consultant	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 15,000.00	
		\$ 22,670.20	\$ 33,770.20	\$ 45,270.20	\$ 56,370.20	\$ 67,470.20	\$ 225,551.00	
2) Complete the Watershed Monitoring Plan with support from the State of Hawaii, Department of Health.	Included in previous funding	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
a) Complete data gathering for Honolua Stream to measure the reduction in turbidity resulting from effective watershed management.		\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 15,000.00	
		\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 3,000.00	\$ 15,000.00	
3) Continue to support the collection of water quality and quantity data throughout the watershed through testimony and access facilitation.	Included in Coordination and Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
a) Support Partner agency efforts to collect stream flow, rainfall, and water quality data from existing stations and support additional water quality and quantity monitoring as needed.	Included in Coordination and Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
4) Maintain and expand existing biological and threat monitoring transects (21 maintained, 11 new), photo points, vegetation plots, and ungulate removal data sets, etc. as indicators of ecosystem and watershed cover health.								
Transects are read annually for ungulate disturbance by % of area impacted	\$1200 each	\$ 26,400.00	\$ 28,800.00	\$ 31,200.00	\$ 33,600.00	\$ 36,000.00	\$ 156,000.00	
The same transects are read every two years for invasive plant presence and absence of all weeds to estimate ranges and monitor for new threats	\$600 each	\$ 12,600.00	\$ -	\$ 15,600.00	\$ -	\$ 18,000.00	\$ 46,200.00	
Photo/veg plots indicate the rate of vegetative recovery post disturbance and depict changes in native vs. non-native composition (95 plots to date)	\$100/plot	\$ 9,500.00	\$ -	\$ 9,500.00	\$ -	\$ 9,500.00	\$ 28,500.00	
Ungulate capture levels over time with sustained effort will also indicate measurable changes in populations levels	Included in Ungulate Control Budget	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Integrate new monitoring techniques to show native vs. non-native forest composition on ridges and streams( i.e. Molokai Understory Monitoring)		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
		\$ 48,500.00	\$ 28,800.00	\$ 56,300.00	\$ 33,600.00	\$ 63,500.00	\$ 230,700.00	







## 8. MANAGEMENT COORDINATION

Successful implementation of this plan will require dedicated long-term leadership. This comes



*Staff collaboration for fence building (right and left photos) and the WMMWP 10-year anniversary commemoration (middle).  
Photo credits: WMMWP*

through the active participation, guidance and knowledge of WMMWP Partners, as well as the experience of resource management teams within and outside of the Partnership. WMMWP Partners meet regularly, on a quarterly basis or as needed, to effectively coordinate and oversee watershed management activities. Internal operating guidelines delineate general administration and operating procedures which are refined with time and experience. To accelerate the completion of management planning objectives, the Partnership elected to support and direct a dedicated resource management team. Since 2000, the WMMWP team has brought greater cohesion in implementing management objectives and generating the necessary funding. A Watershed Coordinator was hired to supervise the implementation of the Watershed Management Plan, raise funds, and increase public awareness. A staff of 10 field and data personnel blends expertise in biological, geographical, and natural resource management. The Partnership's appointed Executive Committee provides oversight while the Watershed Coordinator effectively carries out day to day operations and oversees the staff. High priority projects aimed at reducing watershed threats across landowner boundaries are addressed in this manner, and adaptive management feedback is reported back to the Partners at regular meetings and through other modes of communication.

Every effort must be made to equip WMMWP staff with adequate resources and facilities. Necessities include office space, storage space, a baseyard and staging area, helicopter landing zones, equipment, materials, professional services, transportation, and field supplies. Many strategically placed helicopter landing zones, shelters, and low impact trails already exist but more will be needed to expand management activities into new areas. Additional vehicular access roads should not be constructed within the 47,000-acre project area since roads on steep terrain create severe soil erosion, fragment forest ecosystems, and greatly increase the likelihood for alien species introductions. Any improvements to existing roads, firebreaks, and trails must be designed and maintained to minimize any unwanted impacts such as overuse of sensitive sites, inadvertent introduction of invasive plants on hikers' boots, equipment or vehicles, heightened liability exposure, increased potential for damage to the water system, increased risk of contamination of the water supply, or encouragement of marijuana growing or other illegal activities. Beyond this field infrastructure, WMMWP seeks to establish a permanent base

of operations to provide long term stability for its programs. Additional funding and staff support may be needed to creatively realize management goals.

As discussed above, the non-profit organization Malama Kahalawai, Inc. (MKI) functions in administering and implementing the program goals of WMMWP while serving as a conduit for grant money to WMMWP. Similarly, Tri-Isle RC&D also acts as a fiscal agent for certain grants. Presently, the WMMWP team is hired in cooperation with the University of Hawai'i's Pacific Cooperative Studies Unit (PCSU) and administered through the Research Corporation of the University of Hawai'i (RCUH). Further support may also be hired by any one or several of the partner or supporting organizations or subcontracted to maximize efforts.

More broadly speaking, statewide management efforts are expanding as successes in watershed protection are being publicized. There are now 11 watershed partnerships statewide, all of which belong to the Hawai'i Association of Watershed Partnerships (HAWP). Notably, WMMWP is a founding member and active participant of HAWP. In this forum, annual workshops, symposia and special projects help to further common goals. Sharing management successes and challenges in this way serves to further our collective ability to protect forested watersheds, native species and our State's water supply.

To bring the topic full circle, all the above mentioned collaborators, programs, and infrastructure are designed to maximize on the ground efforts. Coordination of the team and providing them solid direction is fundamental, and the team in turn must justify their efforts with measureable and tangible success. Covering basic logistical needs in the very steep and weather beaten terrain of the West Maui Mountains demands extensive planning and training. Staff qualifications and capabilities need to be maintained and nurtured in several areas including helicopter safety, rappelling, wilderness first aid, fence building, herbicide application, plant identification, backcountry camping, hunting, ground navigation, and GIS. Opportunities for workplace training and career growth are critical, not only to perpetuate our resource knowledge and investments but also to further our goals and strategies.

### **Management Coordination Program Goals**

- Retain qualified personnel and supporting infrastructure necessary to execute WMMWP watershed management goals
- Expand WMMWP knowledge base and access to resources to enable effective watershed management
- Continue cohesive watershed management programs across all Partnership lands
- Advance statewide watershed protection initiatives

### **Management Coordination Program Objectives:**

- 1) Conduct regular WMMWP Partnership meetings and form committees as necessary to maintain information exchange and support for programs inside and outside of the Partnership.

- 2) Maintain and expand the WMMWP staff as necessary to achieve program goals.
  - a. Add an outreach and education coordinator with available funds
  - b. Add contract expertise to further management objectives
  - c. Hire seasonal staff to advance projects as needed
- 3) Provide and maintain adequate support infrastructure for WMMWP staff.
  - a. Maintain office space for WMMWP administrative staff and technicians and locate a permanent WMMWP base of operations
  - b. Maintain three or more 4x4 vehicles capable of transporting crew, materials and supplies
  - c. Maintain transportation systems (e.g. roads, trails, firebreaks, bulldozer, etc.) as necessary for effective watershed management access
  - d. Acquire a passenger van to facilitate the mobilization of volunteers
  - e. Maintain and acquire adequate supplies, materials, equipment, services and communications for field crew
  - f. Provide all necessary travel and training for professional development and safety
- 4) Maintain, expand, and develop funding relationships with agencies, foundations and private entities.
- 5) Maintain existing transportation system through Partner resources (roads, trails, firebreaks, bulldozer, scraper contract, etc.)
- 6) Coordinate use of, and capabilities of, manpower, equipment and communication systems among WMMWP staff and Partners.
- 7) Adhere to appropriate public statutes, rules, regulations and codes.
  - a. Identify applicable regulations that affect our watershed protection efforts
  - b. Enforce regulations within Partnership avenues and educate outside agencies and public on regulations that affect watershed lands and recreation
  - c. Support legislative measures to protect watershed resources
- 8) Maintain efforts to find a permanent base of operations for WMMWP.
- 9) Continue to work with and maintain the support and administration of Malama Kahalawai, Inc.
- 10) Coordinate and cooperate with other organizations that advance WMMWP goals and objectives for watershed management.
  - a. Fiscally via affiliations with Tri-Isle RC&D, University of Hawai'i, Malama Kahalawai, Inc., and others
  - b. Programmatically via Hawai'i Association of Watershed Partnerships, the Maui Conservation Alliance, the Maui Invasive Species Committee, and others

Table 19. Objectives and Costs for Management Coordination Program

Management Strategy: Management Coordination							
Objectives	Cost Per Unit/ Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost
1) Conduct regular WMMWP Partnership meetings and form committees as necessary to maintain information exchange and support for programs inside and outside of the Partnership.	Included in Program Manager Salary & Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
2) Maintain and expand the WMMWP capacity and staff as necessary to achieve program goals.							
a) Maintain Management and Coordination Staffing	Includes % of Manager and Staff plus 3% annual	\$ 100,000.00	\$ 103,000.00	\$ 106,090.00	\$ 109,272.70	\$ 112,550.88	\$ 530,913.58
b) Add an outreach and education coordinator with available funds	50%-100% FTE	\$ 25,000.00	\$ 30,000.00	\$ 35,000.00	\$ 40,000.00	\$ 50,000.00	\$ 180,000.00
c) Add contract expertise to further management objectives	Included in Fencing	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
d) Hire seasonal staff to advance projects as needed	Included in other programs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
		<b>\$ 125,000.00</b>	<b>\$ 133,000.00</b>	<b>\$ 141,090.00</b>	<b>\$ 149,272.70</b>	<b>\$ 162,550.88</b>	<b>\$ 710,913.58</b>
3) Provide and maintain adequate support infrastructure for WMMWP staff.	Include Manager Salary						
a) Maintain office space for WMMWP administrative staff and technicians	Annual plus 5%	\$ 25,000.00	\$ 26,250.00	\$ 27,562.50	\$ 28,940.63	\$ 30,387.66	\$ 138,140.78
b) Maintain three or more 4x4 vehicles capable of transporting crew, materials and supplies	Annual plus 5%	\$ 10,000.00	\$ 10,500.00	\$ 11,025.00	\$ 11,576.25	\$ 12,155.06	\$ 55,256.31
c) Acquire a passenger van to facilitate the mobilization of volunteers	Van/Supporting Costs	\$ 25,000.00	\$ 3,000.00	\$ 3,150.00	\$ 3,307.50	\$ 3,472.88	\$ 37,930.38
d) Maintain and acquire adequate supplies, materials, equipment, services and communications for field crew	Annual plus 5%	\$ 35,000.00	\$ 36,750.00	\$ 38,587.50	\$ 40,516.88	\$ 42,542.72	\$ 193,397.09
e) Provide all necessary travel and training for professional development and safety	Annual plus 5%	\$ 15,000.00	\$ 15,750.00	\$ 16,537.50	\$ 17,364.38	\$ 18,232.59	\$ 82,884.47
		<b>\$ 110,000.00</b>	<b>\$ 92,250.00</b>	<b>\$ 96,862.50</b>	<b>\$ 101,705.63</b>	<b>\$ 106,790.91</b>	<b>\$ 507,609.03</b>
4) Maintain, expand, and develop funding relationships with agencies, foundations and private entities.	Include Manager Salary	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -



Table 19. (Continued)

Management Strategy: Management Coordination Continued								
Objectives	Cost Per Unit/ Notes	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
5) Maintain existing transportation system through partner resources (roads, trails, firebreaks, bulldozer, scraper contract, etc.)	Included in Partner Budgets/Fire Program	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
6) Coordinate use of, and capabilities of, manpower, equipment and communication systems among WMMWP staff and Partners.	Included in Program Manager Salary & Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
7) Adhere to appropriate public statutes, rules, regulations and codes.								
a) Compile an appropriate list of regulations that affect our watershed protection efforts	Included in Coordination and Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
b) Enforce regulations within Partnership avenues and educate outside agencies and public on regulations that affect watershed lands and recreation	Included in Coordination and Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
c) Support legislative measures to protect watershed resources	Included in Coordination and Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
8) Maintain efforts to find a permanent base of operations for WMMWP.	Costs for Construction	\$ 300,000.00	\$ -	\$ -	\$ -	\$ -	\$ 300,000.00	
9) Continue to work with and maintain the support and administration of Malama Kahalawai, Inc.	Included in Coordination and Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
10) Maintain cooperation Coordinate and cooperate with other organizations that advance WMMWP goals and objectives for watershed management.								
a) Fiscally via affiliations with Tri-Isle RC&D, University of Hawaii, Malama Kahalawai, Inc., and others	Overhead and Indirect at 11% of Programs	\$ 242,729.85	\$ 242,729.85	\$ 263,521.74	\$ 278,629.20	\$ 300,483.79	\$ 1,239,977.32	
b) Programmatically via Hawaii Association of Watershed Partnerships, the Maui Conservation Alliance, the Maui Invasive Species Committee, and others	Included in Coordination and Partner Budgets	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
		\$ 242,729.85	\$ 242,729.85	\$ 263,521.74	\$ 278,629.20	\$ 300,483.79	\$ 1,239,977.32	
		Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
<b>TOTAL FOR MANAGEMENT COORDINATION</b>		\$ 777,729.85	\$ 467,979.85	\$ 501,474.24	\$ 529,607.52	\$ 569,825.58	\$ 2,758,499.94	

## V. WMMWP Watershed Management Plan Budget Summary

The budget summary for the West Maui Mountains watershed management program is provided below in Table 20. The table summarizes the eight major program budgets described above, but does not include those costs that are already reflected by ongoing Partner investments. Rather, the costs below indicate the magnitude of new fundraising needs of the Partnership that are required to realize some of the management program innovations and expansions described above.

Table 20. Total Costs of All Programs

Total Costs of All Programs:							
Programs	Year 1	Year 2	Year 3	Year 4	Year 5	Total Cost	
1) TOTAL FOR INVASIVE ANIMAL MANAGEMENT & CONTROL COSTS	\$ 828,114.10	\$1,119,751.95	\$1,283,621.44	\$1,304,230.34	\$1,185,602.61	\$ 5,721,320.45	
2) TOTAL FOR INVASIVE PLANT CONTROL	\$ 845,000.00	\$ 680,000.00	\$ 680,000.00	\$ 680,000.00	\$ 680,000.00	\$ 3,565,000.00	
3) TOTAL FOR OUTREACH & EDUCATION	\$ 96,500.00	\$ 92,500.00	\$ 93,500.00	\$ 94,500.00	\$ 95,500.00	\$ 472,500.00	
4) TOTAL FOR FIRE	\$ 42,750.00	\$ 31,550.00	\$ 31,750.00	\$ 30,550.00	\$ 31,750.00	\$ 168,350.00	
5) TOTAL FOR HUMAN ACTIVITIES MANAGEMENT	\$ 14,500.00	\$ 19,000.00	\$ 19,000.00	\$ 19,000.00	\$ 19,000.00	\$ 90,500.00	
6) TOTAL FOR PROTECTION OF RARE SPECIES	\$ 4,500.00	\$ 4,500.00	\$ 4,500.00	\$ 4,500.00	\$ 4,500.00	\$ 22,500.00	
7) TOTAL FOR WATER AND WATERSHED MONITORING	\$ 92,170.20	\$ 81,570.20	\$ 119,570.20	\$ 106,970.20	\$ 147,970.20	\$ 548,251.00	
8) TOTAL FOR MANAGEMENT COORDINATION	\$ 777,729.85	\$ 467,979.85	\$ 501,474.24	\$ 529,607.52	\$ 569,825.58	\$ 2,758,499.94	
<b>TOTAL FOR ALL PROGRAMS</b>	<b>\$2,701,264.15</b>	<b>\$ 2,496,852.01</b>	<b>\$ 2,733,415.88</b>	<b>\$ 2,769,358.07</b>	<b>\$ 2,734,148.39</b>	<b>\$ 13,346,921.39</b>	

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WEST MAUI MOUNTAINS WATERSHED PARTNERSHIP RARE ELEMENTS LIST							
#	Type	Family Name	Scientific Name	Common Name / A.K.A	Fed/ State Rank	Endemic	PEPP Rank
1	Arthro	Scutelleridae	<i>Coleotichus blackburniae</i>	Koa Bug	SOC	Hawai'i	-
2	Arthro	Drosophilidae	<i>Drosophila neoclavisetae</i>	Hawaiian Picture-Wing Flies	E	Hawai'i	-
3	Arthro	Sphingidae	<i>Manduca blackburni</i>	Blackburn's Sphinx Moth	E	Hawai'i	-
4	Arthro	Coenagrionidae	<i>Megalagrion nigrohamatum</i> ssp. <i>nigrohamatum</i>	Pinao, damselfly	SOC	Hawai'i	-
5	Arthro	Coenagrionidae	<i>Megalagrion pacificum</i>	Pinao 'ula, Damselfly	E	Hawai'i	-
6	Arthro	Coenagrionidae	<i>Megalagrion xanthomelas</i>	Orangeblack megalagrion, Damselfly	C	Hawai'i	-
7	Bird	Strigidae	<i>Asio flammeus sandwicensis</i>	Pueo; short-eared owl	SOC	Hawai'i	-
8	Bird	Anatidae	<i>Branta sandwicensis</i>	Nene	E	Hawai'i	-
9	Bird	Procellariidae	<i>Pterodroma sandwichensis</i>	'U'au; dark-rumped petrel	E	Hawai'i	-
10	Bird	Procellariidae	<i>Puffinus auricularis</i>	'A'o; Newell's shearwater	T	-	-
11	Bird	Fringillidae	<i>Vestiaria coccinea</i>	I'iwi	SOC	Hawai'i	-
12	Fish	Gobiidae	<i>Lentipes concolor</i>	'O'opu alamo'o	SOC	Hawai'i	-
13	Invert	Succineidae	<i>Catinella baldwinii</i>	Formerly Succinea sp., Amber snails	SOC	WM	-
14	Invert	Succineidae	<i>Catinella caduca</i>	Formerly Succinea sp., Amber snails	SOC	WM	-
15	Invert	Colletidae	<i>Hylaeus assimulans</i>	Order Hymenoptera - yellowfaced bee	SOC	Hawai'i	-
16	Invert	Colletidae	<i>Hylaeus difficilis</i>	Order Hymenoptera - yellowfaced bee	SOC	Hawai'i	-
17	Invert	Colletidae	<i>Hylaeus fuscipennis</i>	Order Hymenoptera - yellowfaced bee	SOC	Hawai'i	-
18	Invert	Colletidae	<i>Hylaeus haleakalae</i>	Order Hymenoptera - yellowfaced bee	SOC	Hawai'i	-
19	Invert	Colletidae	<i>Hylaeus laetus</i>	Order Hymenoptera - yellowfaced bee	SOC	Hawai'i	-
20	Invert	Colletidae	<i>Hylaeus unicus</i>	Order Hymenoptera - yellowfaced bee	SOC	Hawai'i	-
21	Invert	Colletidae	<i>Hylaeus volatilis</i>	Order Hymenoptera - yellowfaced bee	SOC	Hawai'i	-
22	Invert	Curculionidae	<i>Nesotocus giffardii</i>	Olapa weevil	SOC		-
23	Invert	Achatinellidae	<i>Newcombia cumingi</i>	Newcombs tree snail	E	Hawai'i	-
24	Invert	Achatinellidae	<i>Partulina crocea</i>	Achatinellid Land Snail	SOC		-
25	Invert	Achatinellidae	<i>Partulina fusioidea</i>	Achatinellid Land Snail	SOC	Hawai'i	-
26	Invert	Achatinellidae	<i>Partulina gouldii</i>	Achatinellid Land Snail	SOC		-
27	Invert	Achatinellidae	<i>Partulina kaaeana</i>	Achatinellid Land Snail	SOC	Hawai'i	-
28	Invert	Achatinellidae	<i>Partulina perdix</i>	Achatinellid Land Snail	SOC	Hawai'i	-
29	Invert	Achatinellidae	<i>Partulina radiata</i>	Achatinellid Land Snail	SOC		-
30	Invert	Achatinellidae	<i>Partulina splendida</i>	Achatinellid Land Snail	SOC	Hawai'i	-
31	Invert	Achatinellidae	<i>Partulina tappaniana</i>	Achatinellid Land Snail	SOC	Hawai'i	-
32	Invert	Achatinellidae	<i>Partulina terebra</i>	Achatinellid Land Snail	SOC	Hawai'i	-

#	Type	Family Name	Scientific Name	Common Name / A.K.A	Fed/ State Rank	Endemic	PEPP Rank
33	Invert	Achatinellidae	<i>Partulina ustulata</i>	Achatinellid Land Snail	SOC	Hawai'i	-
34	Invert	Achatinellidae	<i>Perdicella kuhnsi</i>	Achatinellid Land Snail	SOC	Hawai'i	-
35	Invert	Achatinellidae	<i>Perdicella ornata</i>	Achatinellid Land Snail	SOC	Hawai'i	-
36	Invert	Zonitidae	<i>Philonesia decepta</i>		SOC		-
37	Invert	Zonitidae	<i>Philonesia guavarum</i>		SOC		-
38	Invert	Zonitidae	<i>Philonesia hahakeae</i>		SOC		-
39	Invert	Zonitidae	<i>Philonesia waiheensis</i>		SOC		-
40	Invert	Cerambycidae	<i>Plagithmysus alani</i>	long-horned wood borer	SOC	Hawai'i	-
41	Invert	Cerambycidae	<i>Plagithmysus</i> near <i>longicollis</i>	long-horned wood borer	SOC	Hawai'i	-
42	Invert	Cerambycidae	<i>Plagithmysus</i> spp.	long-horned wood borer	SOC	Hawai'i	-
43	Invert	Curculionidae	<i>Rhynchogonus lahainae</i>	Weevil	SOC		-
44	Mammal	Vespertilionidae	<i>Lasiurus cinereus semotus</i>	Hawaiian Hoary Bat; 'Ope'ape'a	E	Hawai'i	-
45	Plant	Fabaceae	<i>Acacia koaia</i>	Koa, koai'a, koa 'oha	SOC	Hawai'i	-
46	Plant	Rosaceae	<i>Acaena exigua</i>	Liliwai	E	Hawai'i	PEP
47	Plant	Amaranthaceae	<i>Achyranthes splendens</i> var. <i>splendens</i>		SOC	Hawai'i	-
48	Plant	Sapindaceae	<i>Alectryon macrococcus</i> var. <i>macrococcus</i>	Mahoe, 'ala'alahua	E	Hawai'i	ROI
49	Plant	Rhamnaceae	<i>Alphitonia ponderosa</i>	O'a, Kauila	SOC	Hawai'i	-
50	Plant	Orchidaceae	<i>Anoectochilus sandvicensis</i>	Jewel Orchid	SOC	Hawai'i	-
51	Plant	Asteraceae	<i>Argyroxiphium caliginis</i>	Eke Silversword	SOC	WM	-
52	Plant	Asteraceae	<i>Bidens campylothea</i> subsp. <i>pentamera</i>	Ko'oko'olau	E	Hawai'i	-
53	Plant	Asteraceae	<i>Bidens conjuncta</i>	Ko'oko'olau	E	WM	-
54	Plant	Asteraceae	<i>Bidens micrantha</i> subsp. <i>kalealaha</i>	Ko'oko'olau	E	Hawai'i	-
55	Plant	Rubiaceae	<i>Bobea sandwicensis</i>	'Ahakea	SOC	Hawai'i	-
56	Plant	Rubiaceae	<i>Bobea timonioides</i>	'Ahakea	SOC	Hawai'i	-
57	Plant	Convolvulaceae	<i>Bonamia menziesii</i>		E	Hawai'i	ROI
58	Plant	Poaceae	<i>Calamagrostis expansa</i>	Reedgrass	E	Hawai'i	-
59	Plant	Poaceae	<i>Calamagrostis hillebrandii</i>	Reedgrass	C	Hawai'i	-
60	Plant	Poaceae	<i>Cenchrus agrimonioides</i> var. <i>agrimonioides</i>	Kamanomano	E	Hawai'i	ROI
61	Plant	Euphorbiaceae	<i>Chamaesyce celastroides</i> var. <i>laehiensis</i>	'Akoko	SOC	Hawai'i	-
62	Plant	Euphorbiaceae	<i>Chamaesyce celastroides</i> var. <i>lorifolia</i>	'Akoko	SOC	Hawai'i	-
63	Plant	Euphorbiaceae	<i>Chamaesyce olowaluana</i>	'Akoko	SOC	Hawai'i	-
64	Plant	Campanulaceae	<i>Clermontia arborescens</i> subsp. <i>arborescens</i>	'Oha wai nui	SOC	WM	-

#	Type	Family Name	Scientific Name	Common Name / A.K.A	Fed/ State Rank	Endemic	PEPP Rank
65	Plant	Campanulaceae	<i>Clermontia oblongifolia</i> subsp. <i>mauiensis</i>	'Oha wai	E	Hawai'i	PEP
66	Plant	Rhamnaceae	<i>Colubrina oppositifolia</i>	Kauila	E	Hawai'i	ROI
67	Plant	Dryopteridaceae	<i>Ctenitis squamigera</i>	Pauoa	E	Hawai'i	-
68	Plant	Campanulaceae	<i>Cyanea asplenifolia</i>	Haha, 'Oha, 'Oha wai	E	Maui	-
69	Plant	Campanulaceae	<i>Cyanea kunthiana</i>	Haha, 'Oha, 'Oha wai	E	Maui	-
70	Plant	Campanulaceae	<i>Cyanea lobata</i> subsp. <i>lobata</i>	Haha, 'Oha, 'Oha wai	E	WM	PEP
71	Plant	Campanulaceae	<i>Cyanea magnicalyx</i>	Formerly <i>C. grimesiana</i> , Haha, 'Oha, 'Oha wai	E	WM	PEP
72	Plant	Campanulaceae	<i>Cyanea obtusa</i>	Haha, 'Oha, 'Oha wai	E	Maui	PEP
73	Plant	Gesneriaceae	<i>Cyrtandra filipes</i>	Ha'iwale	E	Hawai'i	PEP
74	Plant	Gesneriaceae	<i>Cyrtandra lydgatei</i>	Ha'iwale	SOC	Hawai'i	-
75	Plant	Gesneriaceae	<i>Cyrtandra macrocalyx</i>	Ha'iwale	SOC	Hawai'i	-
76	Plant	Gesneriaceae	<i>Cyrtandra munroi</i>	Ha'iwale	E	Hawai'i	-
77	Plant	Gesneriaceae	<i>Cyrtandra oxybapha</i>	Ha'iwale	C	WM	-
78	Plant	Poaceae	<i>Dichantherium koolauense</i>	Koolau rosette grass	SOC	Hawai'i	-
79	Plant	Aspleniaceae	<i>Diellia erecta</i> f. <i>erecta</i>	erect island spleenwort	E	Hawai'i	PEP
80	Plant	Aspleniaceae	<i>Diellia erecta</i> f. <i>pumila</i>	palapalai lau li'I - "small leaved fern"	E	Hawai'i	PEP
81	Plant	Athyriaceae	<i>Diplazium molokaiense</i>	Formerly <i>Diplazium</i> <i>cristatum</i>	E	Hawai'i	PEP
82	Plant	Poaceae	<i>Dissochondrus biflorus</i>	Hawai'i false bristlegrass	SOC	Hawai'i	-
83	Plant	Blechnaceae	<i>Doodia lyonii</i>		SOC	Hawai'i	-
84	Plant	Asteraceae	<i>Dubautia hanaulaensis</i>		SOC	WM	
85	Plant	Asteraceae	<i>Dubautia plantaginea</i> subsp. <i>humilis</i>	Na'ena'e	E	WM	PEP
86	Plant	Poaceae	<i>Eragrostis deflexa</i>		SOC	Hawai'i	-
87	Plant	Fabaceae	<i>Erythrina sandwicensis</i>	Wiliwili	SOC	Hawai'i	-
88	Plant	Theaceae	<i>Eurya sandwicensis</i>	Anini, Wanini	SOC	Hawai'i	-
89	Plant	Sanatalaceae	<i>Exocarpos gaudichaudii</i>	Hulumoa	SOC	Hawai'i	-
90	Plant	Rubiaceae	<i>Gardenia remyi</i>	Nanu	C	Hawai'i	-
91	Plant	Geraniaceae	<i>Geranium hillebrandii</i>	Formerly <i>Geranium</i> <i>humile</i> , Nohoanu	C	WM	-
92	Plant	Malvaceae	<i>Gossypium tomentosum</i>	Ma'o	SOC	Hawai'i	-
93	Plant	Rhamnaceae	<i>Gouania hillebrandii</i>		E	Hawai'i	-
94	Plant	Asteraceae	<i>Hesperomannia</i> <i>arborescens</i>		E	Hawai'i	-
95	Plant	Malvaceae	<i>Hibiscus brackenridgei</i> subsp. <i>brackenridgei</i>	Ma'o hau hele	E	Hawai'i	PEP
96	Plant	Malvaceae	<i>Hibiscus kokio</i> subsp. <i>kokio</i>	Koki'o 'ula	SOC	Hawai'i	-
97	Plant	Begoniaceae	<i>Hillebrandia sandwicensis</i>	Pua maka nui, Aka 'aka 'awa	SOC	Hawai'i	-
98	Plant	Lycopodiaceae	<i>Huperzia mannii</i>	was <i>Phlegmariurus</i> <i>mannii</i> , Wawae'iole	E	Hawai'i	-
99	Plant	Isoetaceae	<i>Isoetes Hawai'iensis</i>	Hawaiian quillwort	SOC	Hawai'i	-
100	Plant	Joinvilleaceae	<i>Joinvillea ascendens</i> subsp. <i>ascendens</i>	'Ohe	C	Indigeno us	-



#	Type	Family Name	Scientific Name	Common Name / A.K.A	Fed/ State Rank	Endemic	PEPP Rank
101	Plant	Rubiaceae	<i>Kadua formosa</i>		SOC	Hawai'i	-
102	Plant	Rubiaceae	<i>Kadua laxiflora</i>	was Hedyotis mannii; Pilo	E	Hawai'i	PEP
103	Plant	Asteraceae	<i>Lagenifera maviensis</i>	Howaiiaulu, also Keysseria maviensis	SOC	Hawai'i	-
104	Plant	Orchidaceae	<i>Liparis hawaiiensis</i>	'Awapuhiakanaloa	SOC	Hawai'i	-
105	Plant	Primulaceae	<i>Lysimachia lydgatei</i>		E	Hawai'i	PEP
106	Plant	Rutaceae	<i>Melicope hawaiiensis</i>	Alani, Pelea hawaiiensis, Manena, Mokihana Kukae Moa	SOC	Hawai'i	-
107	Plant	Rutaceae	<i>Melicope Sp1</i>	Waihe'e Melicope	SOC		PEP
108	Plant	Dennstaedtiaceae	<i>Microlepia strigosa</i> var. <i>mauiensis</i>		C	Hawai'i	-
109	Plant	Rubiaceae	<i>Morinda trimera</i>	Noni kuahiwi	SOC	Hawai'i	ROI
110	Plant	Myrsinaceae	<i>Myrsine vaccinioides</i>	Kolea	C	WM	-
111	Plant	Urticaceae	<i>Neraudia sericea</i>		E	Hawai'i	PEP
112	Plant	Sapotaceae	<i>Nesoluma polynesianum</i>	Keahi	SOC	Indigeno us	-
113	Plant	Solanaceae	<i>Nothocestrum latifolium</i>	'Aiea	C	Hawai'i	-
114	Plant	Apocynaceae	<i>Ochrosia compta</i>	Holei	SOC	Hawai'i	-
115	Plant	Lamiaceae	<i>Phyllostegia bracteata</i>		C	Maui	PEP
116	Plant	Lamiaceae	<i>Phyllostegia stachyoides</i>		SOC	Hawai'i	PEP
117	Plant	Pittosporaceae	<i>Pittosporum argentifolium</i>	Hawai'i poisonberry tree	SOC	Hawai'i	-
118	Plant	Plantaginaceae	<i>Plantago princeps</i> var. <i>laxifolia</i>	Laukahi kuahiwi, Ale - could say "laxiflora" but real name is laxifolia	E	Hawai'i	PEP
119	Plant	Orchidaceae	<i>Platanthera holochila</i>		E	Hawai'i	PEP
120	Plant	Portulacaceae	<i>Portulaca villosa</i>	'Ihi	SOC	Hawai'i	-
121	Plant	Areacaceae	<i>Pritchardia</i> c.f. <i>munroi</i>	Loulu	E	Hawai'i	PEP
122	Plant	Areacaceae	<i>Pritchardia forbesiana</i>	Loulu	SOC	WM	-
123	Plant	Areacaceae	<i>Pritchardia glabrata</i>	Loulu	SOC	WM	-
124	Plant	Pteridaceae	<i>Pteris lidgatei</i>		E	Hawai'i	PEP
125	Plant	Ranunculaceae	<i>Ranunculus mauiensis</i>		C	Hawai'i	-
126	Plant	Asteraceae	<i>Remya mauiensis</i>		E	WM	-
127	Plant	Araliaceae	<i>Reynoldsia sandwicensis</i>	'Ohe, 'ohe makai, 'ohe kukuluae'o, 'ohe'ohe, 'ohekai	SOC	Hawai'i	-
128	Plant	Apiaceae	<i>Sanicula purpurea</i>		E	Hawai'i	-
129	Plant	Apiaceae	<i>Sanicula sandwicensis</i>		SOC	Hawai'i	ROI
130	Plant	Santalaceae	<i>Santalum haleakalae</i> var. <i>lanaiense</i>	'Iliahi; Sandalwood, also simply Santalum freycinetianum (no variation)	E	Hawai'i	-
131	Plant	Goodeniaceae	<i>Scaevola hobdyi</i>	Hobdy's Naupaka	SOC	WM	PEP
132	Plant	Caryophyllaceae	<i>Schiedea menziesii</i>		SOC	Hawai'i	-
133	Plant	Caryophyllaceae	<i>Schiedea pubescens</i>		C	Hawai'i	POP
134	Plant	Caryophyllaceae	<i>Schiedea salicaria</i>		C	WM	-
135	Plant	Fabaceae	<i>Sesbania tomentosa</i>	'Ohai	E	Hawai'i	-

#	Type	Family Name	Scientific Name	Common Name / A.K.A	Fed/ State Rank	Endemic	PEPP Rank
136	Plant	Cucurbitaceae	<i>Sicyos cucumerinus</i>	Panunukuahiwi	SOC	Hawai'i	-
137	Plant	Apiaceae	<i>Spermolepis hawai'iensis</i>		E	Hawai'i	-
138	Plant	Lamiaceae	<i>Stenogyne calycosa</i>		SOC	Maui	-
139	Plant	Lamiaceae	<i>Stenogyne kauaulaensis</i>		SOC	WM	PEP
140	Plant	Fabaceae	<i>Strongylodon ruber</i>	Nuku I'wi	SOC	Hawai'i	-
141	Plant	Asteraceae	<i>Tetramolopium capillare</i>	Pamakani	E	WM	PEP
142	Plant	Violaceae	<i>Viola lanaiensis</i>		E	Hawai'i	POP
143	Plant	Thymelaeaceae	<i>Wikstroemia bicornuta</i>		SOC	Hawai'i	-
144	Plant	Rutaceae	<i>Zanthoxylum dipetalum</i> var. unknown		SOC	Hawai'i	-
145	Plant	Rutaceae	<i>Zanthoxylum kauaense</i>		SOC	Hawai'i	-
146	Plant	Rutaceae	<i>Zanthoxylum Hawaiiense</i>	A'e	E	Hawai'i	-

Key - Federal and State Rankings				
Abbreviation	Status	Definition		Ranking Total
E	Endangered	Danger of Extinction		48
T	Threatened	Likely to be Endangered		1
C	Candidate	Considered for Listing as T or E		13
SOC	Species of Concern	Needing Conservation or Declining		84
Total Rare Species				146

Key - Plant Extinction Prevention Program (PEPP) Rankings				
Abbreviation	Status	Definition		Ranking Total
PEP	PEP Program Target	<50 Plants in Wild		24
POP	Potentially PEP	> 50 but extremely vulnerable		2
ROI	Rare on Island	<50 Plants on Island		6
Total Species				32

Appendix B. West Maui Mountains Watershed Partnership Fences.

WEST MAUI MOUNTAINS WATERSHED PARTNERSHIP FENCES																
#	Name	FenceSec *	Status	Purpose	Material	NEED_RETRO	LineSrc	MngAgency	DateComp	BltAgency	Height (Ft)	Apron	DateRetrofit	DateReBuilt	Length (m)	TMK
1	10A	10A	Complete	Pig	Hog	NO	GPS	PKW	12/31/1988	PKW	4	Absent	<Null>	<Null>	97	242001001, 241001017
2	12A	12A	Complete	Pig	Hog	NO	GPS	PKW	05/19/1996	PKW	4	Absent	<Null>	<Null>	220	244004010, 244004008
3	12B	12B	Complete	Pig	Hog	NO	GPS	PKW	05/19/1996	PKW	4	Absent	<Null>	<Null>	11	244007006
4	1A	1A	Complete	Pig	Hog	NO	GPS	PKW	04/25/1990	PKW	4	Absent	<Null>	<Null>	4	231006001
5	1B	1B	Complete	Pig	Hog	NO	GPS	PKW	07/10/1992	PKW	4	Absent	<Null>	<Null>	4	241001017
6	1C	1C	Complete	Pig	Hog	NO	GPS	PKW	09/30/1992	PKW	4	Absent	<Null>	<Null>	74	241001017
7	1D	1D	Complete	Pig	Hog	NO	GPS	PKW	12/31/1992	PKW	4	Absent	<Null>	<Null>	16	241001017
8	1E	1E	Complete	Pig	Hog	YES	GPS	PKW	10/27/2003	PKW	4	Complete	<Null>	<Null>	837	241001009, 241001017
9	1F	1F	Complete	Pig	Hog	YES	GPS	PKW	01/01/2006	WMMWP	4	Complete	<Null>	<Null>	1532	241001017, 231006001
10	2A	2A	Complete	Pig	Hog	NO	GPS	PKW	10/20/2001	PKW	4	Complete	<Null>	<Null>	10	241001017
11	2B	2B	Complete	Pig	Hog	NO	GPS	PKW	10/02/2002	PKW	4	Complete	<Null>	<Null>	10	241001017
12	2C	2C	Complete	Pig	Hog	NO	GPS	PKW	10/02/2002	PKW	4	Complete	<Null>	<Null>	50	241001017
13	2D	2D	Complete	Pig	Hog	NO	GPS	PKW	11/15/2002	PKW	4	Complete	<Null>	<Null>	28	241001017
14	3A	3A	Complete	Pig	Hog	NO	GPS	PKW	04/30/1992	PKW	4	Complete	<Null>	<Null>	699	241001017
15	3B	3B	Complete	Pig	Hog	NO	GPS	PKW	04/29/1998	PKW	4	Absent	<Null>	<Null>	9	241001017
16	3C	3C	Complete	Pig	Hog	NO	GPS	PKW	04/28/1998	PKW	4	Absent	<Null>	<Null>	83	241001017, 242001001
17	4A	4A	Complete	Pig	Hog	NO	GPS	PKW	12/31/1994	PKW	4	Complete	<Null>	<Null>	580	242001001
18	4B	4B Honokahua to Koa Camp	Complete	Pig	Hog	NO	GPS	PKW	06/30/1995	PKW	4	Absent	<Null>	<Null>	348	242001001
19	4B	4B Koa Camp to T3	Complete	Pig	Hog	NO	GPS	PKW	06/30/1995	PKW	4	Absent	<Null>	<Null>	163	242001001
20	4C	4C	Complete	Pig	Hog	NO	GPS	PKW	01/04/1998	PKW	4	Absent	<Null>	<Null>	48	242001001
21	4D	4D Arboretum Parking lot to gate	Complete	Pig	Hog	YES	GPS	PKW	08/01/2003	PKW	4	Complete	<Null>	<Null>	175	242001041, 242001001
22	4D	4D Arboretum Parking lot to Honolulu	Complete	Pig	Hog	YES	GPS	PKW	08/01/2003	PKW	4	Complete	<Null>	<Null>	663	242001041, 242001001
23	4D	4D First Gate to Honokahua	Complete	Pig	Hog	YES	GPS	PKW	08/01/2003	PKW	4	Complete	<Null>	<Null>	1994	242001041, 242001001
24	4D	4D Honokahua	Complete	Pig	Hog	YES	GPS	PKW	08/01/2003	PKW	4	Complete	<Null>	<Null>	383	242001001
25	5A	5A	Complete	Pig	Hog	NO	GPS	PKW	12/31/1988	PKW	4	Absent	<Null>	<Null>	53	242001001, 243001001
26	5B	5B	Complete	Pig	Hog	NO	GPS	PKW	12/31/1988	PKW	4	Absent	<Null>	<Null>	28	243001001, 243001017
27	6A	6A	Complete	Pig	Hog	NO	GPS	PKW	12/31/1998	PKW	4	Absent	<Null>	<Null>	37	243001017
28	6B	6B	Complete	Pig	Hog	NO	GPS	PKW	12/31/1998	PKW	4	Absent	<Null>	<Null>	38	243001017
29	6C	6C	Complete	Pig	Hog	NO	GPS	PKW	01/30/2002	PKW	4	Complete	<Null>	<Null>	39	243001017
30	6D	6D	Complete	Pig	Hog	NO	GPS	PKW	06/27/2002	PKW	4	Absent	<Null>	<Null>	141	243001017
31	7A	7A	Complete	Pig	Hog	NO	GPS	PKW	07/18/1989	PKW	4	Absent	<Null>	<Null>	67	242001001
32	7B	7B	Complete	Pig	Hog	NO	GPS	PKW	12/31/1990	PKW	4	Absent	<Null>	<Null>	174	242001001
33	8A	8A	Complete	Pig	Hog	NO	GPS	PKW	12/31/1988	PKW	4	Complete	<Null>	<Null>	194	241001017
34	8B	8B	Complete	Pig	Hog	NO	GPS	PKW	02/22/1990	PKW	4	Complete	<Null>	<Null>	43	241001017
35	9A	9A	Complete	Pig	Hog	NO	GPS	PKW	12/31/1988	PKW	4	Absent	<Null>	<Null>	30	242001001, 244007004
36	Donkey	Alaeloa Ridge	Complete	Deer/Pig	Hog	NO	GPS	PKW	12/31/2008	PKW	8	Complete	<Null>	<Null>	108	243001001, 242001001
37	Donkey	Alaeloa Ridge	Complete	Deer/Pig	Hog	NO	GPS	PKW	12/31/2008	PKW	8	Complete	<Null>	<Null>	91	243001001
38	Donkey	Alaeloa Ridge	Complete	Deer/Pig	Hog	NO	GPS	PKW	12/31/2008	PKW	8	Complete	<Null>	<Null>	70	243001001
39	Donkey	Alaeloa Ridge	Complete	Deer/Pig	Hog	NO	GPS	PKW	12/31/2008	PKW	8	Complete	<Null>	<Null>	100	243001001, 243001001
40	Donkey	Alaeloa Ridge	Complete	Deer/Pig	Hog	NO	GPS	PKW	12/31/2008	PKW	8	Complete	<Null>	<Null>	48	242001001
41	Donkey	Alaeloa Ridge	Complete	Deer/Pig	Hog	NO	GPS	PKW	12/31/2008	PKW	8	Complete	<Null>	<Null>	44	243001001
42	Donkey	Alaeloa Ridge	Complete	Deer/Pig	Hog	NO	GPS	PKW	12/31/2008	PKW	8	Complete	<Null>	<Null>	124	243001001

#	Name	FenceSec *	Status	Purpose	Material	NEED_RETRO	LineSrc	MngAgency	DateComp	BltAgency	Height (Ft)	Apron	DateRetrofit	DateReBuilt	Length (m)	TMK
43	Donkey	Alaeloa to Mailepai	Complete	Deer/Pig	Hog/Mesh	NO	GPS	PKW	<Null>	PKW	8	Complete	<Null>	<Null>	157	243001001
44	Ctenitis Exlosure	Ctenitis Exlosure	Complete	Pig	Hog	NO	GPS	PKW	11/17/1999	PKW	4	Complete	<Null>	<Null>	121	242001001
45	E10	E10	Complete	Pig	Hog	YES	Drawn	WMMWP	<Null>	WMMWP	4	Complete	<Null>	<Null>	220	232014001, 232014002
46	Mauna Alani ridge DB	E14	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	07/08/2008	WMMWP	4	Absent	<Null>	<Null>	5	232014001
47	E15	E15	Complete	Pig	Hog	NO	GPS	WMMWP	04/03/2008	WMMWP	4	Complete	<Null>	<Null>	50	232014001, 232014002
48	Waihee TNC fence	E16	Complete	Pig	Hog	NO	GPS	WMMWP	01/01/2003	WMMWP	4	Complete	<Null>	<Null>	25	232014001
49	E16A	E16A	Complete	Pig	Hog	NO	GPS	WMMWP	01/01/2003	WMMWP	4	Complete	<Null>	<Null>	10	232014001
50	Waihee valley	E17	Complete	Pig	Hog	YES	GPS	WMMWP	07/20/2005	WMMWP	4	Complete	<Null>	<Null>	162	232014001
51	Iao1	E18	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	07/21/2008	WMMWP	4	Absent	<Null>	<Null>	15	233003003
52	Iao2	E19	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	07/21/2008	WMMWP	4	Absent	<Null>	12/07/2010	20	233003003
53	Iao 5	E20	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	12/18/2008	WMMWP	4	Absent	<Null>	<Null>	17	233003003
54	Iao6	E21	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	08/05/2008	WMMWP	4	Absent	<Null>	12/07/2010	15	233002001
55	WAI1	E22	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	08/06/2008	WMMWP	4	Absent	<Null>	<Null>	20	232014001
56	WAI2	E23	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	08/19/2008	WMMWP	4	Absent	<Null>	<Null>	20	232014001
57	Wai3DB	E24	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	10/29/2008	WMMWP	4	Absent	<Null>	<Null>	10	232014002
58	MAUN9	E25	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	12/10/2008	WMMWP	4	Absent	<Null>	<Null>	12	232001001
59	MAUN11	E26	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	12/09/2008	WMMWP	4	Absent	<Null>	<Null>	12	232014001
60	Maun10	E27	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	12/15/2008	WMMWP	4	Absent	<Null>	<Null>	3	232014001
61	Maun7	E28	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	12/23/2008	WMMWP	4	Absent	<Null>	<Null>	10	232014001
62	Maun 7-8	E29	Complete	DirtBike	Barricade	N/A	GPS	WMMWP	12/23/2008	WMMWP	4	Absent	<Null>	<Null>	7	232014001
63	Puu Kaupo	E30	Complete	Pig	Hog	NO	GPS	WMMWP	08/18/2009	WMMWP	4	Complete	<Null>	<Null>	75	232014001
64	Puu Kane	E31	Complete	Pig	Hog	NO	GPS	WMMWP	08/27/2009	WMMWP	4	Complete	<Null>	<Null>	30	233003003
65	Iao3	E32	Complete	Pig	Hog	YES	GPS	WMMWP	01/06/2010	WMMWP	4	Complete	<Null>	<Null>	33	233003003
66	Iao4	E33	Complete	Pig	Hog	YES	GPS	WMMWP	02/09/2010	WMMWP	4	Complete	<Null>	<Null>	70	233003003
67	E4	E4	Complete	Pig	Hog	YES	GPS	WMMWP	07/22/2008	WMMWP	4	Complete	<Null>	<Null>	72	233003003
68	E5	E5	Complete	Pig	Hog	YES	GPS	WMMWP	<Null>	WMMWP	4	Complete	<Null>	<Null>	20	233003003
69	E6	E6	Complete	Pig	Hog	YES	Drawn	WMMWP	<Null>	WMMWP	4	Complete	<Null>	<Null>	30	232014001
70	E7	E7	Complete	Pig	Hog	NO	GPS	WMMWP	10/27/2009	WMMWP	4	Complete	<Null>	<Null>	30	232014001
71	E8	E8	Complete	Pig	Hog	YES	GPS	WMMWP	05/27/2009	WMMWP	4	Complete	<Null>	<Null>	40	232014001
72	E9	E9	Complete	Pig	Hog	YES	GPS	WMMWP	10/30/2008	WMMWP	4	<Null>	<Null>	<Null>	30	232014002
73	Donkey	Field 26	Complete	Deer/Pig	Hog	NO	GPS	PKW	04/11/2008	PKW	8	Complete	<Null>	<Null>	216	243001017, 243001001
74	Donkey	Field 26 to Kahana	Complete	Deer/Pig	Hog/Mesh	NO	GPS	PKW	11/24/2008	PKW	8	Complete	<Null>	<Null>	215	243001017
75	Donkey	Field 26 to Mailepai	Complete	Deer/Pig	Hog/Mesh	NO	GPS	PKW	<Null>	PKW	8	Complete	<Null>	<Null>	107	243001001
76	Donkey	Mahinahina	Complete	Deer/Pig	Hog/Mesh	NO	GPS	PKW	<Null>	PKW	8	Complete	<Null>	<Null>	280	243001017, 243001071
77	Lanilili	NE10	Complete	Pig	Hog	YES	GPS	WMMWP/NARS	05/22/2008	WMMWP	4	Complete	<Null>	<Null>	650	232014001, 231006001
78	NE11-Lanilili picnic table	NE11	Complete	Pig	Hog	YES	GPS	WMMWP/NARS	05/22/2008	WMMWP/NARS	4	Complete	<Null>	<Null>	20	231006001
79	E13- Phase 1	NE2	Complete	Pig	Hog	NO	GPS	WMMWP/NARS	12/14/2005	WMMWP	4	Complete	<Null>	<Null>	75	231006001, 232014001
80	Kahakuloa Phase 2-west	NE4	Complete	Pig	Hog	NO	GPS	WMMWP/NARS	12/01/2005	WMMWP	4	Complete	<Null>	<Null>	198	231006001
81	Kahakuloa Phase 2-east. horse camp	NE5	Complete	Pig	Hog	NO	GPS	WMMWP	10/27/2005	WMMWP	4	Complete	<Null>	<Null>	733	232014001, 231006001
82	Kahakuloa boundary	NE8	Complete	Pig	Hog	YES	GPS	NARS	10/06/2005	WMMWP/NARS	4	Complete	<Null>	<Null>	2836	241001017, 231006001
83	Kahakuloa - Phase 3	NE9	Complete	Pig	Hog	YES	GPS	WMMWP/NARS	02/15/2007	WMMWP/NARS	4	Complete	<Null>	<Null>	2212	231006001, 231006003
84	SE1	SE1	Complete	Pig	Hog	YES	GPS	DOFAW	03/08/2002	DOFAW	4	Complete	<Null>	<Null>	302	236001052, 236001014, 236003001



#	Name	FenceSec *	Status	Purpose	Material	NEED_RETRO	LineSrc	MngAgency	DateComp	BltAgency	Height (Ft)	Apron	DateRetrofit	DateReBuilt	Length (m)	TMK
85	old SE10&11. DROA	SE10	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	11/27/2002	WMMWP	4	Complete	09/23/2010	<Null>	275	236003001
86	SE12	SE12	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	<Null>	WMMWP	4	Complete	11/24/2009	<Null>	538	236003001
87	SE13	SE13	Complete	Pig	Hog	NO	GPS	WMMWP	11/26/2007	WMMWP	4	Complete	<Null>	<Null>	20	235003001
88	Waikapu Valley	SE14	Complete	Pig	Hog	NO	GPS	WMMWP	11/06/2007	WMMWP	4	Complete	<Null>	<Null>	20	235003001
89	Kapi7	SE15	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	11/28/2007	WMMWP	4	Complete	09/14/2011	<Null>	30	235003001
90	KAPI5	SE17	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	04/20/2009	WMMWP	4	Complete	09/13/2011	<Null>	30	235003001
91	Kapi4	SE18	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	03/17/2009	WMMWP	4	Complete	07/06/2011	<Null>	40	235003001
92	KAPI 3	SE19	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	05/13/2009	WMMWP	4	Complete	09/13/2011	<Null>	100	235003001
93	KAPI2	SE20	Complete	Pig	Hog	NO	GPS	WMMWP	04/13/2009	WMMWP	4	Complete	<Null>	<Null>	15	235003001
94	KAPI1	SE21	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	04/01/2009	WMMWP	4	Complete	07/06/2011	<Null>	30	235003001
95	Hanaula barb	SE22	Complete	Deer/Pig	DeerWire	NO	GPS	WMMWP	10/18/2012	WMMWP	8	Complete	<Null>	<Null>	222	236003001
96	SE3	SE3	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	03/01/2000	WMMWP	4	Complete	01/12/2010	<Null>	105	236003001
97	SE5	SE5	Complete	Pig	Hog	NO	GPS	WMMWP	10/04/2002	WMMWP	4	Complete	<Null>	<Null>	1067	236003001
98	SE6	SE6	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	08/16/2002	WMMWP	4	Complete	01/25/2010	<Null>	668	236003001
99	SE6a	SE6a	Complete	Deer/Pig	Hog/Mesh	NO	GPS	WMMWP	07/14/2010	WMMWP	8	Complete	02/04/2010	<Null>	203	236003001
100	OldSE8	SE8a	Complete	Deer/Pig	Hog/Hog	NO	GPS	WMMWP	07/03/2012	WMMWP	8	Absent	<Null>	<Null>	30	236003001
101	S5	SW15	Complete	Pig	Hog	YES	GPS	DOFAW	03/08/2002	DOFAW	4	Complete	<Null>	<Null>	160	248001002
102	S6	SW16	Complete	Pig	Hog	YES	GPS	DOFAW	03/08/2002	DOFAW	4	Complete	<Null>	<Null>	108	248001001, 248001010
103	W1	W1	Complete	Pig	Hog	NO	GPS	WMMWP	03/21/2002	WMMWP	4	Complete	<Null>	<Null>	40	245022003, 245022002
104	W10	W10	Complete	Pig	Hog	NO	Drawn	WMMWP	03/11/2003	WMMWP	4	<Null>	<Null>	<Null>	10	246025002, 246025001
105	Kapunakea, unit 5 fence	W12	Complete	Pig	Hog	NO	GPS	WMMWP	01/01/1995	TNC	4	Complete	<Null>	<Null>	126	245022003, 244007001
106	TNC boundary/old13a&b	W14	Complete	Pig	Hog	YES	GPS	WMMWP	07/19/2002	WMMWP	4	Complete	<Null>	<Null>	1136	245022002, 245022004, 245022005, 245021023, 245021002, 245022006, 245021001, 245022001
107	Kapunakea boundary to Wahikuli ridge	W15	Complete	Pig	Hog	YES	GPS	WMMWP	05/10/2002	WMMWP	4	Complete	<Null>	<Null>	846	245021004, 245022003, 245021024, 245022002
108	TNC boundary	W16	Complete	Pig	Hog	YES	GPS	WMMWP	01/01/1994	TNC	4	<Null>	<Null>	<Null>	1111	244004002, 244004001, 244007001
109	TNC Powerline fence. + Honokowai ditch Ext.	W17	Complete	Pig	Hog	YES	GPS	WMMWP	01/01/1994	TNC	4	Complete	<Null>	<Null>	590	244004006, 244007005, 244007003, 244007001
110	Haenanui extension	W17A	Complete	Pig	Hog	YES	GPS	WMMWP	06/10/2009	WMMWP	4	Complete	<Null>	<Null>	150	244007001, 244004003
111	W18	W18	Complete	Pig	Hog	NO	Drawn	NARS	08/31/1998	TNC	4	Absent	<Null>	<Null>	37	244007004
112	W19	W19	Complete	Pig	Hog	NO	Drawn	NARS	08/31/1998	TNC	4	Absent	<Null>	<Null>	63	244007007
113	W2	W2	Complete	Pig	Hog	NO	GPS	WMMWP	04/19/2002	WMMWP	4	Complete	<Null>	<Null>	20	245022002, 245022003
114	W20	W20	Complete	Pig	Hog	NO	Drawn	NARS	08/31/1998	TNC	4	Absent	<Null>	<Null>	55	244007007
115	Ha'enanui gulch nose	W21	Complete	Pig	Hog	YES	Drawn	WMMWP	02/23/2009	WMMWP	4	Complete	<Null>	<Null>	20	244007001
116	W3	W3	Complete	Pig	Hog	NO	GPS	WMMWP	07/18/2002	WMMWP	4	Complete	<Null>	<Null>	70	245022005, 245022001
117	W4	W4	Complete	Pig	Hog	NO	GPS	WMMWP	04/12/2002	WMMWP	4	Complete	<Null>	<Null>	50	245022004, 245022005, 245022001
118	W5&W7	W5	Complete	Pig	Hog	YES	GPS	WMMWP/NARS	02/08/2002	WMMWP	4	Complete	<Null>	<Null>	271	245022001, 246025002
119	W6	W6	Complete	Pig	Hog	NO	Drawn	WMMWP/NARS	05/01/2003	WMMWP	4	Complete	<Null>	<Null>	222	245022001, 246025002
120	W5&W7	W7	Complete	Pig	Hog	YES	GPS	WMMWP/NARS	02/22/2002	WMMWP	4	Complete	<Null>	<Null>	370	246025002
121	W9	W9	Complete	Pig	Hog	YES	GPS	WMMWP	09/27/2002	WMMWP	4	Complete	<Null>	<Null>	485	246025002
122	PKW DOH funded	DOH fund	Partial	Deer/Pig	Hog/Mesh	<Null>	Drawn	PKW	<Null>	WMMWP/PKW	<Null>	<Null>	<Null>	<Null>	2444	241001009, 242001001
123	Donkey	Kahana Iki	Partial	Deer/Pig	Hog/Mesh	<Null>	GPS	PKW	<Null>	PKW	8	Complete	<Null>	<Null>	293	243001017, 243001071
124	SW1	SW1	Partial	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	WMMWP	8	<Null>	<Null>	<Null>	456	247001024, 247001004
125	PKW WCS funded	WCS fund	Partial	Deer/Pig	DeerWire	<Null>	GPS	PKW	<Null>	WMMWP/PKW	8	<Null>	<Null>	<Null>	1303	241001009

#	Name	FenceSec *	Status	Purpose	Material	NEED_RETRO	LineSrc	MngAgency	DateComp	BltAgency	Height (Ft)	Apron	DateRetrofit	DateReBuild	Length (m)	TMK
126	E1	E1	Proposed	Pig	Hog	<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	164	232014001, 233003003
127	E12	E12	Proposed	Pig	Hog	<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	89	232014001
128	South Waiehu upper	E34	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	58	232014001, 233003003
129	South Waiehu Valley	E35	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	45	232014001, 233003003
130	North Waiehu upper	E36	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	69	232014001
131	North Waiehu Valley	E37	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	45	232014001
132	Waihee Mid Valley	E38	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	49	232014001
133	Mananole	E39	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	64	232014001
134	Honolua	Honolua	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	52	242001001, 241001017
135	Donkey	Kahana Ridge	Proposed	Deer/Pig	Hog	<Null>	GPS	PKW	<Null>	PKW	8	<Null>	<Null>	<Null>	348	243001017
136	Kahoma	Kahoma	Proposed	Pig	Hog	<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	224	245022004, 245022002
137	Kahoma	KahomaRidge	Proposed	Pig	Hog	<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	170	245022005, 245022006
138	Kaulalewelewe	Kaulalewalewa	Proposed	Pig	Hog	<Null>	Drawn	PKW	<Null>	PKW	<Null>	<Null>	<Null>	<Null>	103	244007004, 242001001
139	Maun1_2	Maun1_2	Proposed	DirtBike		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	70	232014002, 232014001
140	Maun10	Maun10	Proposed	DirtBike		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	73	232014001
141	Maun11_12	Maun11_12	Proposed	DirtBike		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	72	232014001
142	Maun3_4	Maun3_4	Proposed	DirtBike		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	72	232014001
143	Maun5	Maun5	Proposed	DirtBike		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	72	232014001
144	Maun6	Maun6	Proposed	DirtBike		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	73	232014001
145	Maun7_8	Maun7_8	Proposed	DirtBike		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	72	232014001
146	Mauna Alani Ridge	MaunRidge	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	130	232014001
147	Donkey	Moomoku Ag	Proposed	Deer/Pig	Hog	<Null>	GPS	PKW	<Null>	PKW	8	<Null>	<Null>	<Null>	176	243001017
148	Donkey	Moomoku Preserve	Proposed	Deer/Pig	Hog	<Null>	GPS	PKW	<Null>	PKW	8	<Null>	<Null>	<Null>	116	243001017
149	Donkey	Moomoku State	Proposed	Deer/Pig	Hog	<Null>	GPS	PKW	<Null>	PKW	8	<Null>	<Null>	<Null>	484	244007006, 244004008
150	Kahakuloa upper	NE12	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	65	231006001
151	Kahak lower valley	NE13	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	684	231006001
152	Kahakuloa to Laniiili	NE14	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	594	231006001
153	Kahaukuloa	NE15	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	99	231006001
154	Donkey	Phase 12	Proposed	Deer/Pig	Hog	<Null>	GPS	PKW	<Null>	PKW	8	<Null>	<Null>	<Null>	257	242001001
155	Donkey	Phase 4 Alaeloa to Honokahua	Proposed	Deer/Pig	Hog	<Null>	GPS	PKW	<Null>	PKW	8	<Null>	<Null>	<Null>	1262	242001001, 243001001
156	Donkey	Phase 5	Proposed	Deer/Pig	Hog	<Null>	GPS	PKW	<Null>	PKW	8	<Null>	<Null>	<Null>	137	243001017
157	Kanaha to Launiupoko	Phase1	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	4205	246025002, 246018003, 246021004, 246025001, 246022001, 247001002, 247001024
158	Launiupokoto Olowalu	Phase2	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	5428	247001024, 247001025, 247010009, 248003040, 248003008, 248003108, 248001002
159	PKW new	PKWNew	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	1175	241004013, 241001009, 241004012, 241004888
160	KAPI6	SE16	Proposed	Deer/Pig	<Null>	<Null>	Drawn	WMMWP	<Null>	WMMWP	<Null>	<Null>	<Null>	<Null>	82	235003001
161	SE2	SE2	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	115	236003001
162	Waikapu north fork	SE23	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	96	235003001
163	Lower Waikapu Valley	SE24	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	98	235003001, 236003001
164	Iao Valley Fence	SE25	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	747	233003003, 235003001
165	Iao lower valley	SE26	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	320	233003003, 235003001

#	Name	FenceSec *	Status	Purpose	Material	NEED_RETRO	LineSrc	MngAgency	DateComp	BltAgency	Height (Ft)	Apron	DateRetrofit	DateReBuild	Length (m)	TMK
166	SE4	SE4	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	119	236003001
167	SE9	SE9	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	133	236003001
168	Lihau5	SW10	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>		0	<Null>	<Null>	<Null>	125	248001002
169	SW17	SW17	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	WMMWP	<Null>	<Null>	<Null>	<Null>	161	248001002
170	SW18	SW18	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	WMMWP	<Null>	<Null>	<Null>	<Null>	125	248001002
171	SW19	SW19	Proposed	Deer/Pig		<Null>	GPS	WMMWP	<Null>	WMMWP	<Null>	<Null>	<Null>	<Null>	190	248001002
172	SW2	SW2	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	153	247001004, 247001024
173	SW20	SW20	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	WMMWP	<Null>	<Null>	<Null>	<Null>	103	248001002
174	Launiupoko Valley Fe	SW21	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	202	247001024
175	Launiupoko lowvalley	SW22	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	82	247001024
176	Olowalu upper Valley	SW23	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	110	248001002
177	Olowalu Valley Fence	SW24	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	71	248001002
178	Ukumehame Valley Fen	SW25	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	189	248001002
179	Ukumehame Valley frt	SW26	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	142	248001002
180	Papalaua strategic	SW27	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	893	248001002
181	Papalaua strategic 2	SW28	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	110	248001002
182	Papalaua Strategic 3	SW29	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	946	248001001, 248001002
183	SW3	SW3	Proposed	Deer/Pig	<Null>	<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	204	247001024
184	Papalaua strategic 4	SW30	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	617	248001001
185	SW5	SW5	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	94	247001024, 248001002
186	SW6	SW6	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	191	247001024
187	Lihau1	SW7a	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>		<Null>		<Null>	<Null>	142	247001024
188	Lihau2	SW7b	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>		<Null>		<Null>	<Null>	122	247001024, 248001002
189	Lihau3	SW8	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>		<Null>		<Null>	<Null>	128	248001002
190	Lihau4	SW9	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>		<Null>		<Null>	<Null>	544	248001002
191	Honokohau upper	UpperHonokohau	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	72	241001017
192	W11	W11	Proposed	Pig		<Null>	Drawn	NARS	<Null>	NARS	<Null>	<Null>	<Null>	<Null>	87	246025002, 245022001
193	Euc fence extension	W16A	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	32	244004002
194	Honokowai-Amalu	W21	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	84	244007011, 244007006
195	Honokowai Valley Fen	W22	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	125	244007001, 244007006, 244004006, 244005026,
196	Honokowai lower	W23	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	83	244004008
197	Kapu Fence	W25	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	91	244007001
198	Hahakea upper valley	W26	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	63	245022002
199	Wahikuli gulch	W27	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	76	245022003
200	Hahakea lower valley	W28	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	95	245022002
201	Kahoma upper valley	W29	Proposed	Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	69	245022001
202	Kahoma Valley Fence	W30	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	56	245022001

#	Name	FenceSec *	Status	Purpose	Material	NEED_RETRO	LineSrc	MngAgency	DateComp	BltAgency	Height (Ft)	Apron	DateRetrofit	DateReBuilt	Length (m)	TMK
203	Kanaha Valley Intake	W31	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	27	246017888, 246017007, 246018007
204	Kahoma to Kanaha div	W32	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	299	246018007
205	Kahoma makai	W33	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	69	246018007
206	Kauaula ridge	W34	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	198	246025002, 246025001
207	Kauaula upper valley	W35	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	82	246025001, 247001024
208	Kauaula Valley Fence	W36	Proposed	Deer/Pig	<Null>	<Null>	Drawn	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	103	246024888, 247001024
209	Pau Pau extension	W37	Proposed	Deer/Pig		<Null>	Drawn	WMMWP	<Null>	<Null>	8		<Null>	<Null>	388	246025002
210	W8	W8	Proposed	Pig	Hog	<Null>	Drawn	NARS	<Null>	NARS	<Null>	<Null>	<Null>	<Null>	115	246025002
211	oldE14	NE1	Unmaintaine	Pig	Hog	<Null>	Drawn	NARS	01/01/1998	NARS	4	Absent	<Null>	<Null>	401	241001017, 231006001
212	SE8	SE8	Unmaintaine	Pig	Hog	<Null>	Drawn	WMMWP	10/18/2002	WMMWP	4	<Null>	<Null>	<Null>	168	236003001