KAUA'I WATERSHED ALLIANCE
Management Plan Update
Detailed Operational Plan
April 2012

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KWA Management Strategy

The first steps of The Nature Conservancy's coordination of KWA resource management efforts included surveys to identify priority areas and key threats to these areas, then formulation of management objectives to address these threats.

Resource Surveys and Threat Analysis

Densely vegetated riparian areas reduce erosion

As KWA coordinator, The Nature Conservancy conducted a thorough inventory and assessment of Kaua'i's watershed resources from 2003 to 2005. Island-wide helicopter surveys (figure 1), expert interviews, GIS data analysis, and on-the-ground site visits contributed to an assessment of the condition of watershed resources across Kaua'i, and an analysis of the primary threats to those resources. This assessment was used to prioritize watershed areas for conservation management, and enable TNC to focus efforts on the areas that would provide the greatest ecological benefit. Landscape prioritization was based on the following criteria:

Epiphytic mosses increase water absorption

1. Hydrological importance: Amount of rainfall (figure 2) and surface water yield,

2. Forest condition: Forest structure and composition, intact groundcover layer, and absence of non-native invasive plants,

3. Management feasibility: Willingness of landowner to participate in conservation management, accessibility, presence of natural boundaries, and ease of access and management.

Current Management Areas

Based on the above criteria, the forests located in the central mountains of Kaua'i were identified as top priority areas for watershed management. Work in these areas will provide the greatest long-term ecological and hydrological benefit:

1. Alaka'i Plateau: Located at the center of the Kaua'i's mountainous interior, the 12,000-acre Alaka'i plateau ranges from 4,000 ft. to 5,500 ft. in elevation and includes both private land owned by McBryde Sugar Ltd., and The State of Hawai'i's Alaka'i Wilderness Preserve (figure3). Rainfall ranges from 4,000 mm per year to 11,000 mm near the highest point on the island, Wai'ale'ale, which is considered one of the wettest places on Earth. The Alaka'i plateau includes the island's largest contiguous, intact, native montane wet forest and bog ecosystems. It also contains a diverse assemblage of flora and fauna, including 87 species of single-island endemic flowering plants, 4 Kaua'i-endemic forest bird species, 46 federally listed endangered plants, and 8 endangered vertebrates. This high diversity and endemism underscore the importance of the Alaka'i to global biodiversity conservation.

Wai'ale'ale

Situated at the head of the five largest aquifers on Kaua'i (Wailua, Waimea, Makaweli, Wainiha, and Hanalei), the Alaka'i provides a substantial proportion of the island's aquifer recharge and stream flow. The water originating from the Alaka'i supplies numerous agricultural operations and residential areas. It is the KWA's top priority for protection. This area includes the management units of McBryde, Upper Koaie, Halehaha-Halepa'akai, Koaie-Drinking Glass, and Mohihi.

Northeast Alaka'i plateau

2. Wainiha Valley: This area is located directly north of the summit of Wai'ale'ale. Surface water flowing from Wai'ale'ale drains north into the Wainiha watershed. The valley (figure 4) represents one of the best examples of intact lowland-wet forest remaining in the state, and is home to dozens of endemic plant and animal species including 19 rare and 63 island endemic plant species and over 70


Wainiha Valley

species of native ferns (Wood, 2009). The Wainiha valley management area is owned by McBryde Sugar Company Ltd.

3. Kanaele Preserve: This 57-acre fenced preserve, located in the heart of the upper Wahiawa drainage (figure 5), contains one of the last intact lowland bog ecosystems in Hawai'i. Kanaele is home to numerous endemic species, including several found nowhere else in the world. Wahiawa's bogs and forests mitigate flood and drought cycles through rainfall absorption and surface water retention, acting as a valuable source of water for agriculture and the growing population of the Kalāheo area. This biologically unique and ecologically important area is owned by McBryde Sugar Company Ltd.


Wahiawa watershed

Resource Management Objectives

Survey analysis, literature research, and case-study reviews conducted by TNC confirmed the conclusion that scientists and resource managers from all around Hawai'i have found true for decades:


Feral pig in Wainiha

the most effective method of completely protecting an area from degradation by feral pigs is to exclude the animals with wire mesh fences. Once pigs and other ungulates are removed, intact native Hawaiian ecosystems are capable of recovering on their own (Jacobi, 1976).


Kahili ginger

Three non-native plant species were also identified as primary threats; Kahili ginger (*Hedychium gerdenarium*), strawberry guava (*Psidium cattleianum*), and Australian tree fern (*Cyathea cooperi*). These species

were selected for their ability to act as "habitat modifiers". Where most non-native invasive plants require ground disturbance (such as pig rooting or landslides) to gain a foothold in a landscape, these species have the ability to establish and expand monotypic populations in previously undisturbed, native dominated landscapes (Mitchell, Ogura, Meadows, Kane, Strommer, Fretz, Leonard & McClung, 2005).


Monotypic stand of strawberry guava

TNC's management efforts are focused on addressing the primary threats to watershed function and ecosystem health. While the two threats of ungulates and weeds can work synergistically; pig activity creates a favorable environment for invasive weeds and invasive weeds can make conditions more favorable for pig survival (Aplet, Anderson, & Stone, 1991), they each present unique challenges to resource managers.

The resource inventory and threat analysis process illuminated four specific management actions that are the cornerstones of successful watershed conservation efforts in Hawai'i:

1. Construct protective fences to isolate ungulate populations
2. Control non-native ungulates inside the fences
3. Maintain fence integrity
4. Control invasive weed species

The management objectives outlined in this plan focus on accomplishing those four basic actions efficiently and effectively. This includes using the best techniques currently available to control non-native animals and weeds, while also working to develop more effective, less expensive ways to meet those objectives. Challenges posed by remote work locations, rugged terrain, plant and animal reproductive abilities, and limited staff necessitate innovation. Seven years ago, TNC began working to accomplish the following management objectives, grouped according to the primary threat that they address.

Ungulate Control Objectives


Feral goats threaten Kauai's watershed

- Isolate animal populations in core of watershed: Construct protective fences that will, in conjunction with natural barriers, isolate animal populations within priority watershed areas. Fences and barriers must be impermeable to target animal species, and completely prevent ingress of new individuals to the fenced area.

- Remove feral ungulates from fenced units: Once populations are isolated in fenced units, animal control efforts can effectively reduce or eliminate the resident population. The rate of removal must exceed the resident population's rate of reproduction. Animal removal efforts and survey/detection methods should be geared toward achieving complete eradication of all ungulates from inside the unit in the least amount of time possible to outpace reproduction.

- Improve animal detection and control methods: In Hawai'i, animal detection methods historically have entailed monitoring of ungulate sign transects and aerial survey counts. Aerial surveys are ineffective in the densely vegetated forests that make up the core of Kaua'i's watershed, and are not a viable option. Ungulate survey transects are limited in the quality and quantity of data that they can provide, which underscores the importance of developing more effective ungulate survey and detection methods.

Weed Control Objectives


ATF invasion in Hanalei

Focus on "forest modifying" species: Non-native plant control efforts should focus on species that pose the greatest threat to ecosystem function. Species-specific objectives should be clearly defined, with measurable goals and timelines tied to survey frequency, plant detectability, and treatment efficacy. Primary target species in KWA management areas are Kahili ginger, Australian tree fern (ATF), and strawberry guava.

- On-the-ground weed control: Conduct on-the-ground sweeps, with the objective of eradicating all target species populations detected within priority watershed areas during the 2003-2005 aerial surveys.

- Develop weed control method for remote/rugged locations: One of the greatest challenges identified in the initial KWA management plan was the control of Australian Tree Fern. This habitat modifying weed reproduces by wind-borne spores, with a widely dispersed pattern of infestation that makes on-the-ground control virtually impossible. New methods of weed control were needed to address this watershed threat.

The immense size and rugged topography of Kauai's interior present unique management challenges

- Develop survey method for large landscapes: Another challenge identified in the original KWA planning process was the need for an accurate, repeatable, and cost effective survey method. The resource assessment helicopter surveys conducted in 2003-05 were too expensive, time-consuming, and dangerous to repeat with the necessary frequency to quantify management impacts. A new survey method was needed in order to identify weed threats, and characterize watershed condition across large landscapes and throughout time.

KWA Resource Management Actions

The following management actions are each focused on meeting one or more of the KWA's core management objectives.

Ungulate Management:


Alaka'i protective fence

Protective Fence Maintenance - After lengthy planning, permitting, and construction processes, the Alaka'i, Wainiha, and Kanaele fences have all been completed. A total of approximately 5 miles of protective fence have been constructed throughout the three units (figure 6). These fences work in conjunction with natural barriers to isolate animal populations in over 5,000 acres of high priority watershed.

Alaka'i – The 4.5 mile Alaka'i protective fence was completed in August 2012. This unit includes both private (McBryde) and public (Upper Koaie) land. TNC will continue to conduct quarterly fence checks, and will employ a variety of methods to remove all pigs and goats from the unit by 2013. Monitoring transects, game cameras, and aerial surveys will inform the early-detection and rapid-response strategy for any ungulate presence in the unit. These monitoring methods will also help detect deer presence, and may indicate that deer barriers and removal will be necessary.


Wainiha protective fence

Wainiha – The .4 mile Wainiha fence was completed in September of 2011. TNC will continue to conduct quarterly fence checks along this barrier. Based on monitoring data, goats and deer do not currently threaten this unit. TNC will employ a variety of methods to remove all pigs from the unit by 2014. Monitoring transects, game cameras, and aerial surveys will inform the early-detection and rapid-response strategy for any ungulate presence in the unit.

Kanaele – The 57 acre Kanaele exclosure has been free of feral pigs since its completion in 2008. Goats and deer do not currently threaten this unit. TNC will

continue semi-annual fence checks. Crews will also inspect known weak points or erosion-prone areas, and survey for ungulate sign during all weed control or restoration field activities.

Ungulate Removal - TNC is currently conducting ungulate control activities in the McBryde and Upper Koaie management units. The strategy involves the use of baited traps as the primary method of pig control, augmented with strategic hunting and snaring efforts. 16 traps have already been constructed throughout the KWA area, and 9 traps are currently active in the Alakaʻi (figure 7).

Baited trap in the Northeast Alakaʻi

Ungulate control activities in the state portion of the Alakaʻi unit began in September 2011. TNC is utilizing the same control methods, with the exception of snaring (figure 8). Adaptive management techniques and pig activity data collected from various monitoring methods will determine the timing and intensity of control activities. While the resident pig population poses the greatest threat to the Alakaʻi ecosystem, there are also a number of feral goats present in these units. Goats will be hunted by TNC staff during feral pig control activities, and additional methods of control will be explored.

Animal control efforts in Wainiha will begin in the spring 2012. Six remote traps have already been constructed in this unit. These traps were activated as part of the trapping strategy test period in the summer of 2009. TNC will re-activate the traps and begin the initial pig-population reduction in the valley in late 2012. There are no other feral ungulate species present in the Wainiha valley unit.

Animal Detection and Control - Motion activated game cameras detect activity, identify individual animals, and quantify ungulate presence. These cameras augment the data collected from monitoring transects, and provide greater detail about the animals present in KWA management areas. Cameras located at traps give detailed information about the number of pigs visiting the bait, and the timing of those visits. Analysis of images collected by cameras placed along primary game trails enables managers to compile lists of individual animals to target for removal, and the frequency of

Infrared game camera photos show night-time trap activity.

detections can serve as an index for animal abundance. Remote camera monitoring can also be used as a monitoring tool after trapping efforts have concluded. Managers can use cameras to detect pig ingress into ungulate-free areas, monitor the effectiveness of natural barriers, and monitor fence integrity.

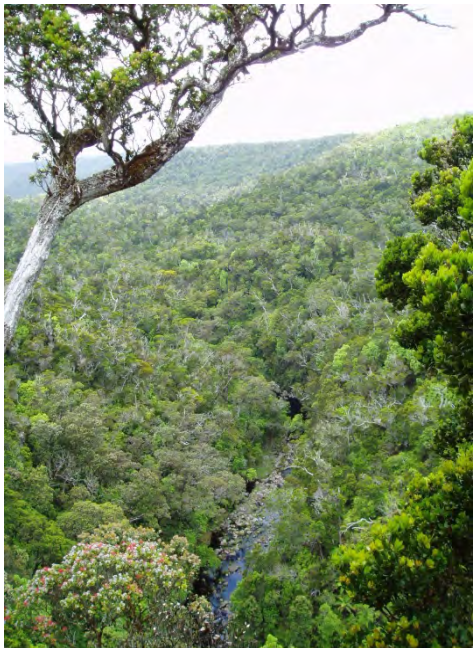
Remote-trapping/camera technology- The greatest impediment to ungulate control efforts is the lack of current information from game cameras and traps. The time-lag between trap visits by pigs (or game camera animal detections) and data recovery by staff, limits our ability to effectively respond to these events. Field crews basically "go in blind" every time they head into the mountains to conduct animal control activities. TNC is currently working with the information technology company Intelesense to address this problem. The goal is to develop the capability to monitor game cameras and manipulate trap mechanisms remotely.

Experimental remote-trapping design

Upon completion of this project, managers will be able to logon to a secure website and view still images or videos captured by motion-activated cameras located at remote trap sites, game trails, and other areas that have shown high pig activity. These images will allow field staff to monitor activity around remote traps during the initial pre-baiting phase. This phase is required to habituate the resident pig population to foraging on bait in and around the trap. In addition to viewing photos, the web interface will also allow managers to arm the traps remotely. When ungulate activity reaches a high level, and the animals in the area show willingness to enter the traps, a signal will be sent to activate a motion-sensing trigger arming the trap's door locking mechanism. The door will close when the next animal enters the trap and triggers the motion sensor. Images will confirm trapping success and field staff will visit the trap to remove the feral animals.

Pigs feeding around a remote trap

Expand ungulate control area: TNC will work with Kaua'i DOFAW, NARS, and other KWA partners to expand watershed protection to additional areas in the Alaka'i Wilderness Preserve. The Halehaha – Halepa'akai and Koaie - Drinking Glass management areas contain some of the most intact, native-dominated forest remaining on Kaua'i (figure 9). These units also serve as critical rainfall and cloud drip catchment areas, providing water recharge for streams that feed into the Waimea River system. This river system and associated ground water is important for agricultural production and other human-uses on Kauai's west side. There is an urgent need for increased protection in these areas due to the ongoing degradation by pigs and weeds, as well as anticipated effects of climate change that threaten to decrease precipitation amounts for leeward Kaua'i (Timm & Diaz, 2009). TNC will work with partners to identify topographic barriers, animal movement corridors, feasible fence routes, and conduct other necessary surveys in 2012, with the goal of beginning fence construction in 2013.



Halehaha watershed

Ungulate Management Summary 2012-2017:

ACTIVITIES: Maintain fenced units. Develop technology to improve monitoring. Construct new protective fences. Monitor ecosystem recovery.

Feral Ungulate Control	FY13	FY14	FY15	FY16	FY17
Fence Maintenance	$85,333	$95,667	$111,000	$121,333	$153,000
Fence Construction	$110,333	$653,412	$1,585,130	$559,543	$1,224,915
Ungulate Control	$271,333	$310,667	$341,000	$381,333	$643,000
Total Ungulate Control	**$467,000**	**$1,059,745**	**$2,037,130**	**$1,062,210**	**$2,020,915**

Invasive Weed Management:

Weed management in fenced units - Priority weeds differ in species, density, and distribution and the priority management areas differ in terrain and accessibility. These different situations require specifically-tailored weed management objectives and approaches. The four weed invasion categories are defined as:

1. Target weed is densely distributed throughout the area, such that the weed frequently occurs in large patches with surrounding outliers.
2. Target weed is sparsely distributed throughout the area mostly in small patches with very few large patches.
3. Target weed is sparsely distributed in small portions of the area.
4. Target weed has not yet been detected in the area.

Each weed invasion category has an associated objective and approach. The following table lists the objectives and approaches for each weed invasion category.

Table 1

Invasion Category	Management Objective	Management Approach
1	Suppression	Treating reproductive, larger patches that require more than 15 minutes.
2	Containment	Only treating small, reproductive-sized, outlying patches and mapping larger patches requiring more than 15 minutes to treat.
3	Eradication	Surveying and removal of all target weed individuals.
4	Exclusion	Conducting surveys in 3-year intervals to detect incipient patches.

Effective weed management requires rigorous monitoring methods, and a rapid response strategy to control newly detected individuals. Aerial imagery surveys will follow weed control efforts every 3 to 5 years. Table 2 below displays TNC's management objectives for the three priority species in each of the KWA's management units.

Table 2

	Kahili ginger	strawberry guava	ATF
McBryde	Exclusion	Exclusion	Eradication
Upper Koaie	Exclusion	Exclusion	Eradication
Halehaha-Halepa'akai	Eradication	Eradication	Eradication
Koaie-Drinking Glass	Eradication	Eradication	Eradication
Mohihi	Suppression	Containment	Containment
Wainiha	Eradication	Exclusion	Suppression
Kanaele	Exclusion	Suppression	Exclusion

A wide variety of methods are used to accomplish these weed control objectives.

Ground-Based Control: TNC has conducted aerial surveys and coordinated on-the-ground weed sweeps on the Alaka'i plateau to support the "Line of Defense" strategy. This strategy, initiated in 2003, aims to create a weed free buffer zone to the west of the Alaka'i protective fence. This two-mile buffer will protect the intact native forest in that area, and reduce the likelihood of new introductions of wind and animal borne seeds to the area inside the fence. This strategy led TNC to develop an ongoing partnership with the Koke'e Resource Conservation Program (KRCP). TNC contracts KRCP staff and volunteers to conduct weed survey and control sweeps through priority areas. KRCP has been a valuable partner for the past seven years (figure 10). On-the-ground weed sweeps are also conducted in Kanaele. This effort is focused on strawberry guava removal, and steady progress has been made in clearing this fenced area of invasives (figure 11). TNC plans to continue its collaboration with the Koke'e Resource Conservation Program. Annual contracts, primarily funded through the State's Watershed Partnership grants, will help maintain previously treated areas every 3 years and conduct weed control around newly detected hotspots.

Katie Cassel leads KRCP's weed control efforts

When practical, the KWA supports the re-establishment of native plants where large, monotypic stands of invasive species are removed.


Precise application of herbicide with Stinger

Stinger Weed Control: TNC, in collaboration with partners and contractors, has developed an innovative, cost-effective means of invasive weed control called the Stinger. This herbicide applicator hangs from a weighted hose below a helicopter, and looks similar to aerial spray devices used for Miconia and other weeds elsewhere in Hawai'i. The key difference is that the Stinger applicator has an inverted cone around the nozzle to shield it from the helicopter's rotor wash. This device is paired with an herbicide formulation developed in cooperation with Dr. James Leary, an invasive plant species management expert from University of Hawai'i, and enables a skilled helicopter pilot to precisely apply the smallest effective dose of low-toxicity herbicide directly to the growing tip of the fern. The Stinger has proven to be an effective and efficient method for removal of this widely dispersed weed target. TNC is currently working with the helicopter contractor Airborne Aviation, who has made great progress controlling ATF in Wainiha (Figure 12).

Until now, TNC has focused its ATF control only inside the fenced KWA units. The core of the ATF infestation on Kaua'i, however, is centered in the windward valleys of Wailua, Hanalei, and Lumaha'i. By expanding control efforts to these areas and focusing on eliminating the largest mature trees and dense clusters of ATF, we hope to reduce production of wind-borne spores and thus decrease the rate of infestation. Pockets of ATF have also been spotted with increasing frequency in and around the Halehaha-Halepa'akai and Koaie-Drinking Glass management areas to the west of the Alaka'i protective fence. Ground-based control is inefficient for controlling these widely scattered groups (figure 13).


Taking aim at ATF with HBT

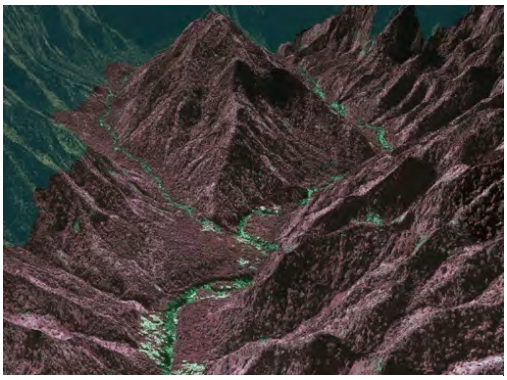
HBT Weed Control: TNC is also collaborating with Dr. James Leary to implement a new method of aerial weed control that he has developed. Herbicide Ballistic Technology (HBT) is a new method for accurate, long-range delivery of small herbicide doses applied directly to individual weed targets. The basic concept of HBT is to infuse herbicide into 0.68 caliber paint balls shot at specific weed targets

with an air gun. Early trials have indicated that HBT is effective for controlling ATF and Kahili ginger. This tool will be used in conjunction with the Stinger to make aerial weed control more effective and efficient.

Forestry Management: The KWA members and Coordinator will consider ways in which forestry and silviculture practices can augment watershed conservation. Native and non-native species can be used for reforestation within already degraded areas that are open to erosion, and sustainable timber harvest may be used to improve watershed function within portions of the KWA's management areas.

Large Landscape Survey Method: TNC began collaborating with Resource Mapping Hawai'i LLC (RMH) in early 2007, with the goal of developing new remotely sensed data collection, processing, and analysis methods for ultra-high resolution aerial imagery. The current RMH system collects imagery with 2-3cm. resolution, and can be used to detect individual target weed occurrences across vast areas. Aerial imagery datasets can also be collected on a recurring basis, allowing temporal comparisons of survey data. In 2010 Resource Mapping Hawai'i collected and analyzed high-resolution imagery of 33,000 acres of the Wainiha and Alaka'i plateau units. Using digital and visual plant profiles, RMH identified 4,136 individual Australian tree ferns and assigned GPS coordinates to each plant. This survey method, combined with the Stinger control method, enables TNC to control ATF and quantify the effectiveness of their efforts at a landscape scale (figure 14).

RMH collects imagery in Wainiha with a fixed-wing plane



Three-dimensional imagery data

Weed Management Summary 2012-2017:

ACTIVITIES: Maintain identified weed control objectives. Utilize on-the-ground and aerial weed control effort's, and continue to expand these technologies into high priority areas. Monitor and track progress and forest recovery.

Invasive Weed Control	FY13	FY14	FY15	FY16	FY17
Weed Control: Aerial	$352,000	$232,333	$242,667	$173,000	$166,333
Weed Control: Ground	$112,000	$102,333	$122,667	$133,000	$186,333
Weed Monitoring	$114,000	$114,333	$114,667	$125,000	$138,333
Total Weed Control	**$578,000**	**$449,000**	**$480,000**	**$431,000**	**$491,000**

Ecosystem Monitoring

Monitoring an East Alaka'i vegetation plot

Ecosystem monitoring is needed to determine the efficacy of fencing and threat abatement. Monitoring methods must be precise enough to detect low levels of ungulate presence or priority weed infestations, but broad enough to capture large-scale and long-term changes. TNC employs a variety of methods to accomplish the four monitoring objectives listed below.

Objective 1 - Measure the effectiveness of ungulate management actions

Actions

1. Install ungulate activity transects along the Hawai'i forest bird transects on the Alaka'i plateau, and along existing trails and stream corridors in the Alaka'i, Wainiha, and Kanaele management units (see figure 15, 16, &17).
2. Monitor transects semi-annually.
3. Compile and analyze data in a GIS database.
4. Make management adjustment as needed.

Objective 2 - Measure the effectiveness of weed control actions

Actions

1. Complete baseline helicopter transect surveys.
2. Initiate second round of aerial surveys in priority areas using ultra-high resolution aerial imagery in place of helicopter transects.
3. Compile and analyze data in a GIS Database.
4. Make management adjustment as needed.

Objective 3 - Measure long-term changes in vegetation cover throughout core management areas

Actions

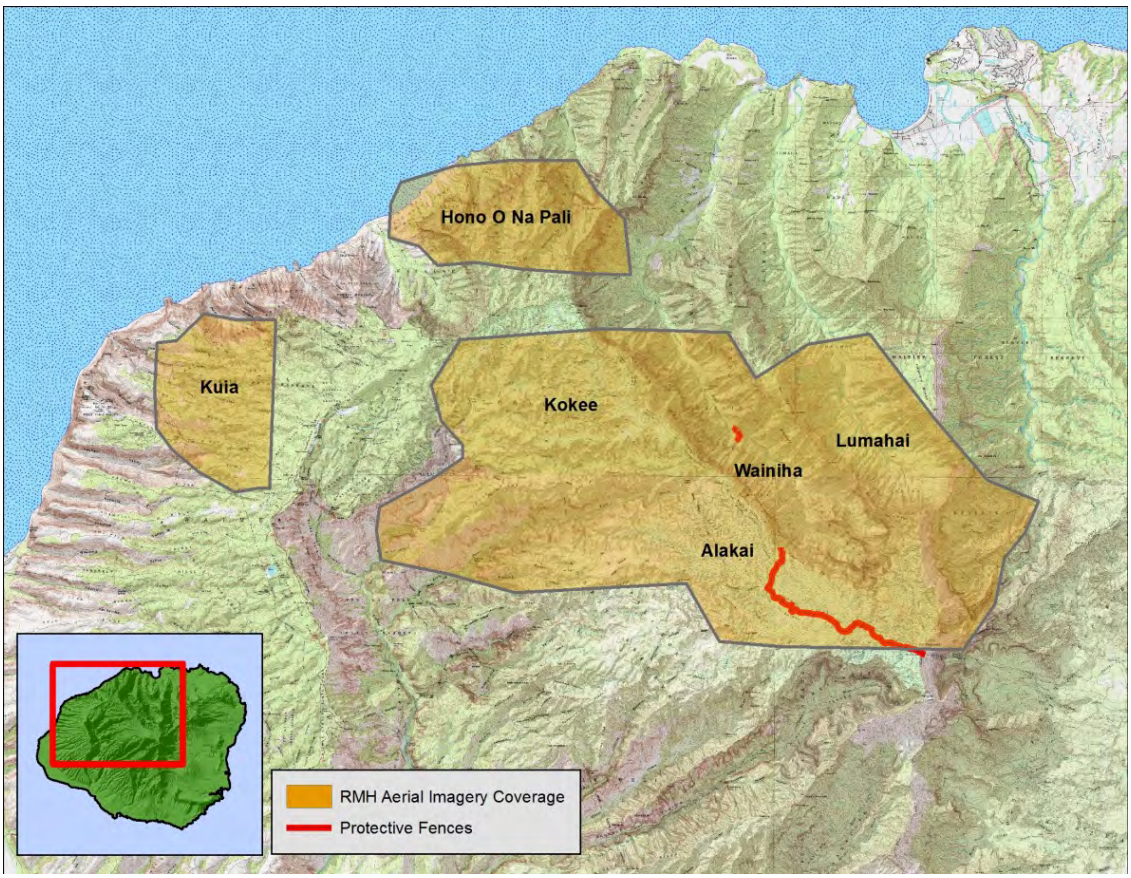
1. Install and sample permanent vegetation plots and transects in Alaka'i, Wainiha, and Kanaele units.
2. Re-sample the plots semi-annually.

3. Compile and analyze data in a GIS database.
4. Make management adjustments as needed.

Objective 4 – Improve early detection abilities for weeds and ungulates

Actions

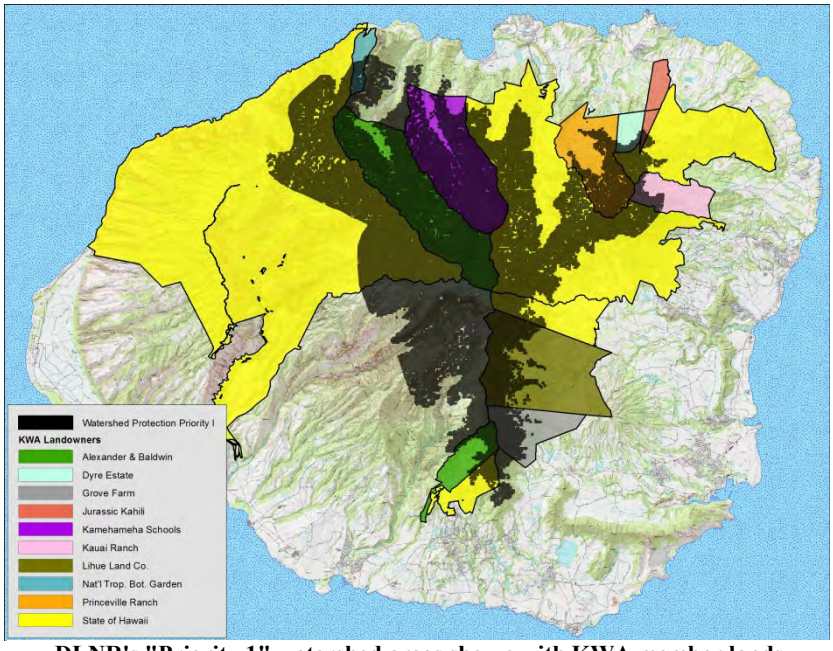
1. Work with Resource Mapping Hawai'i LLC to improve aerial image resolution and image analysis/species detection capabilities.
2. Utilize game camera/remote monitoring technology to improve early detection and rapid response capability for ungulate management and monitoring.



RMH aerial imagery coverage as of April 2012

Rain Follows the Forest

The criteria for selecting priority conservation areas for the DLNR's "The Rain Follows the Forest" plan were similar to TNC's initial prioritization of Kauai's watershed for the KWA. The primary factors for consideration were hydrological importance and forest condition. The Department of Land and Natural Resources compiled data from a variety of sources and categorized watershed areas according to conservation priority. Those areas that fell within the DLNR's strictest parameters were classified as "priority one watershed". On Kaua'i, the top priority watershed area amounted to over 70,000 acres. TNC took those priority areas, and selected 25,000 acres that best exemplified hydrologic importance, pristine forest condition, and also presented the most favorable conditions for "management feasibility". This third criterion takes into account accessibility, presence of natural boundaries (Figure 18), and ease of access and management. Priority was also given to creating management units that would border on each other, creating contiguous management areas that would be easier, and more cost effective, to manage in the future.

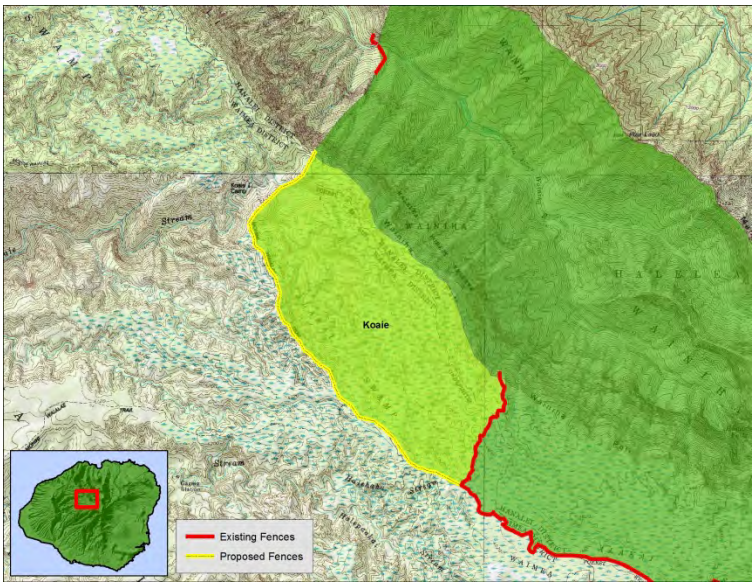


DLNR's "Priority 1" watershed areas shown with KWA member lands

The foundation for TNC's "Rain Follows the Forest" budget is a 6-year timeline for each management unit that includes all the steps required to plan and construct a protective fence, and initiate a resource management strategy that will eliminate or minimize the primary threats to watershed function. The sixth year represents the "maintenance cost" or projected expense of maintaining fence integrity, vegetation and ungulate monitoring and early detection, ongoing weed control, and rapid response to ungulate ingress. The maintenance cost for each unit is projected to remain relatively steady for the ~30-year life expectancy of the fences. This basic framework is repeated for each fenced management unit in the plan, with a corresponding increase in total management cost for each additional unit that is undertaken. The following plan and budget outline presents a blueprint for the conservation of 25,000 acres of Kauai's highest-priority watershed in the next ten years.

Management Units

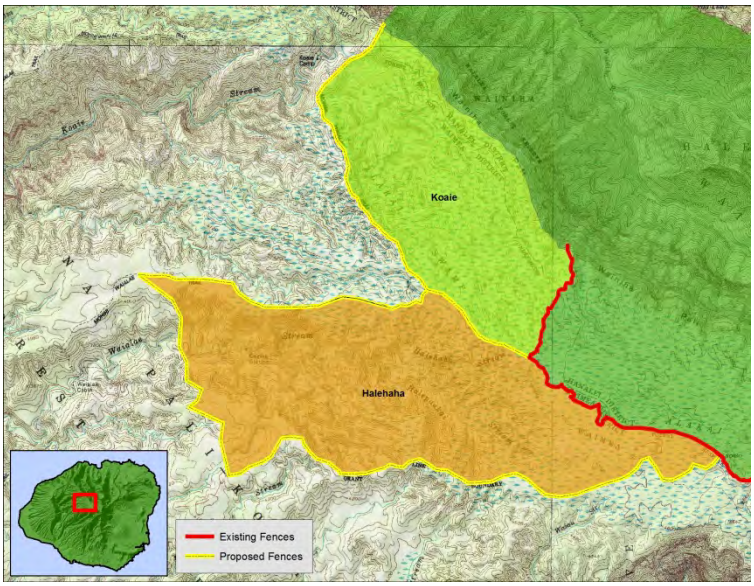
1. Koaie: This unit encompasses approximately 1,000 acres of intact, native-dominated montane wet forest and bogs. The area is a top priority for conservation due to its high rainfall, intact forest, importance to native forest bird populations, as well as its hydrologic function as the headwaters of Koaie Stream. Koaie borders both the Wainiha preserve and the Alaka'i protective fence, and would work in conjunction with the Halehaha and Drinking Glass units to establish a large contiguous ungulate free management area encompassing the wettest parts of the Alaka'i plateau.



Koaie	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	1,040	15,507	14.9	542,745

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	10,000	10,000	10,000	10,000	10,000	10,000	1day, quarterly, heli access
Ungulate Control	20,000	100,000	150,000	200,000	150,000	50,000	pig, goat, deer/ med. size unit/heli req.
Weed Control: Aerial	10,000	10,000	10,000	10,000	10,000	5,000	pali ginger treatment, ATF spot-treatment
Weed Control: Ground	20,000	20,000	10,000	10,000	10,000	5,000	low weeds, hotspot re-treat and maint., easy heli access & terrain
Total	**60,000**	**140,000**	**180,000**	**230,000**	**180,000**	**70,000**	

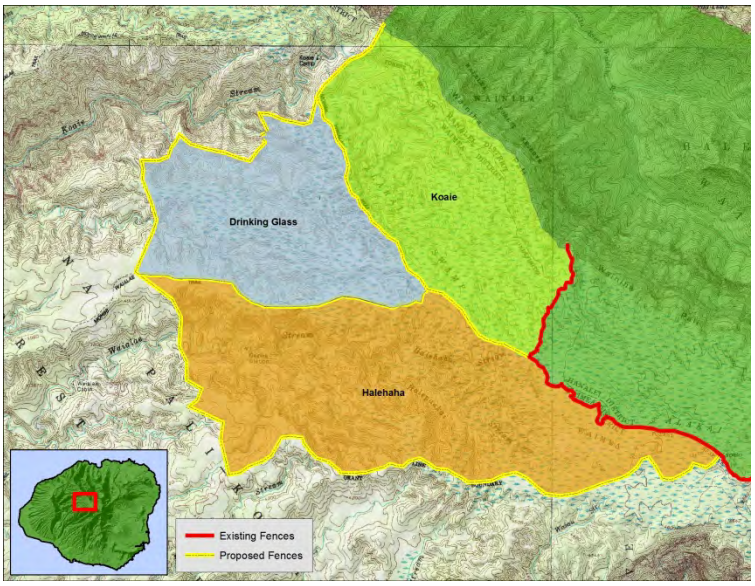
2. Halehaha: This unit encompasses over 1,600 acres of intact, native-dominated montane wet forest and bogs. The area is a top priority for conservation due to its high rainfall, intact forest, and hydrologic function as the headwaters of Waialae Stream. The area surrounding the confluence of the Halehaha and Halepa'akai streams is native forest bird hotspot, and provides critical nesting habitat for the endangered Puaiohi (Mitchell et al., 2005). Halehaha borders the Alaka'i protective fence, and would work in conjunction with the Koaie and Drinking Glass units to establish a large contiguous ungulate free management area encompassing the wettest parts of the Alaka'i plateau.



Halehaha	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	1,667	42,118	25.3	1,474,130

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	15,000	15,000	15,000	15,000	15,000	15,000	2 days, quarterly, heli req.
Ungulate Control	20,000	150,000	200,000	200,000	150,000	55,000	pig, goat, deer/ lrg. size unit / heli req.
Weed Control: Aerial	10,000	10,000	10,000	10,000	10,000	5,000	ATF spot-treatment
Weed Control: Ground	20,000	20,000	10,000	10,000	10,000	5,000	low weeds, hotspot re-treat and maint., easy heli access & terrain
Total	**65,000**	**195,000**	**235,000**	**235,000**	**185,000**	**80,000**	

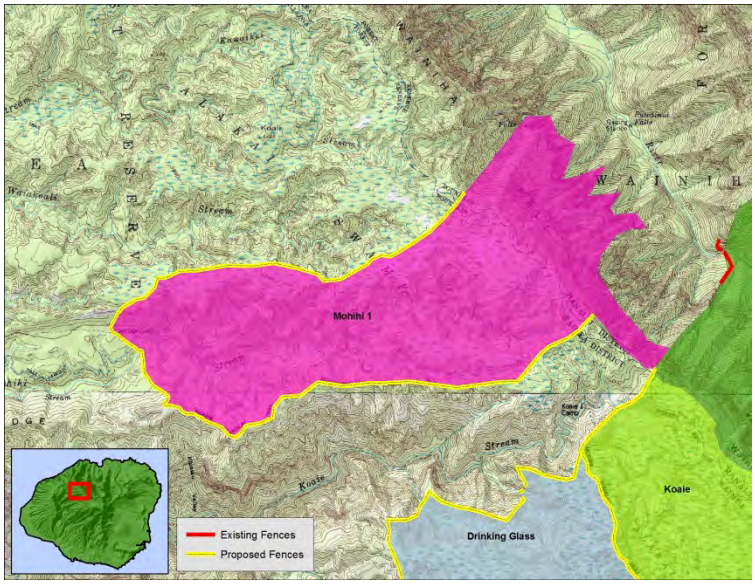
3. Drinking Glass: This unit encompasses almost 1,000 acres of intact, native-dominated montane wet forest and bogs. The area is a top priority for conservation due to its high rainfall, intact forest, importance to native forest bird populations, as well as its hydrologic function as the headwaters of Koaie Stream. The Drinking Glass fence would run parallel to Koaie Canyon, closing the gap between the Koaie and Halehaha units to establish a large contiguous ungulate free management area encompassing the wettest parts of the Alaka'i plateau.



Drinking Glass	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	910	12,806	14.1	448,210

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	10,000	10,000	10,000	10,000	10,000	10,000	1 day, quarterly, heli req.
Ungulate Control	20,000	100,000	150,000	200,000	150,000	50,000	pig, goat, deer/ med. size unit heli req.
Weed Control: Aerial	10,000	10,000	10,000	10,000	10,000	5,000	pali ginger and ATF spot-treatment
Weed Control: Ground	20,000	20,000	10,000	10,000	10,000	5,000	low weeds, hotspot re-treats, easy heli access & terrain
Total	**60,000**	**140,000**	**180,000**	**230,000**	**180,000**	**70,000**	

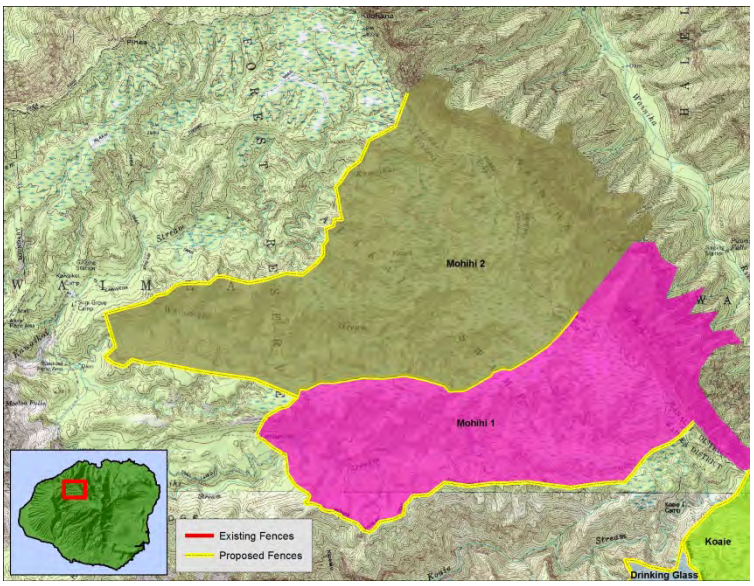
4. Mohihi 1: This unit encompasses 1,600 acres of fairly intact, montane wet forest and bogs. While portions of this area have already been degraded by feral pigs and invasive weeds, it is a priority for conservation due to its high rainfall, native-dominated forest canopy, importance to native forest bird populations, and hydrologic function as the headwaters of both Mohihi and Koaie Streams. The Mohihi 1 fence would run from Wainiha pali, parallel to Koaie Canyon, then back along Camp 10 flats to Wainiha pali by way of Circle Bog.



Mohihi 1	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	1,601	30,769	19.2	$1,076,915

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	15,000	15,000	15,000	15,000	15,000	10,000	2 days, quarterly, no heli req.
Ungulate Control	20,000	150,000	150,000	150,000	100,000	40,000	pig, goat, deer/ large. size unit / very easy foot-sling access
Weed Control: Aerial	30,000	20,000	20,000	10,000	10,000	5,000	ATF spot, and large-scale ginger treatment
Weed Control: Ground	50,000	50,000	40,000	40,000	30,000	10,000	high weed density, very high in some areas. Very easy access & terrain
Total	**115,000**	**235,000**	**225,000**	**215,000**	**155,000**	**65,000**	

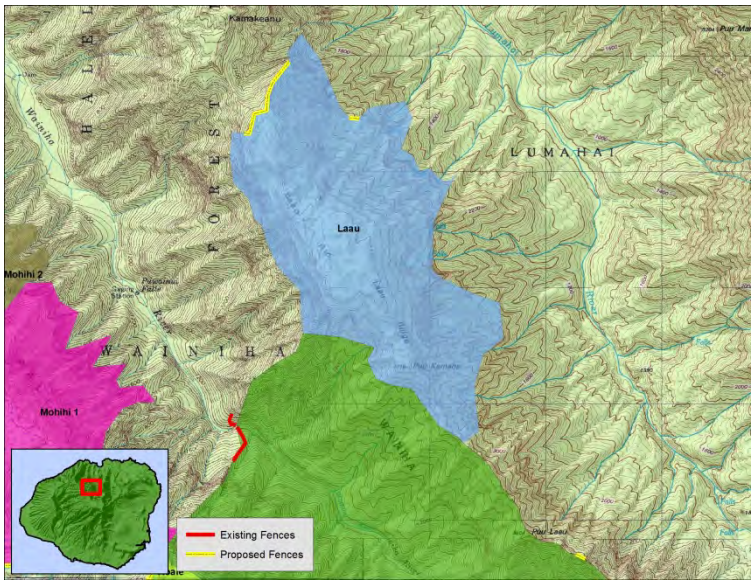
5. Mohihi 2: This unit encompasses over 2,000 acres of fairly intact, montane wet forest and bogs. While parts of this area have already been heavily degraded by feral pigs and invasive weeds, it is a priority for conservation due to its high rainfall, native-dominated forest canopy, and hydrologic function as the headwaters of both Kawaikoi and Waiakoali Streams. This management area is also the source of water for much of the irrigation ditch system that provides water resources to the West Kaua'i agricultural community.



Mohihi 2	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	2,216	23,251	10.5	$813,785

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	15,000	15,000	15,000	15,000	15,000	10,000	2 days, quarterly, no heli req.
Ungulate Control	20,000	150,000	150,000	150,000	100,000	40,000	pig, goat, deer/ extra-large size unit / very easy foot-sling access
Weed Control: Aerial	30,000	20,000	20,000	10,000	10,000	5,000	ATF spot. and large-scale ginger treatment
Weed Control: Ground	50,000	50,000	40,000	40,000	30,000	10,000	high weed density, very high in some areas. Very easy access & terrain
Total	**115,000**	**235,000**	**225,000**	**215,000**	**155,000**	**65,000**	

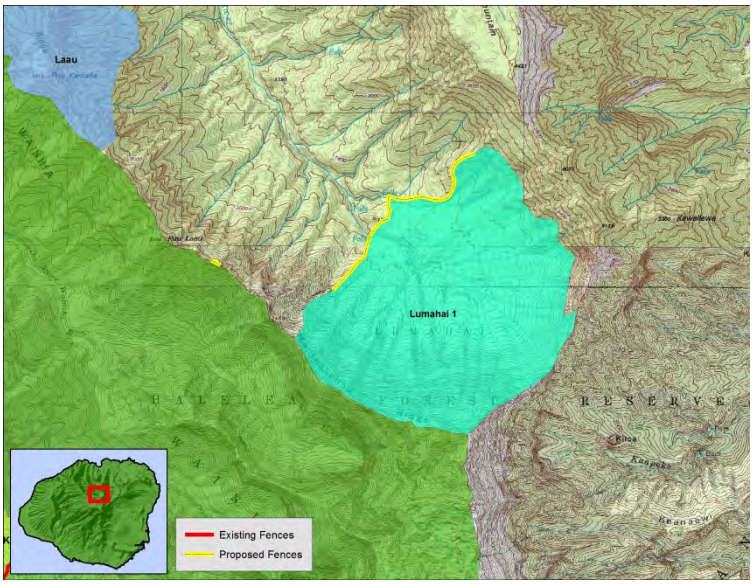
6. La'au: This unit encompasses almost 1,000 acres of intact, native-dominated montane wet forest and bogs, perched at the top of the ridge between Wainiha and Lumaha'i valleys. La'au plateau is almost entirely surrounded by near-vertical pali that limit access routes for feral animals, while also making management activities more challenging. The area is currently being impacted by a small resident feral pig population, and has low levels of Kahili ginger and ATF. Feral goats are not known to populate this area, and strawberry guava is not found here. La'au is a top priority for conservation due to its high rainfall, intact forest, importance to native forest bird populations, and role as a water source both Wainiha and Lumaha'i Rivers. The unit would work in conjunction with the existing Wainiha preserve and proposed Lumah'i 1 and 2 units to establish a large contiguous ungulate free management area encompassing the wettest parts of Northern Kauai's watershed.



La'au	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	956	2,940	3.1	$102,900

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	10,000	10,000	10,000	10,000	10,000	5,000	1 day, quarterly, heli req.
Ungulate Control	20,000	10,000	10,000	10,000	10,000	5,000	pig only /small size unit / difficult heli access
Weed Control: Aerial	10,000	5,000	2,500	2,500	2,500	2,500	ATF spot and ginger HBT
Weed Control: Ground	20,000	10,000	10,000	10,000	10,000	5,000	low weed density (ginger &ATF only), difficult access & terrain
Total	**60,000**	**35,000**	**32,500**	**32,500**	**32,500**	**17,500**	

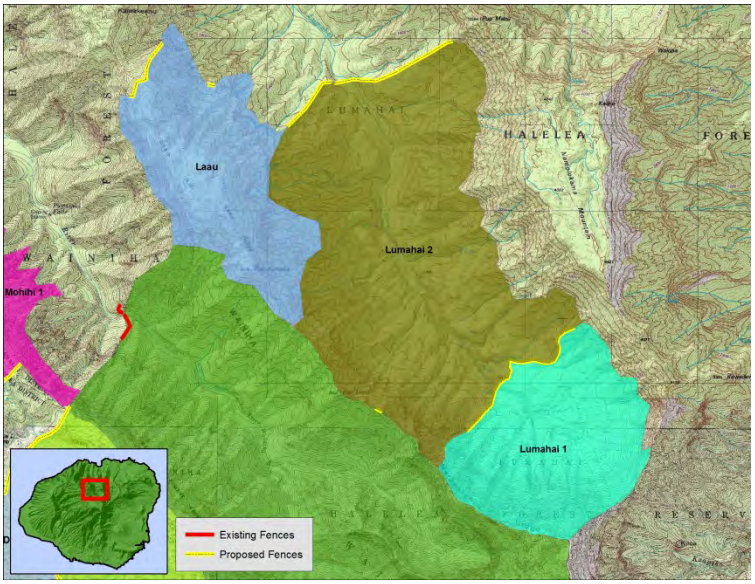
7. Lumaha'i 1: This unit encompasses almost 1,000 acres of native-dominated lowland wet forest. The back of Lumaha'i valley is almost entirely surrounded by near-vertical pali that limit access routes for feral animals, allowing a large land area to be protected with a relatively short fence. The area is currently being heavily impacted by feral pigs and goats, and has one of the highest density ATF populations of any area on Kaua'i. Surveys are needed to determine the threats posed by other weed species. Lumaha'i is a priority for conservation due to its high rainfall, native dominated forest, and hydrologic function as the headwaters of the Lumaha'i River. This unit would be surrounded on all sides by other KWA management units, helping to create a large contiguous ungulate free management area encompassing the core of Kaua'i's watershed.



Lumaha'i 1	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	954	6,833	7.2	$239,155

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	10,000	10,000	10,000	10,000	10,000	12,000	1 day, quarterly, heli req.
Ungulate Control	20,000	100,000	150,000	200,000	150,000	50,000	pig, and possibly goat / med. size unit / easy heli access
Weed Control: Aerial	80,000	50,000	50,000	10,000	10,000	5,000	Large-scale ATF treatment, ginger on pali
Weed Control: Ground	0	10,000	10,000	20,000	20,000	10,000	yr. 2 & 3 ground surveys, identify priorities for yr. 4&5
Total	**110,000**	**170,000**	**220,000**	**240,000**	**190,000**	**77,000**	

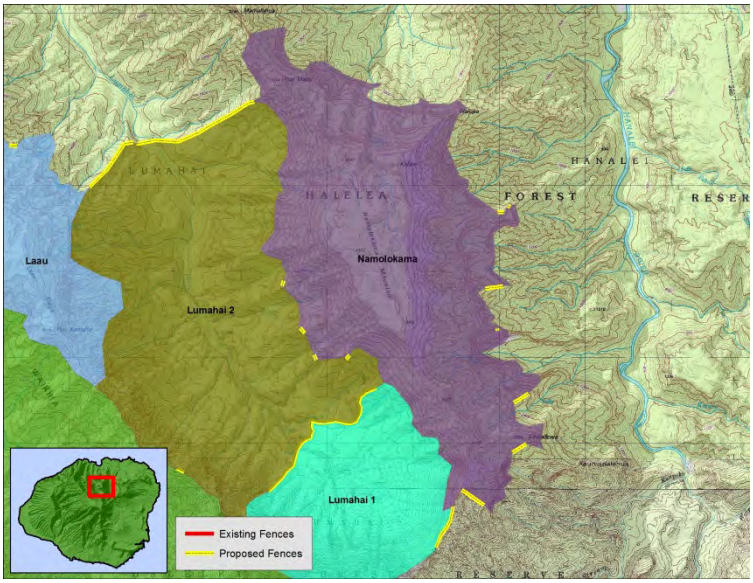
8. Lumaha'i 2: This unit encompasses over 2,000 acres of native-dominated lowland wet forest. The back of Lumaha'i valley is almost entirely surrounded by near-vertical pali that limit access routes for feral animals, allowing a large land area to be protected with a relatively short fence. The area is currently being heavily impacted by feral pigs and goats, and has one of the highest density ATF populations of any area on Kaua'i. Surveys are needed to determine the threats posed by other weed species. Lumaha'i valley is a priority for conservation due to its high rainfall, native-dominated forest, and hydrologic function as the headwaters of the Lumaha'i River.



Lumaha'i 2	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	2,356	7,376	3.1	$258,160

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	10,000	10,000	10,000	10,000	10,000	12,000	1 day, quarterly, heli req.
Ungulate Control	20,000	150,000	200,000	200,000	150,000	55,000	pig and possibly goat / med. size unit / easy heli access
Weed Control: Aerial	80,000	80,000	50,000	30,000	15,000	5,000	Large-scale ATF treatment, ginger on pali
Weed Control: Ground	0	20,000	20,000	40,000	40,000	10,000	yr. 2 & 3 ground surveys, identify priorities for yr. 4&5

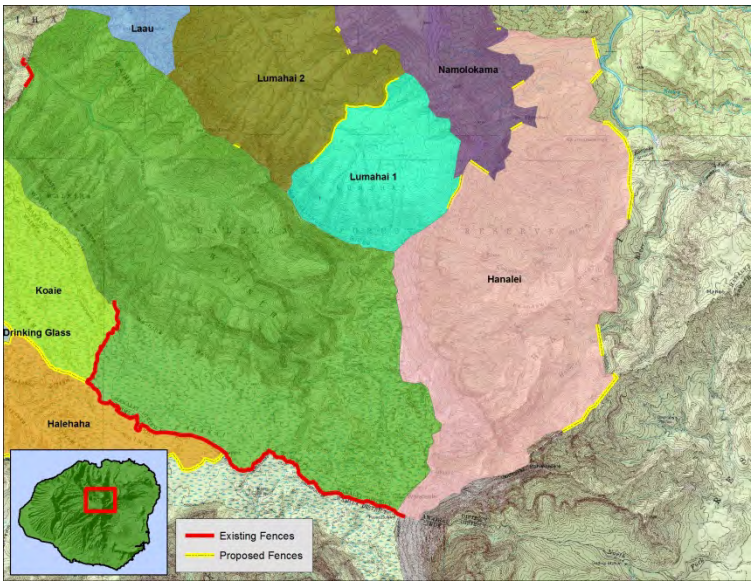
9. Namolokama: This unit encompasses over 2,000 acres of native-dominated montane wet forest and bogs, perched at the top of the ridge between Lumahaʻi and Hanalei valleys. Namolokama plateau is almost entirely surrounded by near-vertical pali that limit access routes for feral animals, however feral goat and pig populations are known to be established here already. Much of this unit is comprised of hanging valleys, likely inaccessible to feral animals. TNC has not conducted extensive weed or ungulate surveys in this unit, so the forest condition and status of primary threats are not well known. Namolokama is a top priority for conservation due to its high rainfall, relatively intact forest and wet cliffs, importance to native forest bird populations, and role as a water source for Lumahaʻi, Waioli, and Hanalei Rivers.



Namolokama	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	2,342	6,070	2.6	$212,450

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	30,000	30,000	30,000	30,000	30,000	10,000	1 day, with multi heli-drop-offs
Ungulate Control	20,000	30,000	30,000	20,000	10,000	5,000	pig and goat / small area accessible to animals / difficult heli access
Weed Control: Aerial	15,000	10,000	10,000	5,000	5,000	2,500	ATF spot treatment. Additional species unknown
Weed Control: Ground	20,000	20,000	20,000	20,000	10,000	5,000	Unknown species presence & dist., difficult access & terrain
Total	**85,000**	**90,000**	**90,000**	**75,000**	**55,000**	**22,500**	

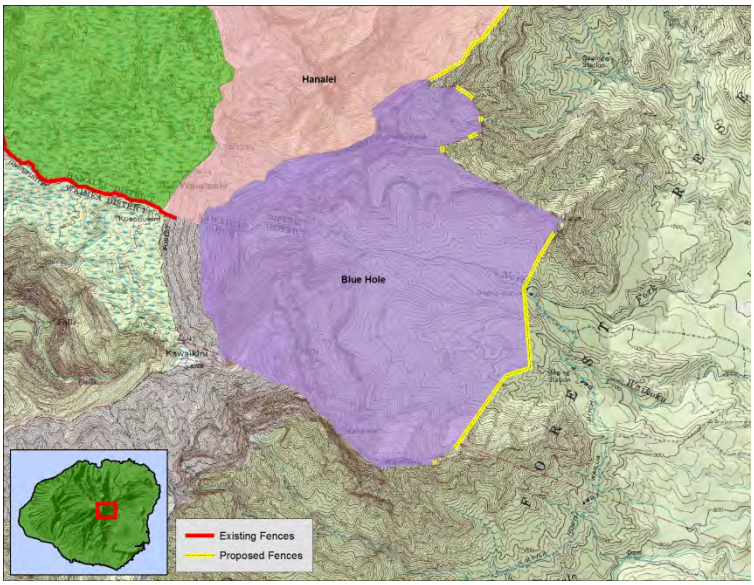
10. Hanalei: This unit includes over 3,000 acres of native-dominated lowland wet forest and wet cliffs. The proposed fences for this unit are very theoretical at this point, and very little is known about the extent of threats posed by non-native animals and invasive weeds. Aerial surveys have shown this area to hold one of the highest density ATF infestations on all of Kaua'i. Extensive surveys (both aerial and on-the-ground) will be required to delineate the most intact forest, identify potential fence routes, and evaluate threats. The area is a priority for conservation due to its high rainfall, native dominated forest, and hydrologic function as the headwaters of the Hanalei River.



Hanalei	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	3,376	12,162	3.6	$425,670

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	25,000	25,000	25,000	25,000	25,000	25,000	2 days, quarterly, with multiple heli drop-offs
Ungulate Control	20,000	150,000	200,000	200,000	150,000	60,000	pig and possibly goat / med. size area accessible to animals / medium difficulty heli access & high difficulty terrain
Weed Control: Aerial	80,000	80,000	50,000	30,000	15,000	5,000	Large-scale ATF treatment, additional species unknown
Weed Control: Ground	0	20,000	20,000	40,000	40,000	10,000	yr. 2 & 3 ground surveys, identify priorities for yr. 4&5
Total	**125,000**	**275,000**	**295,000**	**295,000**	**230,000**	**100,000**	

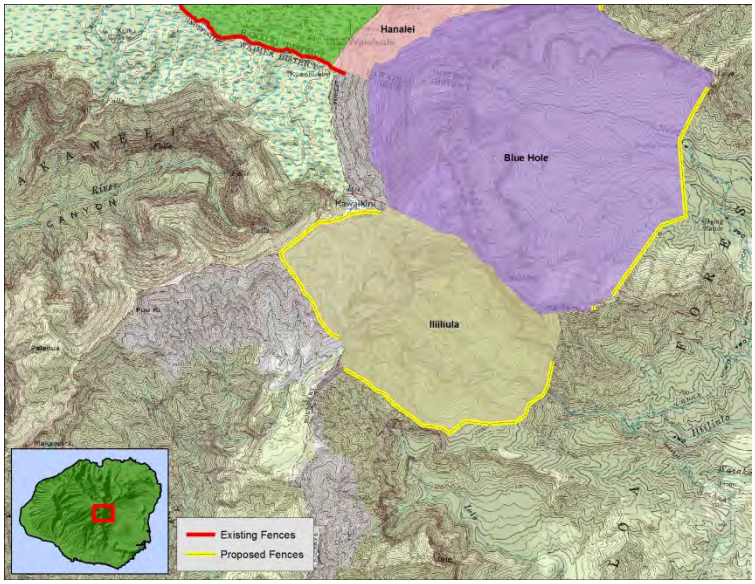
11. Blue Hole: This unit encompasses over 1,500 acres of native-dominated lowland wet forest and wet cliffs. Blue Hole is the head of Wailua river watershed and backed by near-vertical pali that extend up to Wai'ale'ale. One 7,000 ft. fence would stretch from Kamanu, northward past the uppermost gaging station, and tie into the pali extending down from Pohakupele. Additional wing fences would likely be required to block access on the ridges leading up to Pohakupele. The upper Wailua watershed also has one of the highest density ATF populations of any area on Kauai. Additional surveys will be needed to determine the threats posed by other weed species, and evaluate feral animal populations. Blue Hole is a priority for conservation due to its high rainfall, native dominated forest, and hydrologic function as the headwaters of the Wailua River.



Blue Hole	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	1,647	8,746	5.3	$306,110

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	25,000	25,000	25,000	25,000	25,000	20,000	2 days, quarterly, with multiple heli drop-offs
Ungulate Control	20,000	100,000	150,000	200,000	150,000	50,000	pig and possible goat / med. size unit / medium difficulty heli access & terrain
Weed Control: Aerial	80,000	50,000	50,000	10,000	10,000	5,000	large-scale ATF treatment
Weed Control: Ground	0	10,000	10,000	20,000	20,000	10,000	yr. 2 & 3 ground surveys, identify priorities for yr. 4&5
Total	**125,000**	**185,000**	**235,000**	**255,000**	**205,000**	**85,000**	

12. Ili'ili'ula: This unit includes almost 800 acres of native-dominated lowland wet forest and wet cliffs. The proposed fences for this unit are very theoretical at this point, and very little is known about the extent of threats posed by non-native animals and invasive weeds. The terrain in Ili'ili'ula unit is some of the most radical in all of the KWA management area. On-the-ground surveys conducted in 2007 revealed that much of the area was inaccessible on foot, and extensive helicopter assistance would be required for any management efforts. Extensive surveys (both aerial and additional on-the-ground work) will be required to delineate the most intact forest, identify potential fence routes, and evaluate threats. The area is a priority for conservation due to its high rainfall, native dominated forest, and hydrologic function as the headwaters of the Ili'ili'ula stream and South Fork of the Wailua River.

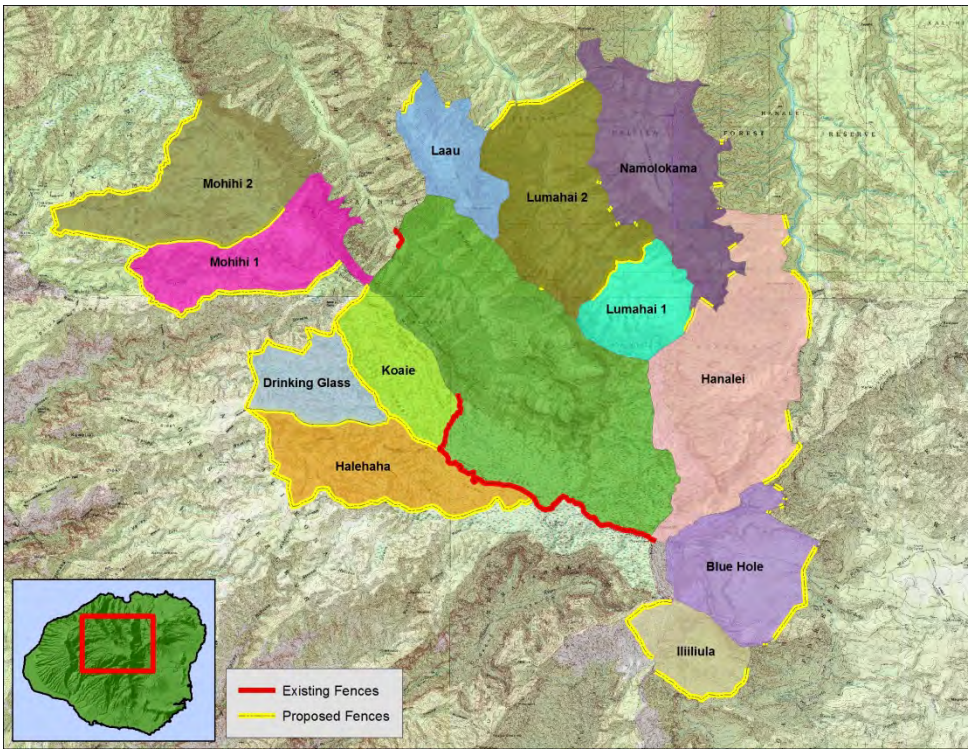


Ili'ili'ula	Acres	Fence Ft.	Ft / Acre	Fence Cost
Protective Fence	797	14,716	18.5	$515,060

Management Costs	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr. 6-∞	Notes
Fence Maintenance	25,000	25,000	25,000	25,000	25,000	25,000	2 days, quarterly, with multiple heli drop-offs
Ungulate Control	20,000	20,000	20,000	10,000	10,000	50,000	pig and possibly goat / small area accessible to animals / difficult heli access and terrain
Weed Control: Aerial	10,000	10,000	10,000	10,000	10,000	10,000	ATF spot-treatment, additional species unknown
Weed Control: Ground	0	10,000	10,000	20,000	20,000	5,000	yr. 2 & 3 ground surveys, identify priorities for yr. 4 & 5
Total	**55,000**	**65,000**	**65,000**	**65,000**	**65,000**	**90,000**	

Ten Year Timeline and Budget

	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Current Fenced Units	1,045,000	906,000	858,000	740,000	755,000	692,000	752,000	759,000	809,000	761,000
Koaie	$1,045,000	602,745	140,000	180,000	230,000	180,000	70,000	70,000	70,000	70,000
Halehaha		$1,508,745	1,519,130	65,000	195,000	235,000	235,000	185,000	80,000	80,000
Drinking Glass			$2,517,130	508,210	140,000	180,000	230,000	180,000	70,000	70,000
Mohihi 1				$1,493,210	1,191,915	235,000	225,000	215,000	155,000	65,000
Mohihi 2					$2,511,915	928,785	235,000	225,000	215,000	155,000
La'au						162,900	35,000	32,500	32,500	32,500
Lumaha'i 1						$2,613,685	349,155	170,000	220,000	240,000
Lumaha'i 2							368,160	260,000	280,000	280,000
Namolokama							$2,499,315	297,450	90,000	90,000
Hanalei								550,670	275,000	295,000
Blue Hole								$2,944,620	431,110	185,000
Ili'ili'ula									$2,727,610	570,060
										$2,893,560



The twelve new fenced units will work with existing fences to protect over 35,000 acres of Kauai's core watershed

Figures

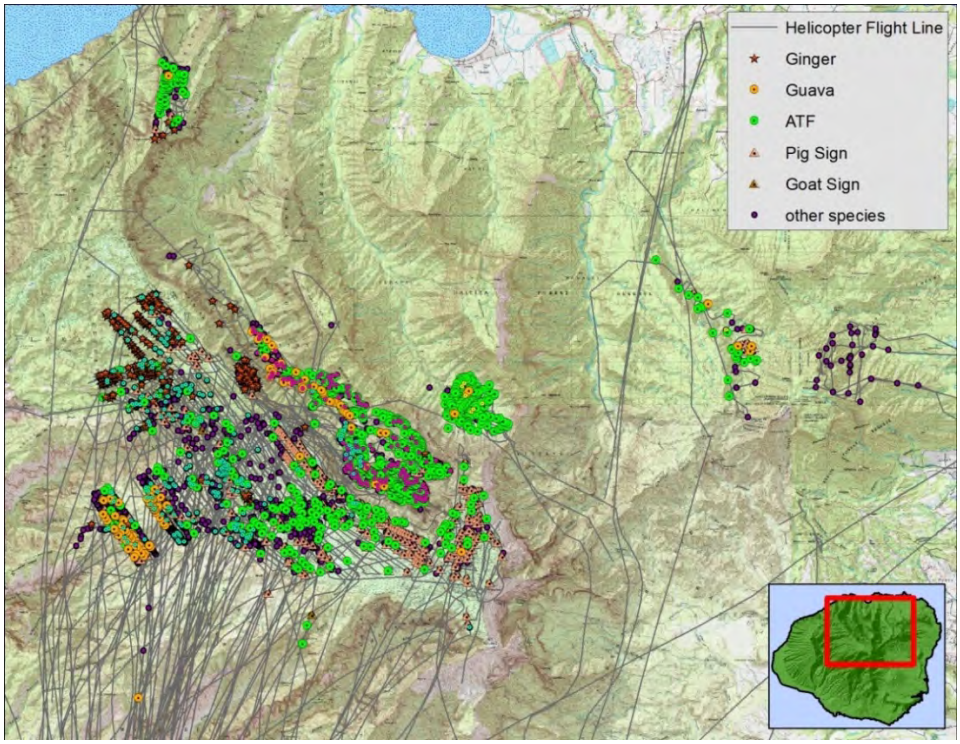


Figure 1: Helicopter flight-lines and invasive species detections from 2003-2005 surveys

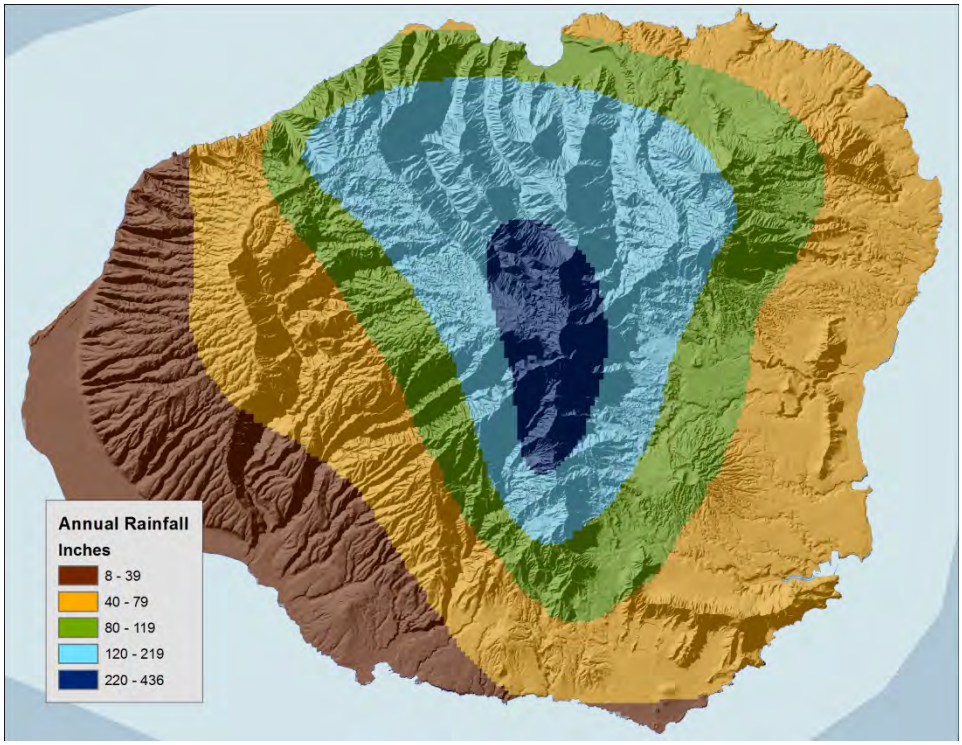


Figure 2: Rainfall zones on Kaua'i

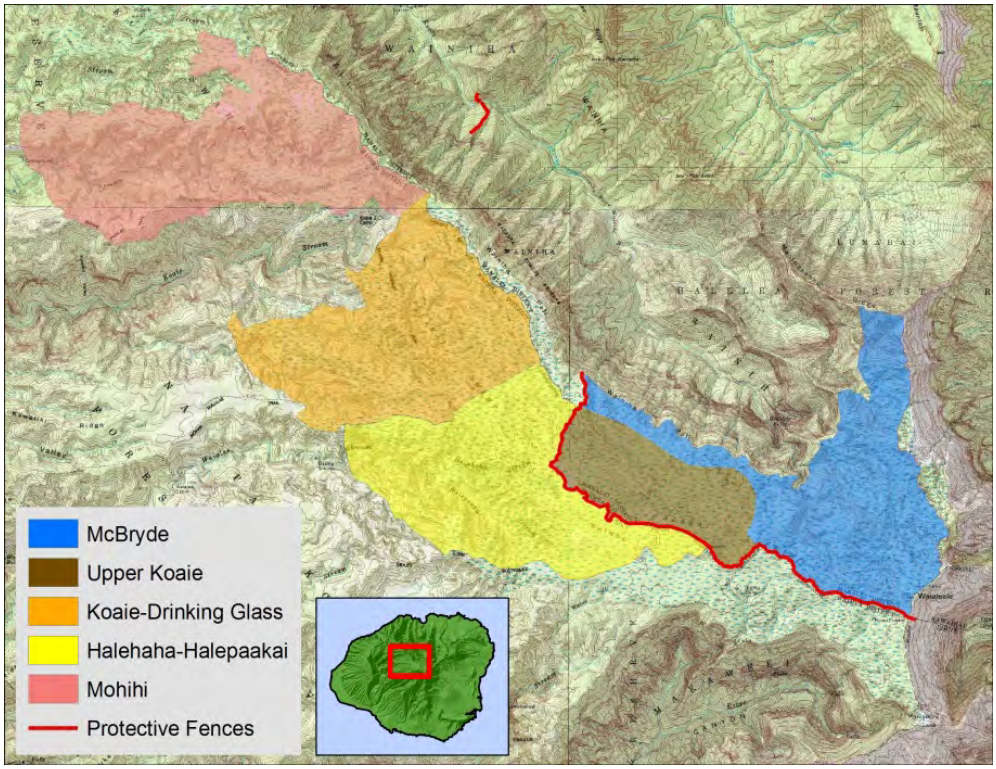


Figure 3: Current Alaka'i Plateau management units

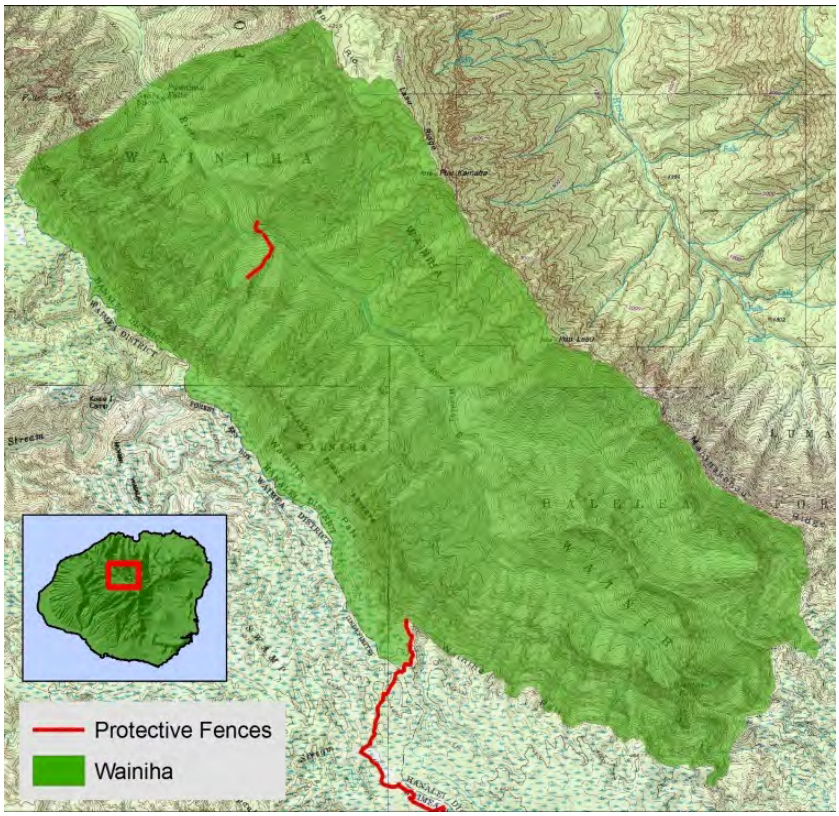


Figure 4: Wainiha Valley management unit

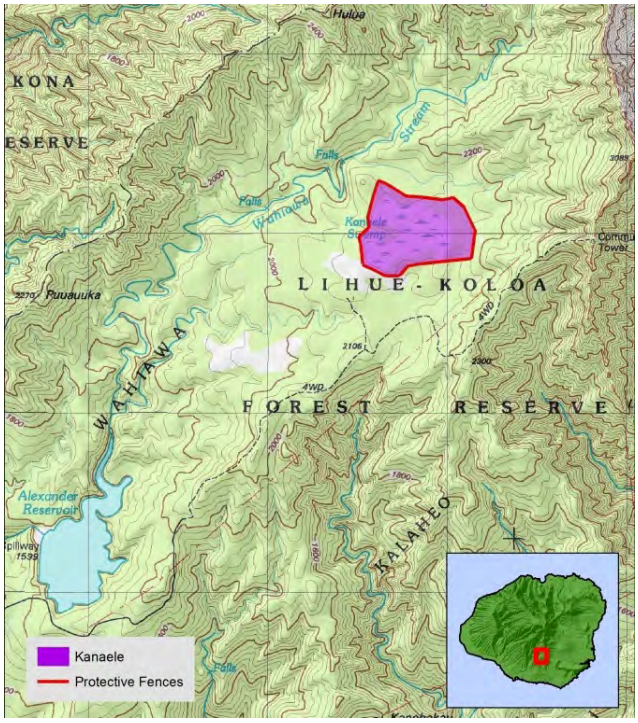


Figure 5: Kanaele management unit

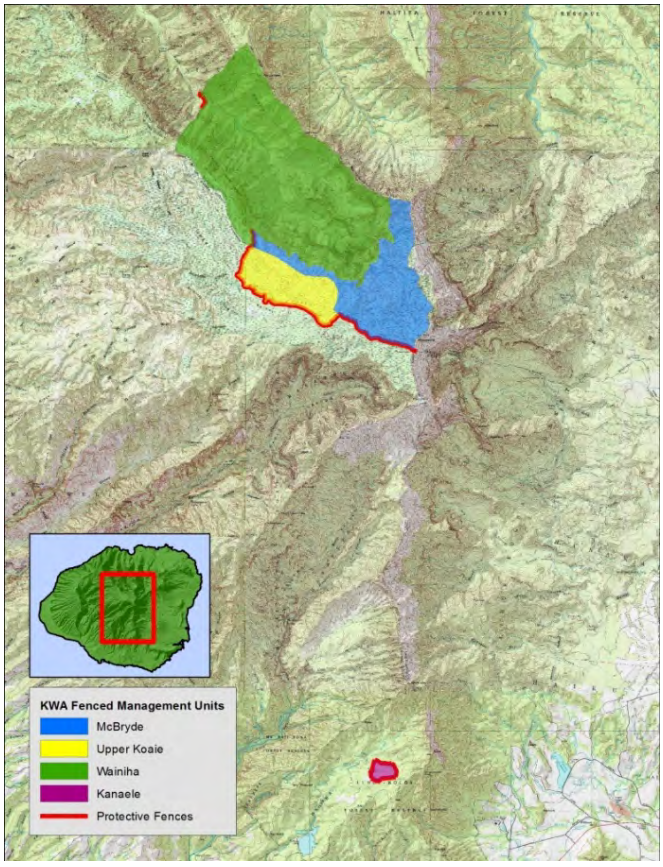


Figure 6: Completed KWA fenced units

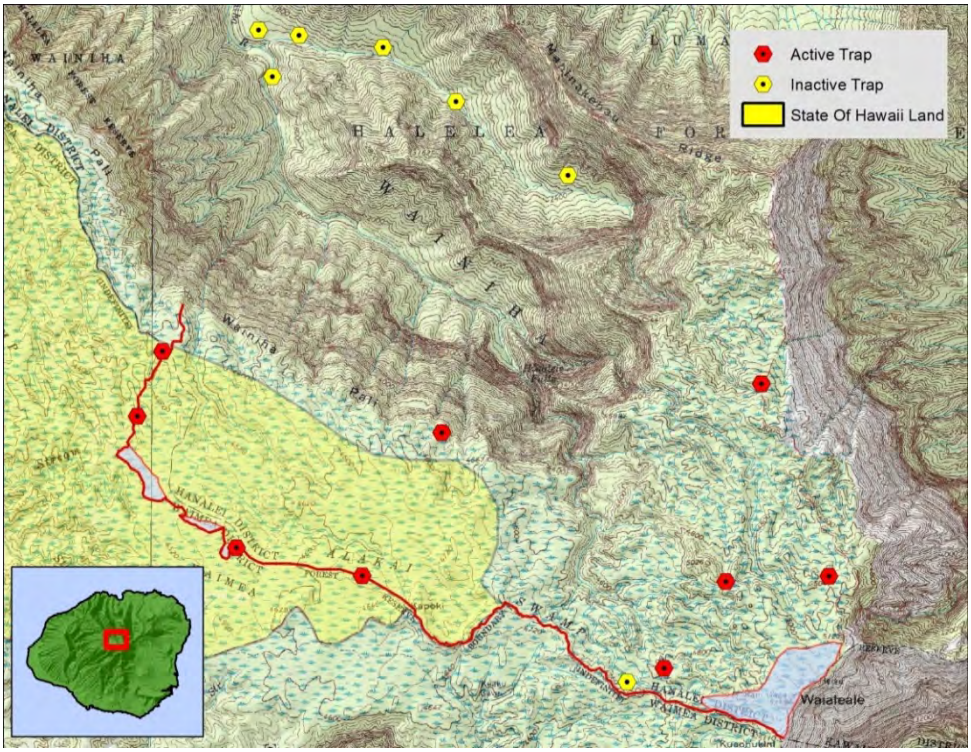


Figure 7: Pig traps, and status as of April 2012

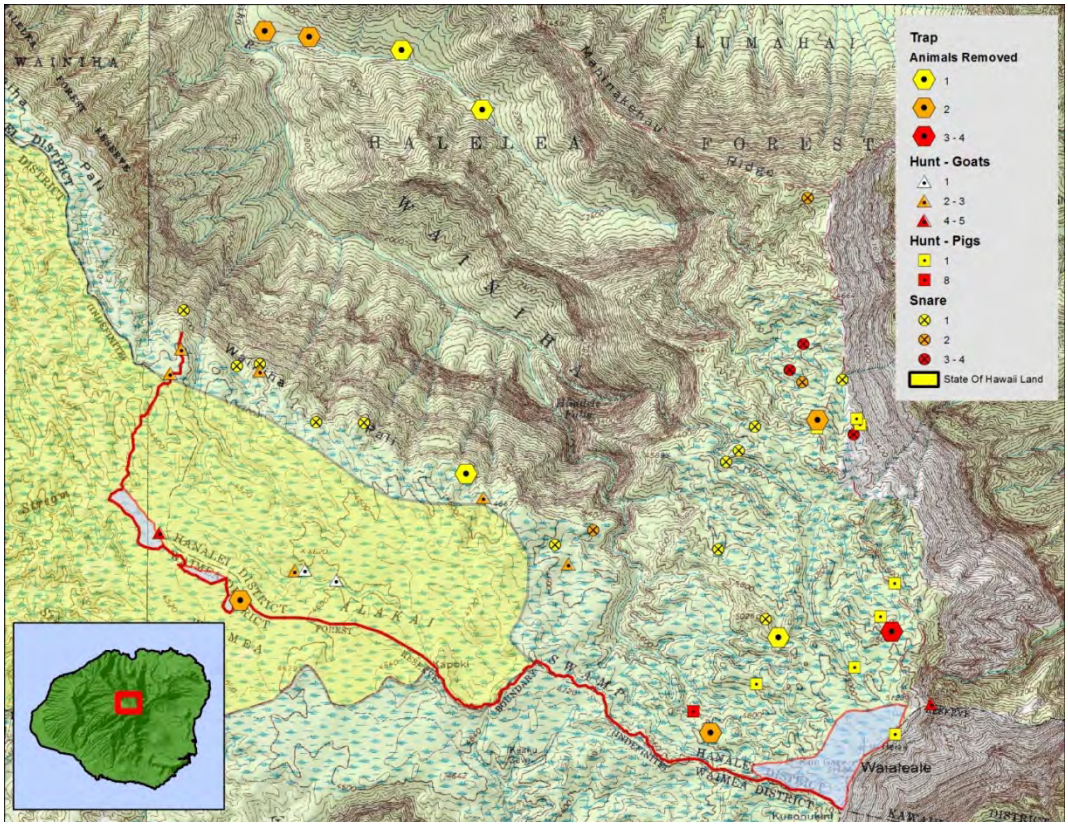


Figure 8: Animal control in KWA area, as of April 2012

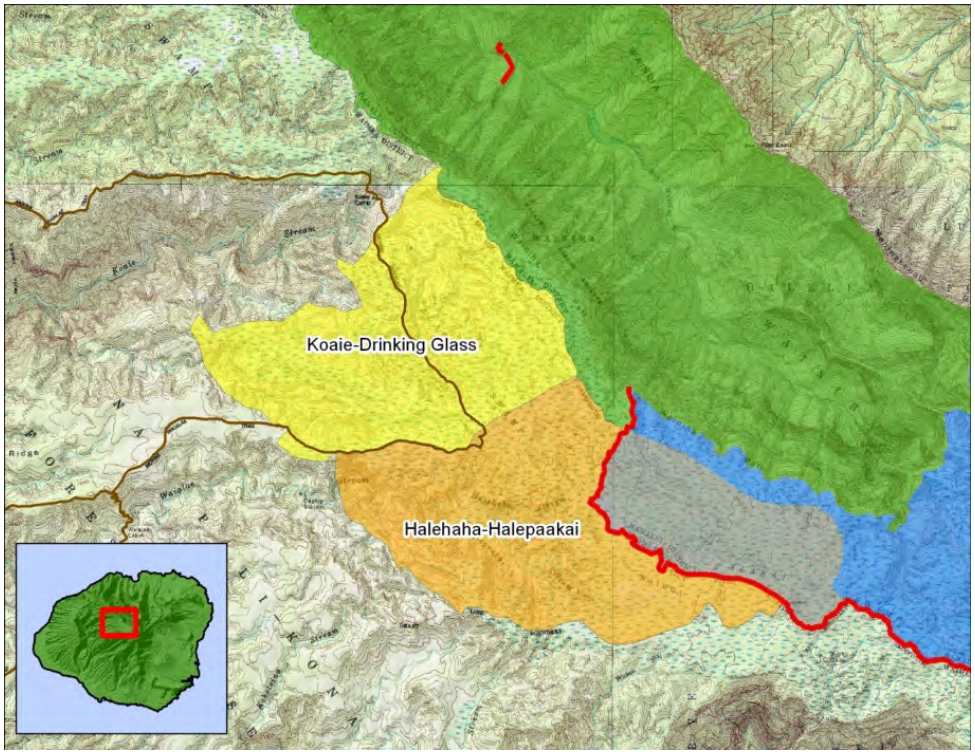


Figure 9: Priority Alaka'i management areas

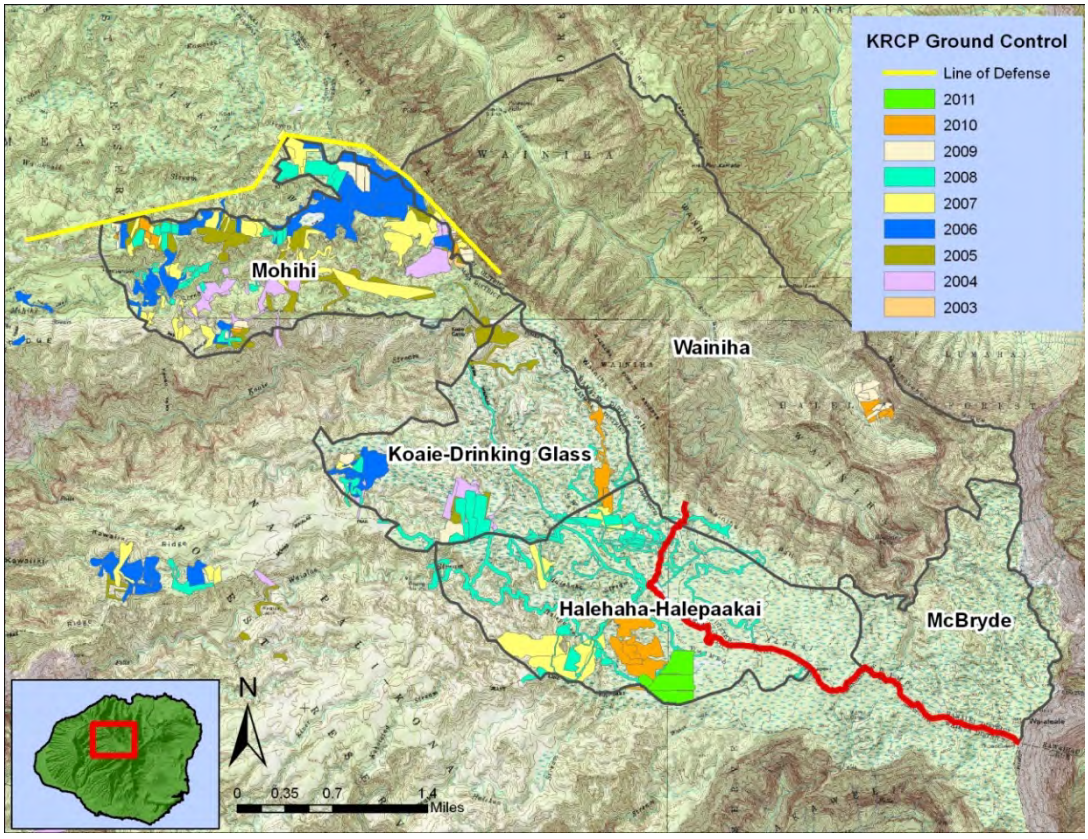


Figure 10: KRCP weed survey/control areas with "Line of Defense"

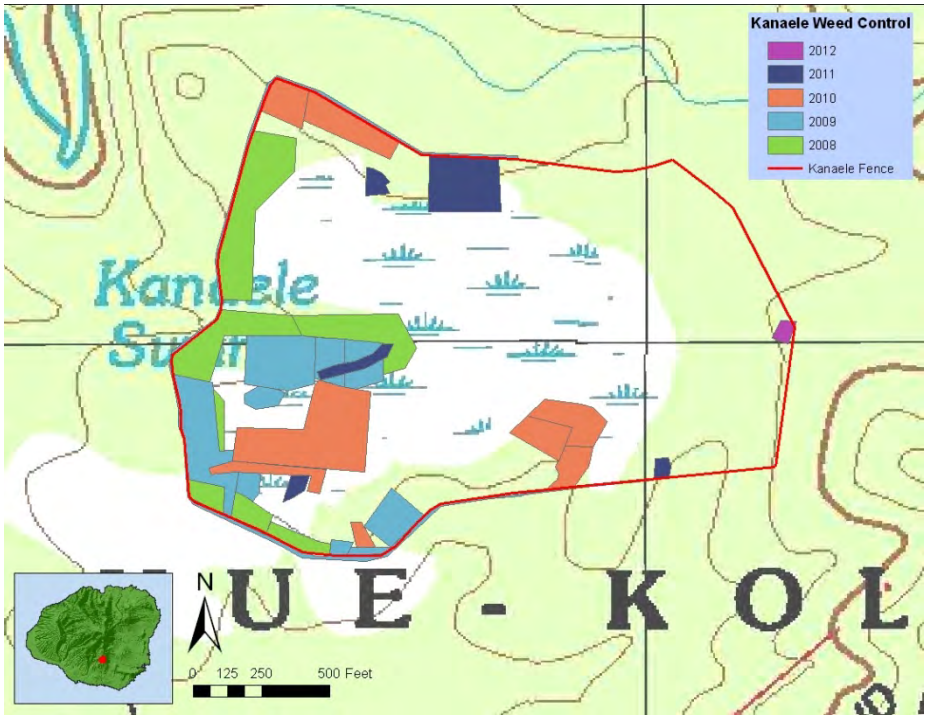


Figure 101: Kanaele weed control 2008-2011

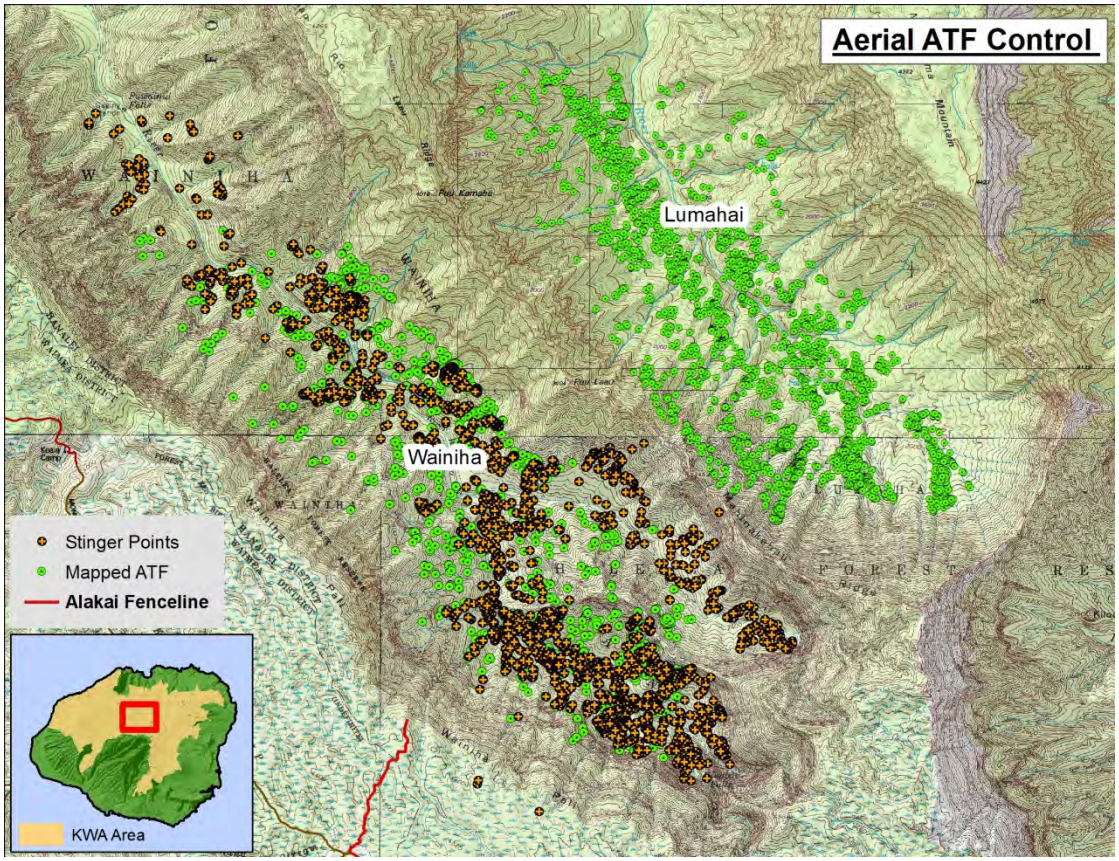


Figure 112: Aerial ATF control in Wainiha valley

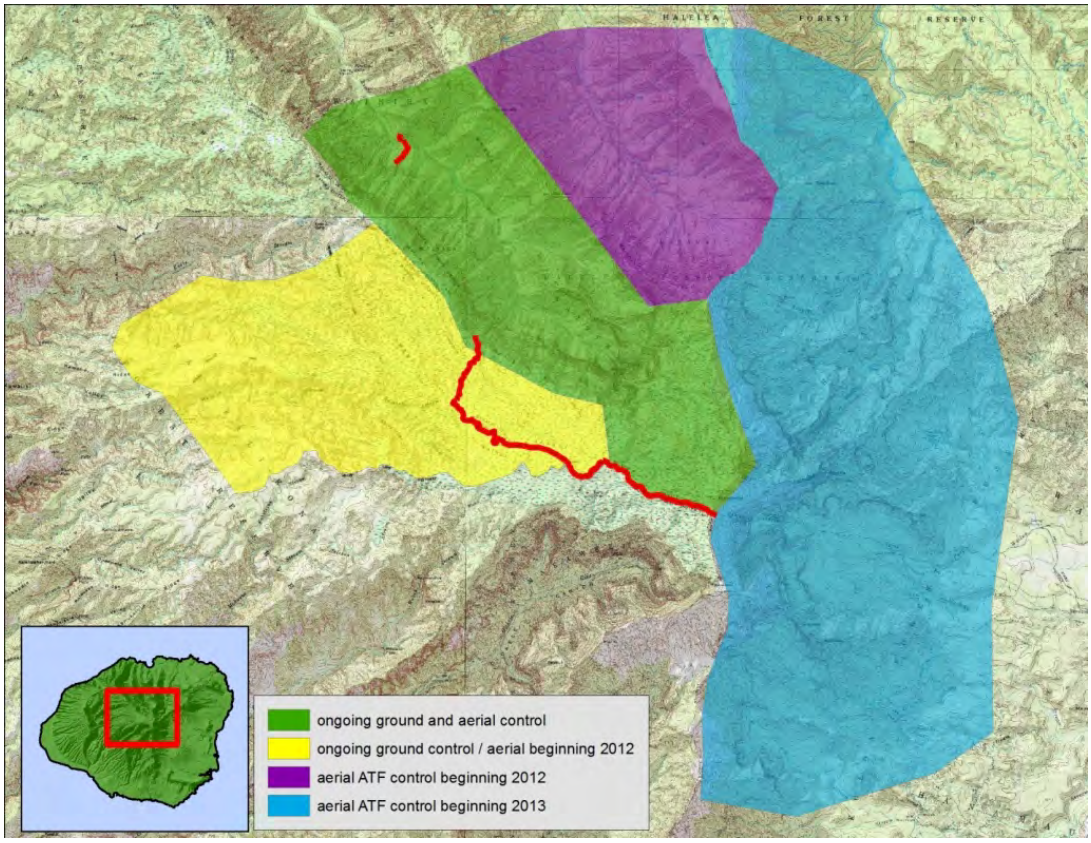


Figure 123: KWA weed control areas

Figure 134: Wainiha ATF before/after aerial treatment

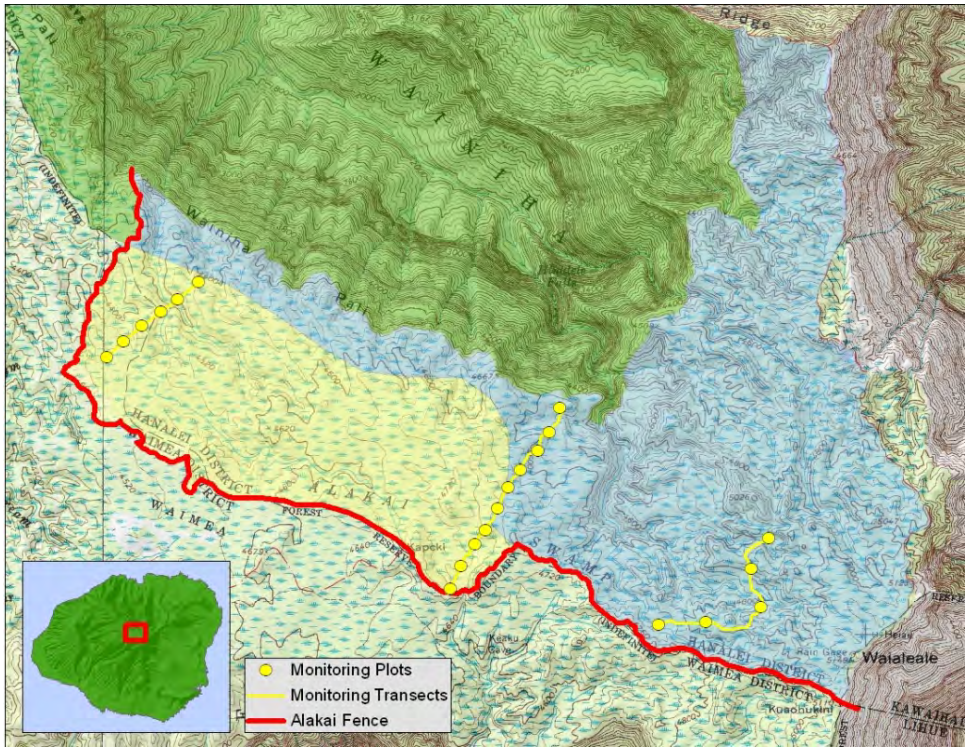


Figure 14: Alaka'i monitoring transects

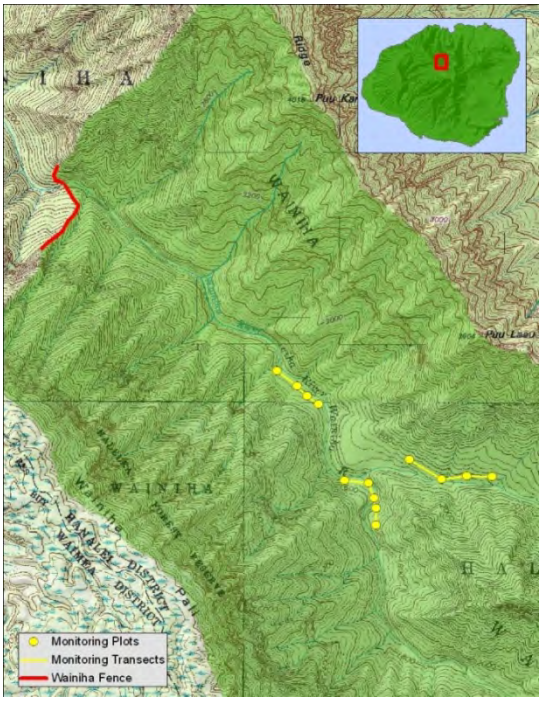


Figure 15: Wainiha monitoring transects

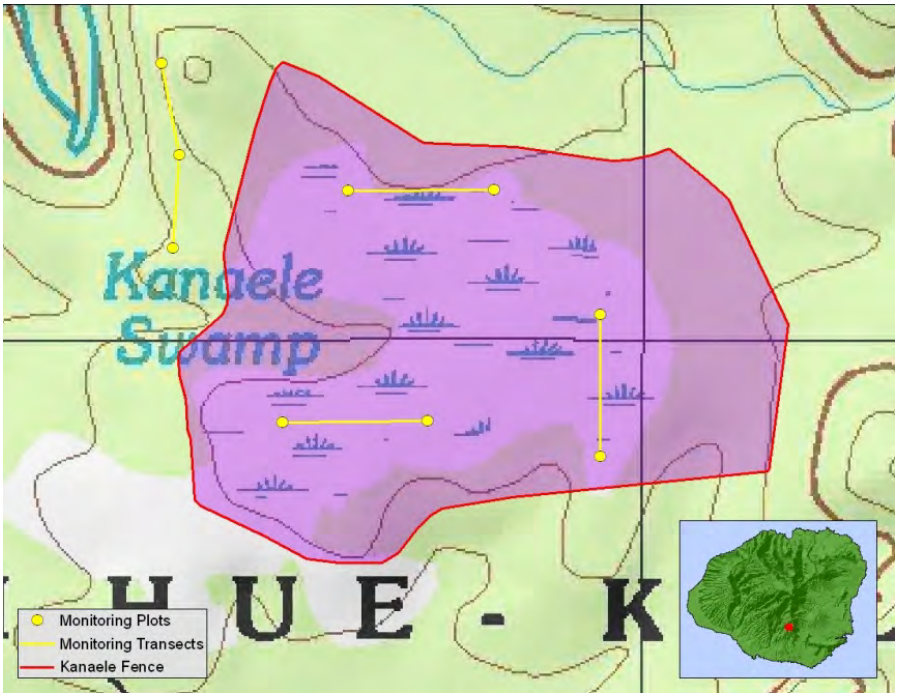


Figure 16: Kanaele monitoring transects

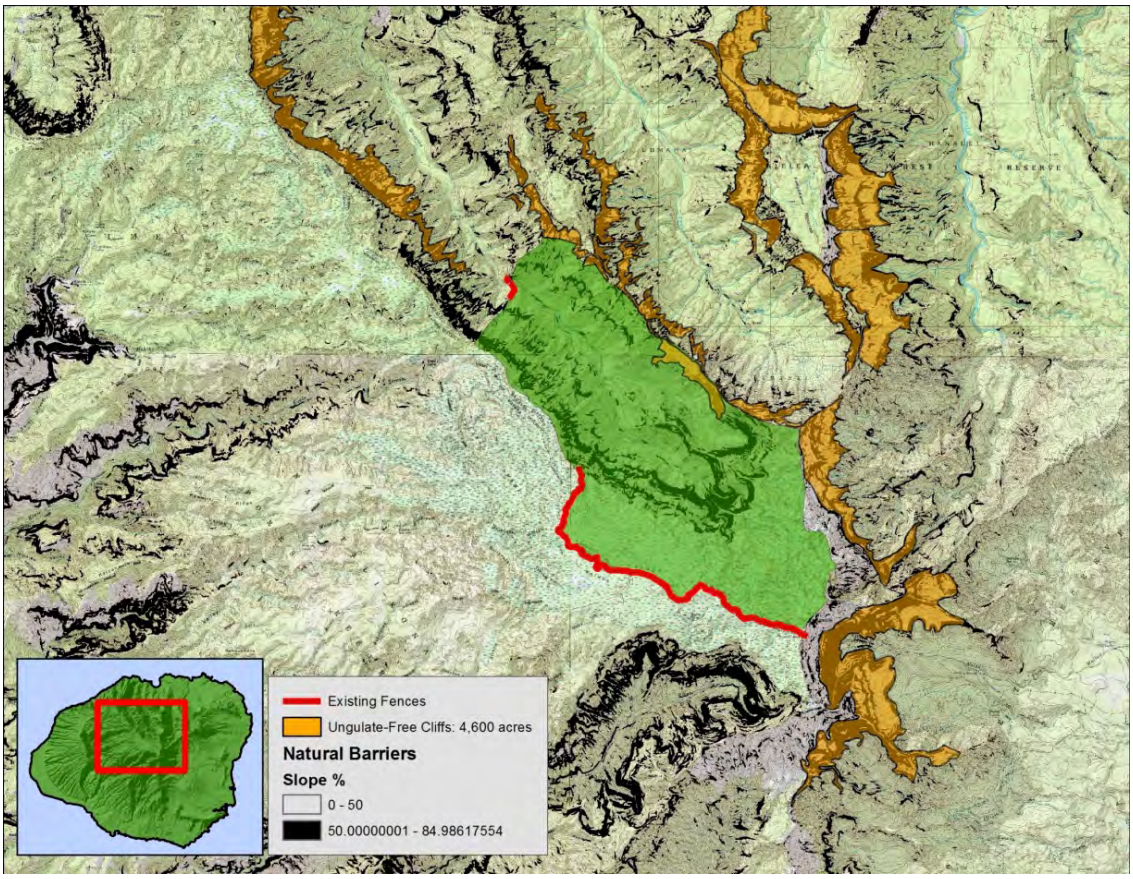


Figure 17: Natural ungulate barriers

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