Working Draft (Partner Review)
Wai‘anae Mountains Feral Goat Management Plan
October 2023

State of Hawai‘i

Department of Land and Natural Resources

Division of Forestry and Wildlife

O‘ahu Branch

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Executive Summary

This plan highlights how feral goats (*Capra hircus*) will be managed across a variety of state lands in the Waiʻanae Mountains, including the Department of Land and Natural Resources (DLNR) division of Forestry and Wildlife Forest Reserves (FR), Natural Area Reserves (NAR), one Game Management Area (GMA), and lands managed by private and public partners. These designations are the primary layer for how goats will be managed. Goats are considered an invasive species in Hawaiʻi and highly impact watershed values, spread invasive species, and threaten native ecosystems and endangered species. They are also important to many members of the Waiʻanae community, as they provide recreational hunting opportunities and a local food source to hunters and their communities.

A combination of community input, long-term plans for management units, and an analysis of environmental sensitivity to goat presence (section 3.2 & Appendix 4) was used to determine goat management priorities. As a result, individual prescriptions for Forestry and Wildlife-managed lands in the Waiʻanae Mountain Range have been made as it pertains to management and hunting opportunities (Section 3.3).

Public hunting can be used to keep goat populations from growing unchecked in certain areas. Forestry and Wildlife has worked with other landowners to create new hunting opportunities in areas previously unavailable to residents and visitors, and to increase hunter access points to Forestry and Wildlife-managed lands. Some examples include the creation of hunter access to Kamaileʻunu and the development of wildlife control permits in Mākaha Valley. However, some areas still necessitate staff control to ensure the protection of sensitive resources.

Forestry and Wildlife will focus staff control on Kaʻala NAR, Mokulēʻia FR, the mauka sections of Waiʻanae Kai FR, Lualualei FR and Lualualei Annex, and Honoʻuliʻuli FR. Efforts in the mauka areas of Waiʻanae Kai FR, Lualualei FR, and Lualualei Annex will focus on reducing goat populations, but the full number of actions required for complete removal, including a combination of trapping, pushing, and aerial shooting, will not be implemented at this time. Mokulēʻia FR, Kaʻala NAR, mauka areas of Waiʻanae Kai FR, Honoʻuliʻuli FR, Lualualei FR, and Lualualei Naval Annex where there are very low quantities of goats and either difficult or no current public access, will be focus areas for complete goat removal. Efforts will be made to include public salvage and collaboration on Forestry and Wildlife staff control whenever possible.

Currently, there are no plans for staff control in Makua Keaʻau FR, the Kamaileʻunu and Waiʻanae Valley Ranch sections of Waiʻanae Kai FR, or the Board of Water Supply (BWS) land in Makaha Valley. Public hunting will be the main form of goat control in those locations. Current areas enclosed by fences (<5 acres) will help protect threatened and endangered (T&E) species and restoration sites. However, remote sensing of vegetation within these areas will be monitored over the next 10 years, and if these data indicate a declining trend in vegetation cover, staff control may be utilized to reduce goat populations in these areas.

These goals may be revised as conditions change (i.e., watershed health declines or improves, improved access, land acquisitions, etc.), and will be done in collaboration with the hunting community and management partners. Forestry and Wildlife will continue to try to increase hunting opportunities, either through new access points or by issuing special use permits (SUPs). Monitoring of vegetation cover, goat

distribution, and other watershed risks such as drought and wildfire, will be used to guide goat control and watershed protection actions in the future.

There is an opportunity to balance resource and endangered species protection with public hunting needs in the Wai‘anae Mountains. Community input has meant that Forestry and Wildlife will not pursue the goat control project as originally envisioned, and has developed different approaches with adaptive management and collaboration with the hunting community. The issues are multifaceted; however, Forestry and Wildlife hopes that if approached with aloha, we will all find a way forward in the spaces where there is alignment.

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1.0 Introduction

The purpose of this plan is to address the presence of goats on various lands managed by the Division of Forestry and Wildlife and partner groups in the Waiʻanae Mountains. Forestry and Wildlife is mandated to both 1) conserve, manage and protect watersheds, native and endangered species and their ecosystems, and 2) preserve, protect, and promote public hunting. Forestry and Wildlife's mission is as follows:

The Division of Forestry and Wildlife protects, manages, and restores natural and cultural resources in collaboration with the people of Hawai'i.

This plan includes a variety of State Managed Lands under Forestry and Wildlife's jurisdiction including Forest Reserves, Natural Area Reserves, and one Game Management Area. These designations are the primary purpose in which lands are to be managed, including the presence or control of ungulate populations. Natural Area Reserves (NAR) are solely designated for the protection and conservation of the native Hawaiian plants and animals within them. Game Management Areas (GMA) are dedicated to the enhancement of public hunting opportunities. Forest Reserves (FR) are managed for a variety of purposes, but especially watershed protection, as guided by the Executive Order (EO) or Governors Proclamation (GP) that established each FR. Forestry and Wildlife incorporates public hunting area (PHA) overlays in some areas, particularly in forest reserves, as a tool to help control ungulate populations in those places. However, the public hunting area overlays are always subject to change in order to ensure that the primary management objectives for the area are being met.

The lands mentioned in this plan include Waiʻanae Kai FR, Makua Keaʻau FR, Honoʻuliʻuli FR, Mokulēʻia FR, Lualualei FR, Nānākuli FR, Kuaokalā FR, Kuaokalā Game Management Area (GMA), Kaʻala NAR, and Pahole NAR (Figure 1). The plan area also includes lands where partnership agreements exist or have the potential for future agreements, including Honolulu Board of Water Supply (BWS) land in Makaha Valley, Lualualei Annex, and Waiʻanae Valley Ranch.

In some areas, the presence of goats may be acceptable because of the public benefits of goats as a food source and as a recreational hunting opportunity. In other areas, the presence of goats is unacceptable because of their negative impact on watershed functions, forest and ground cover, soil stability, threatened and endangered species, and other related problems. Forestry and Wildlife is dedicated to protecting and promoting hunting for recreation and subsistence where appropriate, as mandated by §183D-2 (12) of the Hawaiʻi Revised Statutes (HRS). Forestry and Wildlife also utilizes public hunting as a tool for ungulate (hooved animals such as goats) control to prevent the degradation of watersheds and other resources.

The hunting program in Hawaiʻi is based entirely on introduced animal species including goats (*Capra hircus*), axis deer (*Axis axis*), pigs (*Sus scrofa*), and sheep (*Ovis aries*), all of which contribute to the degradation of native ecosystems and watershed health. In many places, hunter control has not proven to be sufficient in reducing ungulate populations, and other areas lack public access, so other options such as fencing and staff control are necessary to reduce and/or remove ungulates from those areas. The impact of introduced ungulates varies across landscapes, is dependent on ecosystem type, animal species, population levels, and the type and intensity of any control measures being used.

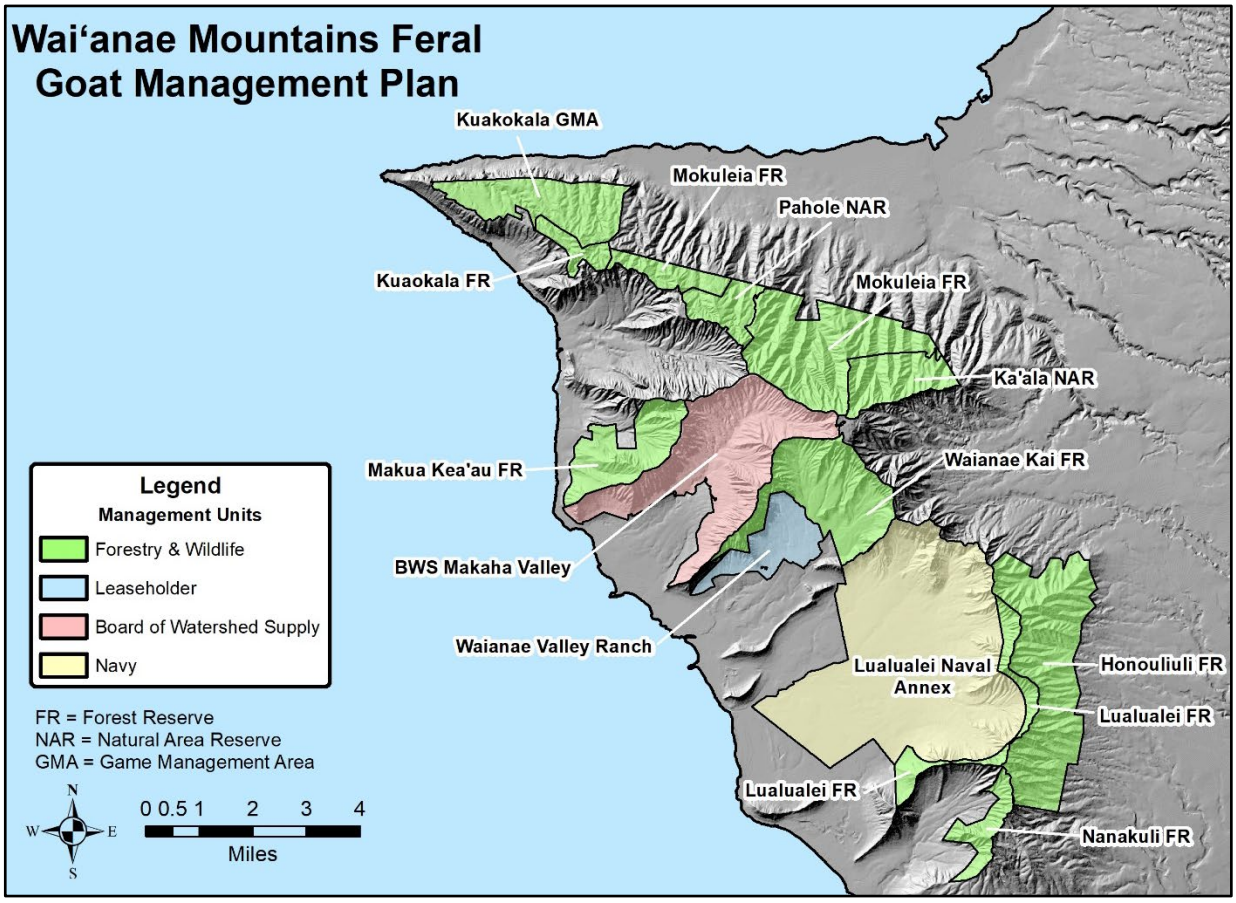

Figure 1 DOFAW managed (green) and other lands described in this plan

1.1 Partnerships & Cooperating Agencies

Lands within the Wai‘anae Mountain Range are often cooperatively managed between Forestry and Wildlife and other groups that have similar missions and support needs. Multiple agencies, non-profit groups, and community organizations work in tandem to manage natural and cultural resources and conduct threat abatement throughout the area.

Wai‘anae Mountains Watershed Partnership

The Wai‘anae Mountains Watershed Partnership was established in 2010, by and through a memorandum of understanding (MOU) between its partners which include: the DLNR, by and through its Board of Land and Natural Resources; Gill-Olson Joint Venture; BWS; Ka‘ala Farm, Inc.; United States Army Garrison, Hawai‘i; United States Navy, Region Hawai‘i; and the Wai‘anae Community Re-Development Corporation (MAO Organic Farms). These parties are collectively known as the Wai‘anae Mountains Watershed Partnership (WMWP) and individually referred to as Partners. The mission of the WMWP is to cooperatively develop and implement management strategies for the Wai‘anae Mountains, mauka to makai, that bring people together to responsibly manage watershed areas, native species and their habitats,

and historical, cultural, and socio-economic resources for all who benefit from the health of all of the Waiʻanae ahupuaʻa. WMWP is a key partner with Forestry and Wildlife in doing surveys to control and monitor feral goat populations in the Waiʻanae Mountains.

The Navy

The Lualualualei Annex is a large parcel of land in the southern Waiʻanae Mountain Range owned by the Navy. Comprising approximately 9,220 acres, Lualualei Annex contains rugged mountainous terrain where goat populations have been observed. The Navy's Integrated Natural Resource Management Plan (INRMP) includes a goal to remove the goats in the area to protect the forests, watersheds, and threatened and endangered species. This area is not a public hunting area and due to the heightened security of the area, public access is restricted. Conversations with the Navy have made it clear that the public will not be allowed to bring firearms onto their property. The Navy is open to discussions with Forestry and Wildlife regarding help with goat control.

Board of Water Supply

Tax Map Keys (TMKs) 8-4-30-1 and 8-4-30-4 are in Makaha Valley and owned by the City and County of Honolulu BWS. Together, both TMKs cover approximately 4,008 acres. They also contain rugged mountainous terrain that is home to large populations of goats. The BWS also wishes to remove the goats to protect the forests, watersheds and threatened and endangered native species. As this area is not a Public Hunting Area, Forestry and Wildlife and the BWS established a hunt by a permit system that is administered by Forestry and Wildlife. This permit system is currently in place and an archery goat control program is being implemented. Participants are required to submit a permit application, have a valid hunting license, and provide hunter catch data via a newly designed app (OuterSpatial).

Waiʻanae Valley Ranch

Waiʻanae Valley Ranch is adjacent to the Waiʻanae Kai FR and located on public land leased to ranch managers. Currently, Forestry and Wildlife is working with ranch managers to permit access to allow hunters to pass through their land to Waiʻanae Kai FR. If hunters are interested in hunting on the ranch, Forestry and Wildlife can coordinate communication with the ranch managers, who will make the decision whether hunters can hunt on the property by agreement, permit, or both.

Organized Hunting Groups (Waiʻanae Hunters Association & Others)

Forestry and Wildlife has previously and will continue to work closely with public hunting groups. Forestry and Wildlife has worked with the Waiʻanae Hunters Association (WHA), as well as the Oʻahu Pig Hunters Association, to understand the needs of hunters and help improve opportunities. WHA has historically helped in the upkeep of hunter check stations and in collecting data from hunter check in stations. Forestry and Wildlife is open to working with other hunting groups that would like to advocate and help steward hunting opportunities in the Waiʻanae Mountains.

Game Management Advisory Commission

The Game Management Advisory Commission (GMAC) serves in an advisory capacity related to game management and hunting opportunities to the Board of Land and Natural Resources, which sets policies

for DLNR and Forestry and Wildlife. There are currently two representatives for the island of Oʻahu that are specifically consulted in public hunting matters pertaining to the Waiʻanae mountains.

2.0 Goats in the Waiʻanae Mountains

2.1 Current Goat Presence

Goats are not believed to be present in all areas of the Waiʻanae Mountain Range. Figure 2 shows the relevant areas related to this plan and the known presence or absence of goats within those areas. Goat populations can vary dramatically, and this map is only meant to indicate their presence or absence, not the population levels or management intentions for those areas. Many areas, such as Kaʻala NAR, Mokulēʻia FR, and Honoʻuliʻuli FR, have very few goats (Honoʻuliʻuli FR may have <5 total). It is also important to note that there are no plans to move goats to areas they are not already present, and there will no tolerance for incipient populations of goats in new areas if found.

2.2 Goat Impacts

Goats are not native to Hawaiʻi and were first introduced by European contact just before the 19th century. Hawaiian ecosystems evolved in the absence of any mammalian herbivores and, as a result, are vulnerable to damage by introduced grazers (Cuddihy and Stone, 1990). Goats (*Capra hircus*) are considered especially destructive, leading some to call them "the single most destructive herbivore" introduced to island ecosystems globally (King 1985). Goats can browse on almost any type of vegetation, including native grasses, shrubs, small trees, and seedlings, which can lead to devegetation and result in primary and secondary impacts on ecosystems (Campbell and Donlan 2005). Goat over-population destroys native vegetation and reduces the overall cover of native and introduced tree species, which impairs watershed functions and impedes forest restoration efforts.

Goat browsing also leads to soil erosion and damage to streams and nearshore waters. Ungulate presence has also been linked to spreading forest diseases, such as Rapid ʻŌhiʻa Death (ROD). The complete mechanism is not understood, but it is believed that by wounding trees or disturbing soil, ungulates may create entrance areas for the ROD fungus to infect new trees. Ungulates are also known to spread seeds of invasive plant species to new areas. While some studies have shown that goats can provide short-term suppression of fire and control of some invasive plants, no studies have demonstrated the long-term benefits of goats to the Hawaiian environment. Appendix 3 shows further research demonstrating the negative effects of goats in Hawaiʻi.

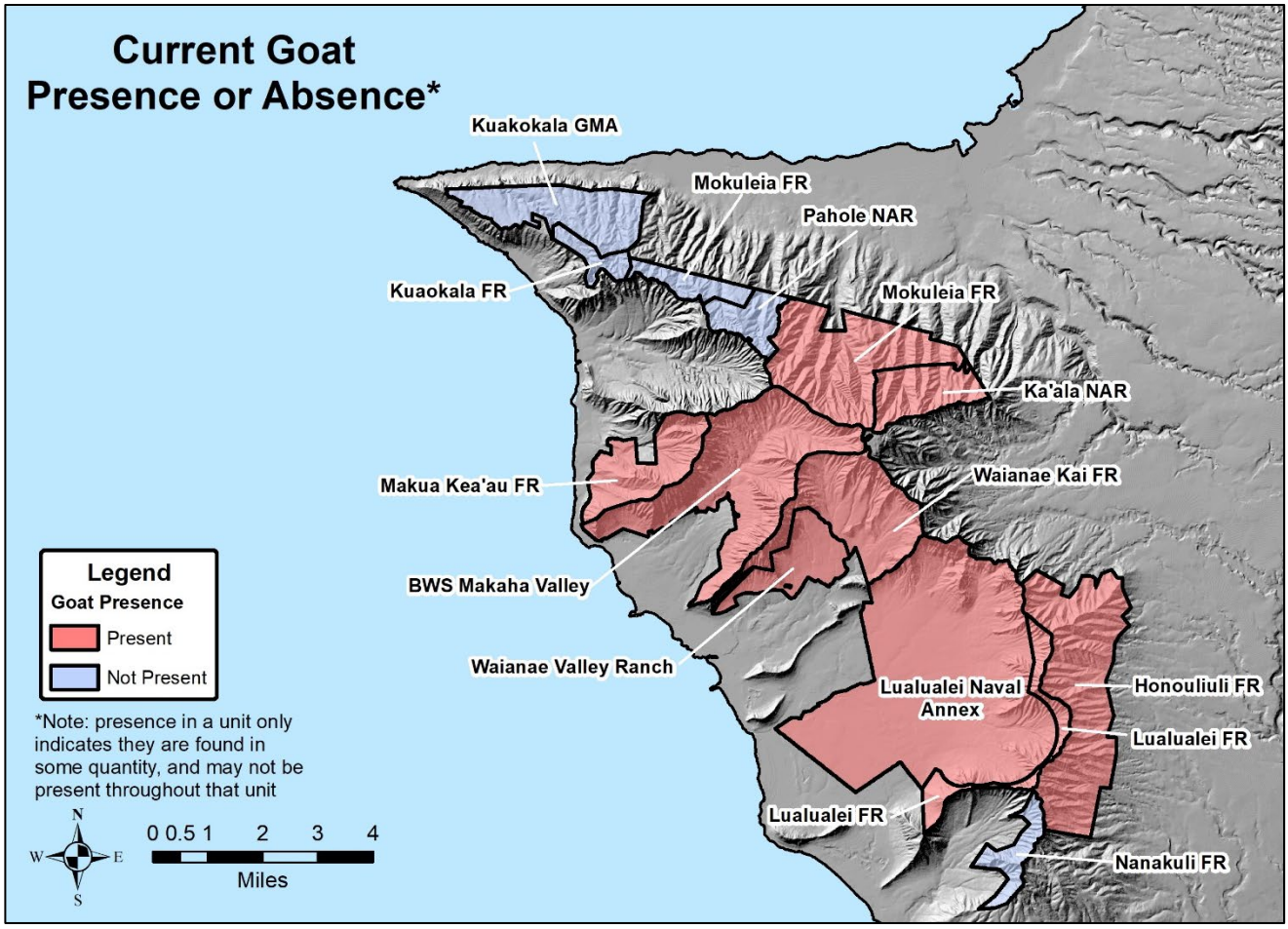

Figure 2 Current Presence or Absence of Goats. Note: Presence in a unit only indicates they are found in some quantity, and may not be present in high numbers or throughout the entire unit

2.3 Goats as a Resource

Goats are a valuable resource to some members in the Waiʻanae community. Goats are valued as a food source, while goat hunting is also a cherished tradition that is practiced from one generation to the next. Hunting provides both a recreational, and to some, a cultural activity for individuals in the outdoors, and is a way to support and provide food for themselves, their family, and their community. Members of this hunting community are opposed to the idea of restricting goat hunting opportunities and want to be involved in discussions and any efforts to control goat populations.

2.3.1 Current Hunter Use – Hunter Check Station Data

As part of its game program and to fulfill federal grant requirements, Forestry and Wildlife collects and monitors data of hunter usage of public hunting areas (PHAs). Data is collected when hunters check in, either online or at physical check stations, and sign out any game that was captured. Data are collected on a monthly basis and help managers understand user frequency, type and number of game species taken, seasonal differences, and popularity/functionality of access points.

Data from current publicly accessible hunter check stations at Kuaokalā GMA, Makua Kea‘au PHA, and two Wai‘anae Kai PHA access points (Wai‘anae Valley Road Access and Kamaile‘unu Access) show that an average of 150.2 goats are taken from the Wai‘anae Mountains each year. The data also show that about 506 hunters utilize the Wai‘anae range every year, but this number represents both pig and goat hunters. The Kamaile‘unu access was recently added in 2018, and yeilded a high number of goats taken. Based on records received from the hunter check station data, this access continues to be a highly utlized area and yeilds a greater success of goats taken as years progress.

The Public Hunter Check Station data is based on an honor system in which the state relies on the public to submit truthful and accurate data. These data are useful as they provide a general sense of activity in a hunting unit, but the data do not reflect the total amount of hunting activity as many hunters do not register. For updated numbers and examples of check station data trends please reference Appendix 2.

3.0 Management

3.1 Wai‘anae Goat Management History

Since the early 1900s, foresters have recognized goats as an invasive species and suggested control to protect forested areas in Hawai‘i. The primary resource concern for the creation and designation of Forest Reserves in the early 20th century was to protect and restore watershed functions to areas. The Hawaiian Forester and Agriculturist, 1904, Volume 1., Page 19 stated:

> *Goats were introduced into the islands many years ago and have been particularly active agents of destruction.*
>
> *As soon as the (forest) reserves are formed all cattle should be driven out, and the portions which are accessible to cattle should be fenced. Those wild cattle which cannot be driven out, and the wild goats, should be shot. An effective ranger service should then be put into operation to keep stock and fire out of the forest.*
>
> *With the reserves well protected, the forest will replace itself in many of the damaged areas, as reproduction under some conditions takes place rapidly.*

In December 1906, the Hawaiian Forester and Agriculturalist gives specific direction for goat control in Lualualei and Wai‘anae Kai:

> *...the essential reasons for the creation of a forest reserve on the Lualualei and Wai‘anae-Kai lands are, by the re-establishment and maintenance of a forest cover, to assist in securing a more regular flow in the springs and brooks on the lands, and to put to economic use areas, which from their topography and situation are incapable of being profitably used for any other purpose than producing trees. Much of the proposed reserve is indeed too steep and rough even for this use, but by making it a forest reserve it will later be possible to put into effect a comprehensive system of forest management, which will include the systematic extermination of the wild goats and, in cooperation with the owners or lessees of adjoining lands, a definite policy of tree planting.*

Until the 1950s, hunting on public lands was confined to these animal removal efforts on forest reserves carried out by Division of Forestry staff and their public assistants (Walker 1978). The 1950s and 60s saw an expansion of game mammal hunting opportunities, and some areas began to be managed to maintain

mammal populations instead of only removal efforts. Increased access to recreational hunting and management of hunting populations began to occur in the middle 20th century. However, during the latter half of the 20th century an increased focus on native species and threatened and endangered species, through bills such as the Endangered Species Act (NEPA) and Hawai‘i Environmental Protection Act (HEPA), meant state lands began to be managed more intensely for protection, combined with watershed and hunting values. Hunting also became more intensely managed as a recreational activity and for assisting in animal control across varying public lands, including public lands in the Wai‘anae Mountains.

In the 21st century, a combination of factors led Forestry and Wildlife to the conclusion that increased goat control was needed to adequately protect resources within the Wai‘anae Mountain Range. In 2009, Forestry and Wildlife revised the O‘ahu Foresty and Wildlfie Management Guidelines, adding the *conservation class* guideline that designates levels and areas of concern for rare species, critical habitat, and vegetation (https://dlnr.Hawai‘i.gov/dofaw/lands/#map). In 2010, the formation of the Wai‘anae Mountains Watershed Partnership (WMWP) brought further focus on watershed values across the mountain range.

In 2014, aerial surveys of the Wai‘anae Kai FR revealed goats accessing hanging valleys in the back cliff area; areas inaccessible to hunters and hikers. These back areas are particularly vulnerable to erosion and are valuable for maintaining watershed values for leeward O‘ahu. This documented goat presence led to greater concern over the expanding distribution of goats, and managers began planning ways to control goats in these areas.

In 2015, hunting rules were changed on O‘ahu in an effort to increase hunting opportunities by providing year-round access to game mammals and increasing bag limits. This rule revision went through a public process with no opposition. The changes made are highlighted in yellow in Table 1 below:

Table 1. Hunting Rules for Wai‘anae Kai PHA Unit C Pre and Post 2015

Time Period	Game Mammals to be taken	Permitted Hunting Methods	Bag Limits	Open Hunting Periods	Open Hunting Days
Pre 2015	Feral pigs and goats	Rifles, shotguns, handguns, knives, spears, bows, and arrows. Dogs permitted.**	One pig and one goat of either sex per hunter per day. No season limit.	May through January	Saturday, Sunday, and State Holidays except on legal bird hunting days.
2015-Present	Feral pigs and goats	Rifles, shotguns, handguns, knives, spears, archery. Dogs permitted.**	Two pigs and two goats of either sex per hunter per day. No season limit.	Year-round	Daily

A 10-year review of the hunter check-in station data from 2004-2014 implied that hunters were not taking goats in the Waiʻanae Kai Forest Reserve. This, combined with the lack of hunter/walk-in access to these hanging valleys led Forestry and Wildlife staff to believe aerial control of goats was necessary and would not be controversial. In 2017, Forestry and Wildlife started initial public outreach through meetings with various legislators explaining the intention to implement aerial control of goats throughout the mountain range, and letting them know how to contact us should they receive inquiries from the public. Meetings were also held with Aha Moku Representatives from the Waialua, Kapolei, and Waiʻanae Moku. Separate meetings were held with Kahu from the Kunia and Honoʻuliʻuli areas. Forestry and Wildlife and WMWP conducted multiple presentations at the North Shore, Nānākuli, and Waiʻanae Neighborhood Board Meetings as well as the Game Mammal Advisory Commission.

However, after implementing aerial shoot missions in 2017, Forestry and Wildlife started receiving public pushback on the practice of aerial control of goats. After this public pushback, Forestry and Wildlife suspended aerial control and initiated a broader public outreach campaign.

Over the following years DOFAW attended meetings with the neighborhood boards in Nānākuli and Waiʻanae, the Aha Moku Council, the Game Management Advisory Commission (GMAC), and targeted special interest groups including the Pig Hunters Association of Oʻahu and the Waiʻanae Hunters Association. Forestry and Wildlife provided information on the animal control operation and the accompanying measures to be implemented within the wider watershed and Waiʻanae Mountains.

The open dialogue with the public revealed many ways to incorporate the community into this project. As such, the following adjustments to management strategies were adopted:

- Creation of a new access point and hunter check-in station on Kaulawaha Road to access Kamaileʻunu.
- Attempting to create a new access point and hunter check-in station at Piliuka Place/Kawiwi Way to access Kamaileʻunu.
- Attempting to work on an agreement establishing a new access point through Waiʻanae Valley Ranch.
- Issuing increased bag limit permits.
- Issuing salvage permits for goat carcasses.
- Establishment of a temporary *no aerial shoot* zone at Kamaileʻunu to allow hunters to remove goats themselves.
- Collaboration with BWS to open archery goat control in Makaha Valley via a permit system run by Forestry and Wildlife.
- Issuing Wildlife Control Permits to access the Restricted Watershed portion of the Waiʻanae Kai FR.
- Work on opportunities for the public to salvage goat carcasses in Lualualei Annex.
- Commitment to draft a Goat Management Plan for the Waiʻanae Mountain Range

This plan is a direct result of these conversations and will help guide ongoing management of goats in the Waiʻanae Mountain Range. Through this planning process, Forestry and Wildlife is committed to continue working with the public on devising strategies to carry out the responsibilities of Forestry and Wildlife and DLNR.

3.2 Analysis of Environmental Sensitivity to Goat Presence

As part of Forestry and Wildlife's goat management plan, a spatial analysis was conducted on the entirety of Forestry and Wildlife-managed lands in the Wai'anae range to determine the potential impacts of goats and the environmental sensitivity to goat presence. This analysis factored in multiple environmental and regulatory factors including: vegetation cover, rare species presence, soil erodibility, slope, infrastructure, and regulatory designations of areas. The output was utilized to identify potential areas where continued goat presence may be acceptable, where goat presence is less or marginally acceptable, and areas where goat presence is not acceptable and goats must be prevented from accessing.

The results of this analysis can be seen below in Figures 3 and 4. Figure 3 shows the "score" of each spatial area, with a lower score meaning it is more environmentally sensitive to goat presence. The output of the spatial analysis was then divided into three categories as shown in Figure 4. Red indicates where the combination of factors (native forest cover, endangered species presence, high-quality watershed, steep slopes, etc.) results in high environmental sensitivity and the presence of goats being unacceptable, and public hunting ranks low. Yellow indicates moderate environmental sensitivity where goat presence is marginally acceptable and/or public hunting opportunities rank medium, and green indicates low environmental sensitivity where goats may potentially be acceptable, and if already present, can remain as a resource and public hunting ranks high. Currently, Forestry and Wildlife has made a management decision to not introduce goats outside their current extent, and therefore, places that may be potentially acceptable but do not currently have goats will remain goat-free.

This information will be used to guide management decisions, but it is not the only factor that will influence decisions. Also, due to the wide range and mobility of goats, it will not be possible to be as targeted as these maps demonstrate. For example, some areas that are less environmentally sensitive may not be intended for long-term goat presence, as they are adjacent to more sensitive resources and it may be impossible to prevent encroachment of the goat population to sensitive areas, and vice versa.

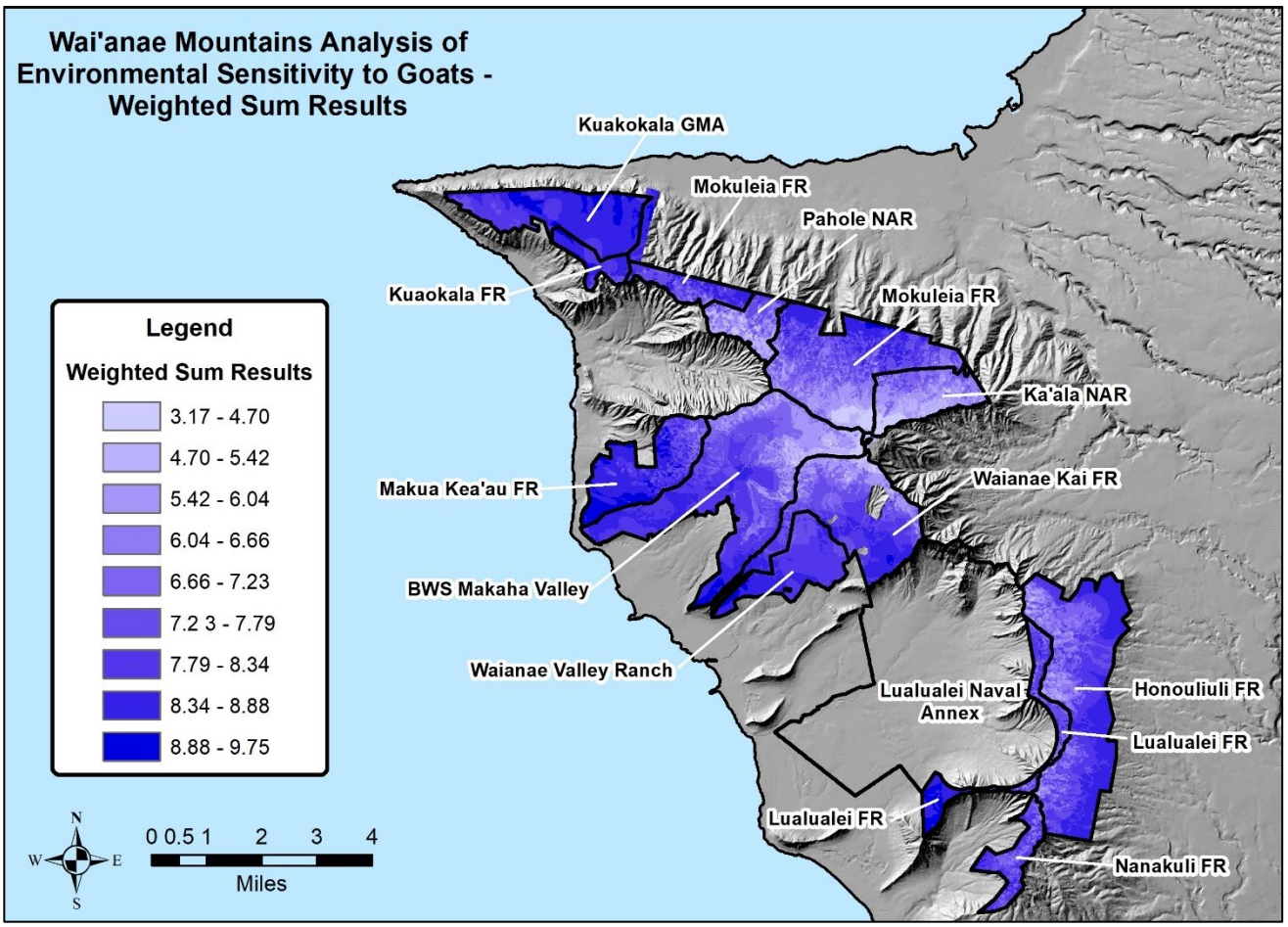

Figure 3. Weighted sum results of the spatial analysis. Note: lower numbers show a higher sensitivity and less suitability to goat presence.

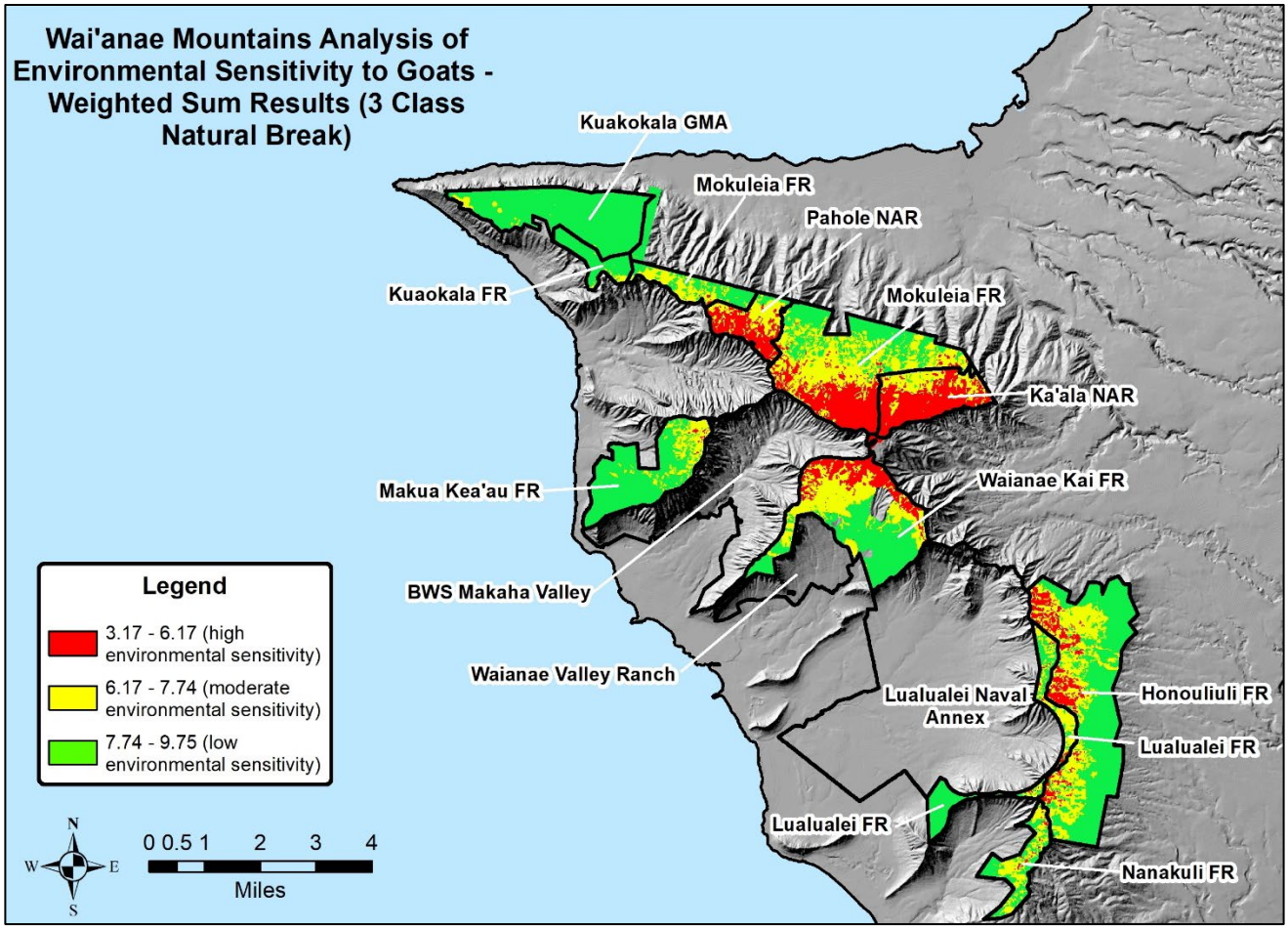

Figure 4. Weighted sum results of the spatial analysis shown in 3 natural class breaks.

3.3 Goat Management Prescriptions by Area

Based on the presence or absence of goats in Figure 2, the analysis of environmental sensitivity shown in Figure 3 and Figure 4, and long-term goals for specific management units, Forestry and Wildlife has created goat control prescriptions for each unit in the Wai‘anae Mountains. The area-by-area assessment resulted in the following management goals map below in Figure 5, with in-depth discussion of goals for below.

One important note: current presence of goats on Forestry and Wildlife-managed lands in the Wai‘anae Mountains is limited to Forest Reserves and Natural Area Reserves (Figure 2). No goats are present in the one Game Management Area. Forestry and Wildlife has made a management decision to not introduce goats outside of their current extent, therefore, any places that do not currently have goats will remain goat-free. There will be no tolerance for incipient goat populations if found in or somehow introduced to these areas, and Forestry and Wildlife will take the required actions to ensure that these populations do not carry on to stabilizing numbers.

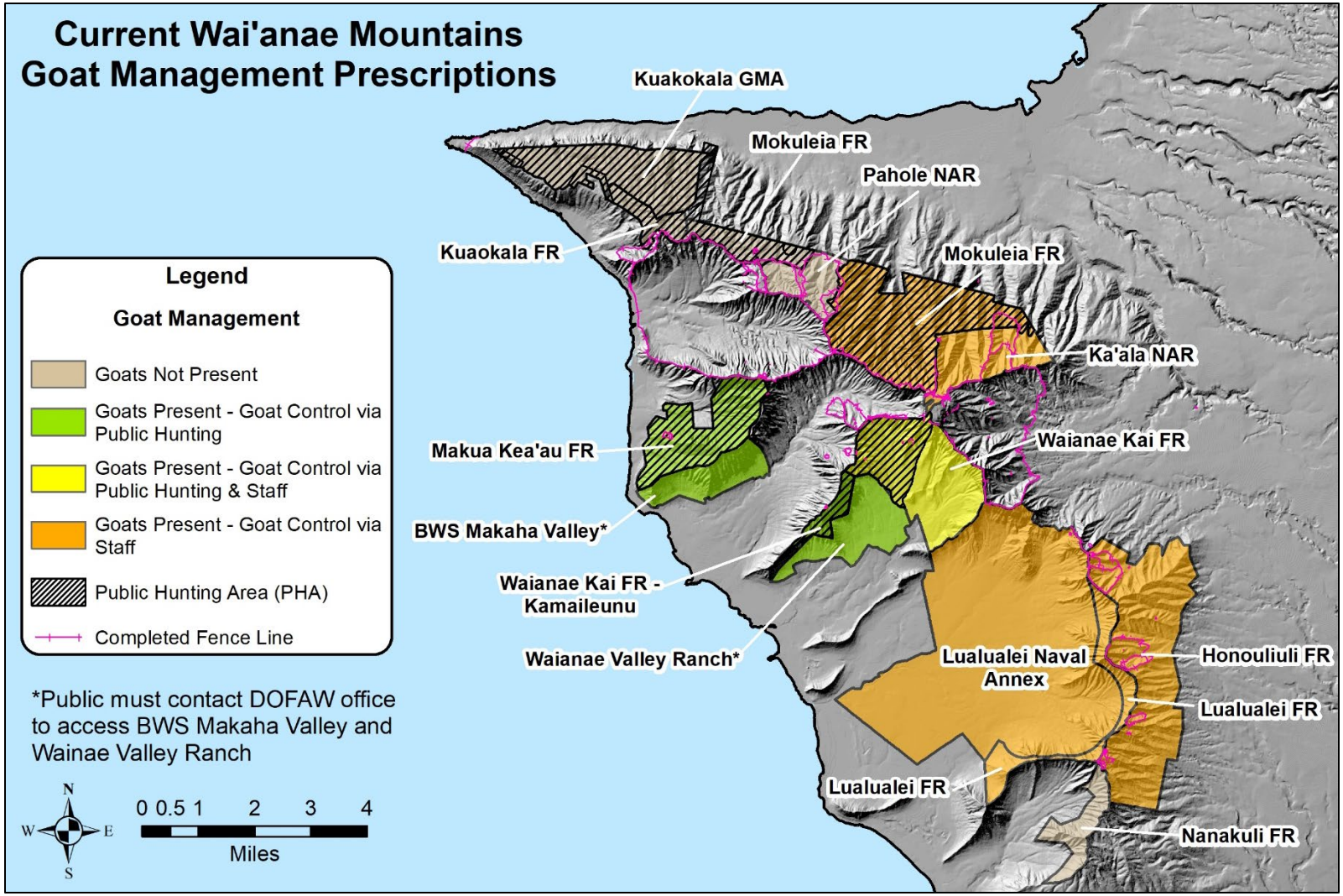

Figure 5. Current Management Prescriptions for DOFAW and Partner Lands in the Wai‘anae Mountain Range. Goat presence will not be tolerated in orange or yellow areas, and staff control will be initiated with a goal of eradicating the population. Similarly, incipient goat populations will not be tolerated in areas where they are not currently present. Goat presence will be tolerated in green areas where public hunting is the primary method of control. Staff control will be initiated in green areas if monitoring indicates significant degradation to vegetation.

Goat Control by Management Units (North to South):

Kuaokalā Game Management Area

There are currently no goats in this area. Incipient goat populations will not be tolerated.

Kuaokalā Forest Reserve

There are currently no goats in this area. Incipient goat populations will not be tolerated.

Mokulēʻia Forest Reserve

There are two separate sections of Mokulēʻia FR. Goats are not present in the western section and incipient populations will not be tolerated.

In the eastern section, upper portions of the forest reserve rank unfavorable for Goat Acceptability. These areas have a high density of rare and native plant species. Lower portions of the FR rank higher for Goat Acceptability. Although this area is open as a PHA, the unit is landlocked, access for the public is difficult, and staff hunting is likely required to protect natural resources from destruction. Existing fences already protect the eastern section of Mokulēʻia FR from the rest of the mountain range (Figure 5). Much of the topography precludes this area for safe public hunting. Goat control has been ongoing for two decades and only small pockets of animals remain, much of which is only accessible via helicopter. Forestry and Wildlife will continue to work to eradicate goats in this area through staff control.

Pahole Natural Area Reserve

Pahole NAR ranks unfavorable for Goat Acceptability. There are extremely high densities of native species and native ecosystems that need to be protected. Currently, the entire Pahole NAR is fence-protected and ungulate-free (Figure 5). Complete ungulate removal activities through staff control have been ongoing for decades. An incipient goat population will not be tolerated in this area as it would conflict with the NAR System's mission of native ecosystem protection and restoration, and it would jeopardize the native ecosystems and threatened and endangered species.

Kaʻala Natural Area Reserve

Kaʻala NAR ranks unfavorable for Goat Acceptability. There are extremely high densities of native species and native ecosystems that need to be protected. Goat removal has been ongoing for two decades.

Existing fences already protect this area from the rest of the range (Figure 5). Eradication of all goats in this area through staff control is the goal. An incipient goat population will not be tolerated in this area as it would conflict with the NAR System's mission of native ecosystem protection and restoration, and it would jeopardize the native ecosystems and threatened and endangered species.

Makua Keaʻau Forest Reserve

Forestry and Wildlife has no plans for staff control of goats in this area and public hunting ranks high. Hunter control of goats will be utilized to manage populations. Specific small restoration sites and/or threatened and endangered species populations will be protected by small fenced units (<5 acres; Figure 5). Vegetation monitoring will be conducted annually using Landsat Normalized Difference Vegetation Index (NDVI). If annual monitoring for 10 years indicates a significant reduction in vegetation, staff

control of goats may be initiated to reduce the goat population while still providing opportunities for hunters.

Makaha Valley (BWS-owned land)

Forestry and Wildlife negotiated with the BWS to develop a hunt by a permit system, administered by Forestry and Wildlife in part of the BWS-managed land. This permit system is currently in place and an archery goat control program is being implemented. Participants are required to apply for a wildlife control permit application, have a valid hunting license, and provide hunter catch data via a newly designed app (OuterSpatial).

Due to this area being under the jurisdiction of BWS, Forestry and Wildlife is unable to expand further opportunities of possible PHA designation. Maintenance of the land license agreement and updates to the control permit hunt will continue to present the opportunity for public hunters. Based on hunter reports from trial periods, the possibility to expand the hunting area or changes to the Wildlife Control Permit would have to be negotiated with BWS. It is Forestry and Wildlife's understanding that BWS's intent in supporting public hunting on their land is for the purpose of controlling the number and extent of feral goats and pigs. BWS does not intend to retain a population of animals on their property for the purpose of hunting opportunities as their mission is to manage their lands for watershed purposes.

Forestry and Wildlife currently has no plans to implement staff control of goats in Makaha Valley. Any increased goat control options outside of public hunting will need to be driven by Honolulu BWS.

Waiʻanae Kai Forest Reserve

Waiʻanae Kai FR is often discussed in two separate sections, the valley sections in the back closer to Mt. Kaʻala summit, also known as the "brain" (yellow section on Figure 5), and the Kamaileʻunu ridge section, or "stem" (green section on Figure 5). Staff control in Waiʻanae Kai FR will be restricted to the brain or mauka section, particularly the extremely steep cliff areas near Mt. Kaʻala where hiker/hunter access is not possible. Staff control will not extend to the Kamaileʻunu stem area. Goat populations in the Kamaileʻunu ridge area will be primarily managed through public hunting. Long-term vegetation monitoring may indicate that public hunting cannot maintain population numbers to an acceptable level (i.e., minimized goat-caused detrimental effect on the forest and ecosystem health), but no staff control will be implemented without further planning and consultation with the hunting community.

In the "brain" or valley section of Waiʻanae Kai FR, staff control will focus on eradicating goats and driving them out of the steep back sections of Waiʻanae Kai FR near the Mt. Kaʻala summit area, where hiker and hunter access is not possible due to the topography. Staff believe a more intense effort, including a combination of pushing, trapping, and aerial shooting would be needed to completely remove goats in the area. Currently, the western portion of the valley section is in a public hunting area and Forestry and Wildlife encourages hunter control of goats in these areas. However, this does not imply that a goat population will be tolerated and sustained for public hunting opportunities; rather, this implies that public hunting will be utilized as a method of control for goat eradication in this area.

The other half of the area is designated as a Restricted Watershed and is not in a public hunting area. However, if hunters are interested in hunting in this area, Forestry and Wildlife is open to issuing special

use permits (SUPs) for hunting access in those areas. Fencing the valley and Restricted Watershed portion has been considered, but due to the extreme topography fencing does not seem practical at this time.

Waiʻanae Valley Ranch

Waiʻanae Valley Ranch is adjacent to the Waiʻanae Kai FR and located on public land leased to ranch managers (Figure 5). Goat management is currently left to the ranch managers, and Forestry and Wildlife does not influence their decisions for managing goat populations. Currently, Forestry and Wildlife is working with ranch managers to permit access to allow hunters to pass through their land to Waiʻanae Kai FR. If hunters are interested in hunting on the ranch, Forestry and Wildlife can coordinate communication with the ranch managers, who will make the decision on whether hunters can hunt on the property by agreement, permit, or both.

Lualualei Annex

The Navy is required to adhere to Federal and Department of Defense (DOD) Regulations when addressing populations of non-native and invasive species, including impacts of feral goats to threatened and endangered species. The Navy safety protocols do not allow the public use of firearms at Lualualei Annex, therefore public hunting is not possible in this area. As public hunting is not an option, the Navy is interested in looking into future partnerships with Forestry and Wildlife to control goats at Lualualei Annex. Where possible, Forestry and Wildlife will pursue public salvage options in coordination with DOD when staff hunts are conducted.

Lualualei Forest Reserve

The Lualualei FR ranked in the mid-range for Goat Acceptability (Figure 3 & 4), but it is adjacent to areas of the Honoʻuliʻuli FR that are unnacceptable for goat presence due to sensitive watersheds and presence of threatened and endangered species. This area is not designated as a PHA and access for the public is non-existent, thus goat populations should be kept to a minimum or eliminated. Negotiations with the Navy to allow public access have not been fruitful. Lualualei Annex is a high-level security installation and the benefit of having the public access the area with firearms does not outweigh the Navy's security risks. Therefore, staff hunting appears to be the only option for control.

Honoʻuliʻuli Forest Reserve

Very few goats are believed to be present in Honoʻuliʻuli FR, maybe as few as 5-10 indiviudals. Upper portions rank low for Goat Acceptability (Figure 3 & 4). These areas have a high density of rare and native species. Lower portions of the FR rank higher for Goat Acceptability; however, there are no populations of goats in the lower sections of the FR.

This area is not designated as a PHA and there is currently no public access; however, Forestry and Wildlife is currently pursuing permitted public access, including hunters. Any remnant goat populations in the upper portions of the FR will be removed by Forestry and Wildlife staff.

Nānākuli Forest Reserve

There are currently no goats in this area. Incipient goat populations will not be tolerated.

3.4 Goat Control Methods

Public Hunting

Public hunting will be the main tool for controlling goat populations in the areas marked in green in Figure 5. Public hunting will most likely not decrease goat populations, but may keep numbers from expanding. Currently, no staff control operations are planned for these areas (Makua Kea‘au FR, the Kamaile‘unu section of Wai‘anae Kai FR). A combination of vegetation monitoring and surveys of goat populations will be used to monitor the pressure goats are putting on these areas. If it appears that goat populations grow to unnacceptable levels, Forestry and Wildlife may find it necessary to implement additional control operations to minimize damage to resources in the area. Control methods will be revisited in 10 years.

Public hunting will also be the main method of control in the PHAs in the yellow section of Wai‘anae Kai FR in Figure 5, except for the sheer cliffs in the back section of the FR. Other Forestry and Wildlife-managed lands not shown as green or yellow on this map may be available to hunters through the issuance of a Special Use Permit (SUP). If a hunter is interested in this, they can contact the O‘ahu Forestry and Wildlife Branch office at (808) 973-9787.

Staff Control

Current staff control operations will be targeted to areas that are mostly inaccessible to the public, such as Lualualei FR, Ka‘ala NAR, and the steep back cliff areas of Wai‘anae Kai FR. Staff has multiple means of control, including snaring/trapping, pushing, ground control, and aerial control. In areas where there are small populations remaining and complete removal is the target, such as Ka‘ala NAR, Mokulē‘ia FR, and Hono‘uli‘uli FR, staff will employ multiple control measures simultaneously to remove goats. In other areas where reduction in populations is the goal, a less robust control effort will be implemented, such as the back of Wai‘anae Kai FR and Lualualei FR.

Aerial control is one method that has proven especially controversial, but is a highly valuable tool for managing goats. This is especially true because Forestry and Wildlife has targeted staff control in hard-to-access areas. Aerial control is the only possible control option in many steep, highly eroded areas that are not safe for ground access. Forestry and Wildlife will maintain the possibility of implementing aerial shooting of goats and will work with the community to salvage meat from these operations where possible and to increase the transparency of operations. Communication between Forestry and Wildlife and the hunting community will be kept open so that Forestry and Wildlife can adjust management (i.e., new hunting accesses) as needed.

If aerial gunning is utilized, the frequency and timing of missions will vary by location. Changes in population size will warrant changes in frequency (i.e., fewer goats will mean fewer missions). A proposal of mission frequency by location is listed in the table below.

Table 5. Sample Five Year Aerial Shoot Plan

Location	Year 1	Year 2	Year 3	Year 4	Year 5
Lualualei/ Mokulēʻia	Bi-annual Missions	Bi-annual Missions	Bi-annual Missions	Bi-annual Missions	Bi-annual Missions
Waiʻanae Kai (mauka cliff areas only)	Bi-annual Missions	Bi-annual Missions	Annual Missions	Annual Missions	As needed

Forestry and Wildlife will continue to receive input from the community and adjust management strategies as appropriate. Collaboration with hunters comes in the form of increased access, increased bag limits, and management strategies that were developed through public input. Forestry and Wildlife will continue to prioritize public hunting as a primary means of goat population control where possible and has adapted current goals in the plan to accomodate hunter needs in the area. Collaboration notes are as follows:

- Forestry and Wildlife will use public hunters to assist in bringing goat populations down by continuing to issue permits for increased bag limits.
- Permits can be issued to areas that are not in the PHA such as the Restricted Watershed Areas of Waiʻanae Kai FR and BWS land in Makaha Valley.
- Forestry and Wildlife will issue salvage permits for goat carcasses resulting from aerial shoot missions.
- Forestry and Wildlife will continue to run the Makaha goat control program for the BWS.
- Public hunting and public salvage of goat carcasses opportunities in Lualualei have been proposed to the Navy.
- Forestry and Wildlife staff will continue working with the Waiʻanae community in an adaptive management approach, focusing on how the community can be more involved with feral goat population control efforts to ensure hunting opportunities, and better support watershed recovery and management.

3.5 Monitoring

The analysis of environmental sensitivity to goat presence (see section 3.2 and Appendix 4), combined with long-term goals of management units, has driven current goat management prescriptions over the next 5-10 years. However, continued monitoring of multiple factors, including vegetation cover, wildfire risk, rare species presence, and goat population numbers, will guide the future management decisions of goats in the Waiʻanae Mountains. The main purpose of goat control is to protect watershed health, therefore monitoring of vegetation cover will be the main driver of management actions. However, monitoring of goat populations in select areas and continued tracking of rare species presence will also guide management actions.

3.5.1 Vegetation Monitoring

Goat presence and browsing negatively impacts vegetation cover, and a higher presence of goats leads to increased grass and bare ground cover and lower tree and shrub cover. Grass and bare ground are worse at capturing and storing water than trees and shrubs, therefore goat presence negatively affects watershed

benefits of an area. Long-term monitoring of vegetation cover will be used to monitor and determine the impact goats are having on watershed health. If vegetation cover appears to be decreasing in an area where goats are present, and it cannot be explained by other factors such as drought or wildfires, then increased goat control measures may be considered.

Vegetation cover will be tracked using normally difference vegetation index (NDVI) analysis, a method to track healthy green vegetation in an area using satellite imagery. This will be used in roughly five-year increments to monitor changes in vegetation over time. If new monitoring techniques, such as improved sattelite imagery, artificial intelligence or machine learning, allow for more accurate and historical monitoring of changes, then monitoring techniques may be revisited.

Other threats, namely wildfire and drought, also threaten watershed health. Therefore, continued monitoring of wildfire trends and climatilogical trends across the mountain range will also be considered when monitoring vegetation. If an area is severely prone to repeat wildfires, goat control may not be as useful to protect watershed benefits that may be impacted by repeated fires, unless goat control is combined with other management actions such as fuel breaks or reforestation.

3.5.2 Goat Population Surveys

As part of its game program and to fulfill federal grant requirements, Forestry and Wildlife conducts aerial surveys to understand game mammal population trends and range distribution in certain areas in the Waiʻanae Mountains. Aerial surveys currently occur at Makua Keaʻau public hunting area (PHA) and Waiʻanae Kai PHA 1-2 times per year. These areas were selected because they are the most active and accessible game mammal units that house feral goat populations. Surveys are meant to assess the size of goat herds, their location, and the habitat characteristics of where they are found. Further information and results of these surveys can be seen in Appendix 1. Surveys will continue at Makua Keaʻau PHA and Waiʻanae Kai PHA, and may be used at other locations that require feral goat monitoring. Other monitoring techniques, such as the use of drone or Forward Looking InfaRed (FLIR) applications may be incorporated into surveys in the future. These surveys will allow managers to interpret patterned movements and population fluctuation to create better management decisions. However, goat population numbers will not be the sole driver of management decisions, as current staff control of goats is focused on decreasing the damage goats cause and not on sustaining long-term populations.

3.6 Planned Management Actions

Table 6. Proposed Management Actions

Project/Action	**Timeframe**	**Estimated Cost**
Continue working on hunter access at Kawiwi Way	TBD	Staff time
Analyze hunter check station data and protocols to measure effectiveness. Forestry and Wildlife will also work with the community and GMAC to promote accurate record-keeping and compliance with the check stations from the public hunters.	Monthly	Staff time
Amend permit to require hunters to report data on permitted activities.	Completed	N/A

Project/Action	Timeframe	Estimated Cost
Amend Hunting Rules to eliminate bag limits for goats in Waiʻanae Kai FR.	TBD	Staff time
Provide new or designate existing hunter access points to the PHA at Kamaileʻunu and permitted Restricted Watershed areas.	Completed	Staff time
Set up permit system to allow designated hunter access into the Makaha Valley Board of Water Supply Watershed Area.	Completed	Staff time
Signage will be inspected and maintained so information is disseminated properly to hunters and other users in the areas. Includes purchase of signs, posts, fasteners, barriers, paint, cement, lumber, etc.	On-going	< $2,000/year
Maintain and inspect Hunter Check Stations. Maintenance includes the purchase of supplies: Lumber, mailboxes, fasteners, sign-in sheets, etc. Repairs and maintenance to equipment, vehicles, and tools.	On-going	< $2,000/year
Program to issue special use permits (SUPs) to non-PHA's, such as the restricted watershed section of Waiʻanae Kai FR, at management discretion. Permits are issued to allow for public recreational hunting opportunities in these areas.	On-going	Staff time
Staff control of goats in select areas as detailed in section 3.3	On-going	TBD
Collaborate with Department of Health to take water quality samples at Kaʻala Farm and Punanaula Spring	After each aerial shoot, or as needed	Staff time
Surveys of the Waiʻanae Kai and Mākua Kea'au PHA to observe feral goat populations. (1-2x year)	Annual aerial surveys	$12K heli time, staff and management costs
Utilize forest health monitoring techniques, such as satellite imagery analysis, wildfire trends, and/or vegetation surveys, to monitor watershed health of Forest Reserves	On-going	TBD
Utilize radio/satellite colored animals to facilitate control and/or track heard movements in response to control.	TBD	TBD

TBD = to be determined

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Appendix 1 Goat Survey Methodology and Data

Population Estimates

Estimate the total area of each respective "sub-strata"; each "sub-strata" represents an individual FR, watershed, and other partnership lands within the Waiʻanae Mountains.

Estimate the total area surveyed along the transect line and within the 500-foot distance marker on both sides of the aircraft.

Calculate the total number of goats based on the number of goats seen multiplied by the percent area surveyed to get an estimate. For example, for a specific valley if Forestry and Wildlife has seen 100 goats and estimates that the ground cover is about 25% not surveyed (75% surveyed) 100 goats seen x 1.33 (add on for the 25% not surveyed) = 133 goats estimated in area.

Compare population estimates in conjunction with harvest data from previous years are to aid in setting visible trends to assist in decisions such as setting bag limits, seasons, and overall management of the game mammals.

Utilization of the video-recorded flight operation can assist with re-counting the animals present during the survey day and comparing numbers to those that were originally recorded through visual observations.

Area of Operation

The survey sites were located at the Waiʻanae Kai Public Hunting Area (PHA) and the Makua Keaʻau PHA (Figure 1). These two locations were chosen due to the previous year's aerial goat surveys sightings in these areas. Each location was divided into four elevation transects at 1400 feet, 1800 feet, 2200 feet, and 2600 feet. Each transect was taken as a different survey and began at the elevation transect of 2600 feet and then descended to 1400 feet.

This image shows the two locations, Wai‘anae Kai PHA and Makua Kea‘au PHA, in which the survey was conducted. Orange circles depicted are the location data points for each herd spotted. The size of the circle corresponds to the individual number of feral goats tallied. The total amount of goats observed on 09/2020 for both areas combined was 252 individuals.

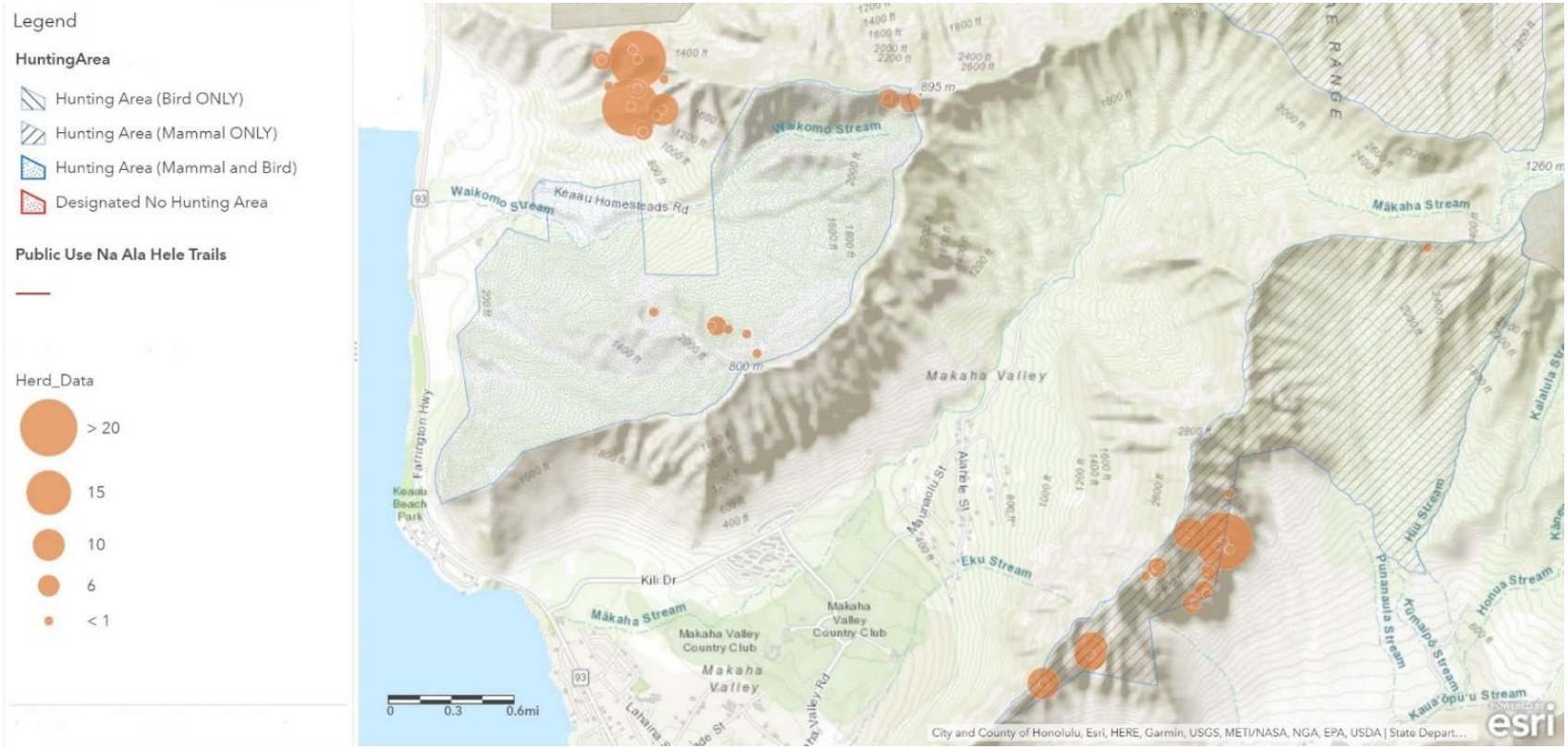


Figure 1. Aerial Goat Survey September 2020.

Wai‘anae Kai Public Hunting Area

The survey site of Wai‘anae Kai Valley began at the northwest back section of the valley at 2,600 feet and then descended to each elevation transect (Figure 2).

This image shows a closeup of the Wai‘anae Kai portion of the 2020 Aerial Goat Survey. Orange circles correspond to the size of the herd that was spotted within the area located and marked. The herd locations can also be compared to the delineation of the Wai‘anae Kai Public Hunting Area. The total amount of goats observed on 09/2020 was 118 individuals.

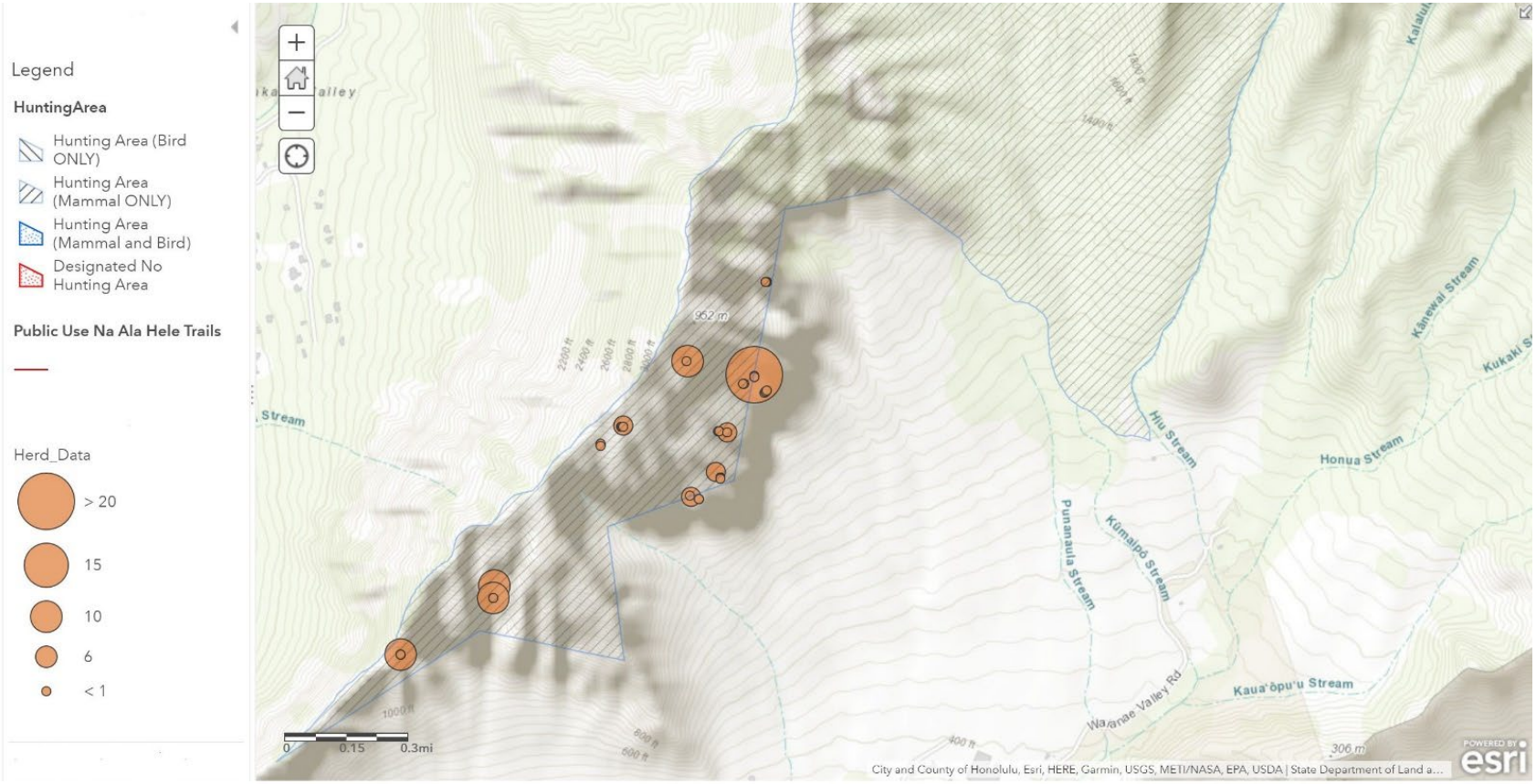


Figure 2. Wai‘anae Kai Aerial Goat Survey 2020.

This image shows a closeup of the Wai‘anae Kai portion of the 2020 Aerial Goat Survey. The heat density map provides a visual aid to where these game mammals were mostly spotted and possible preferred habitat within the hunting unit. The total amount of goats observed on 09/2020 was 118 individuals.

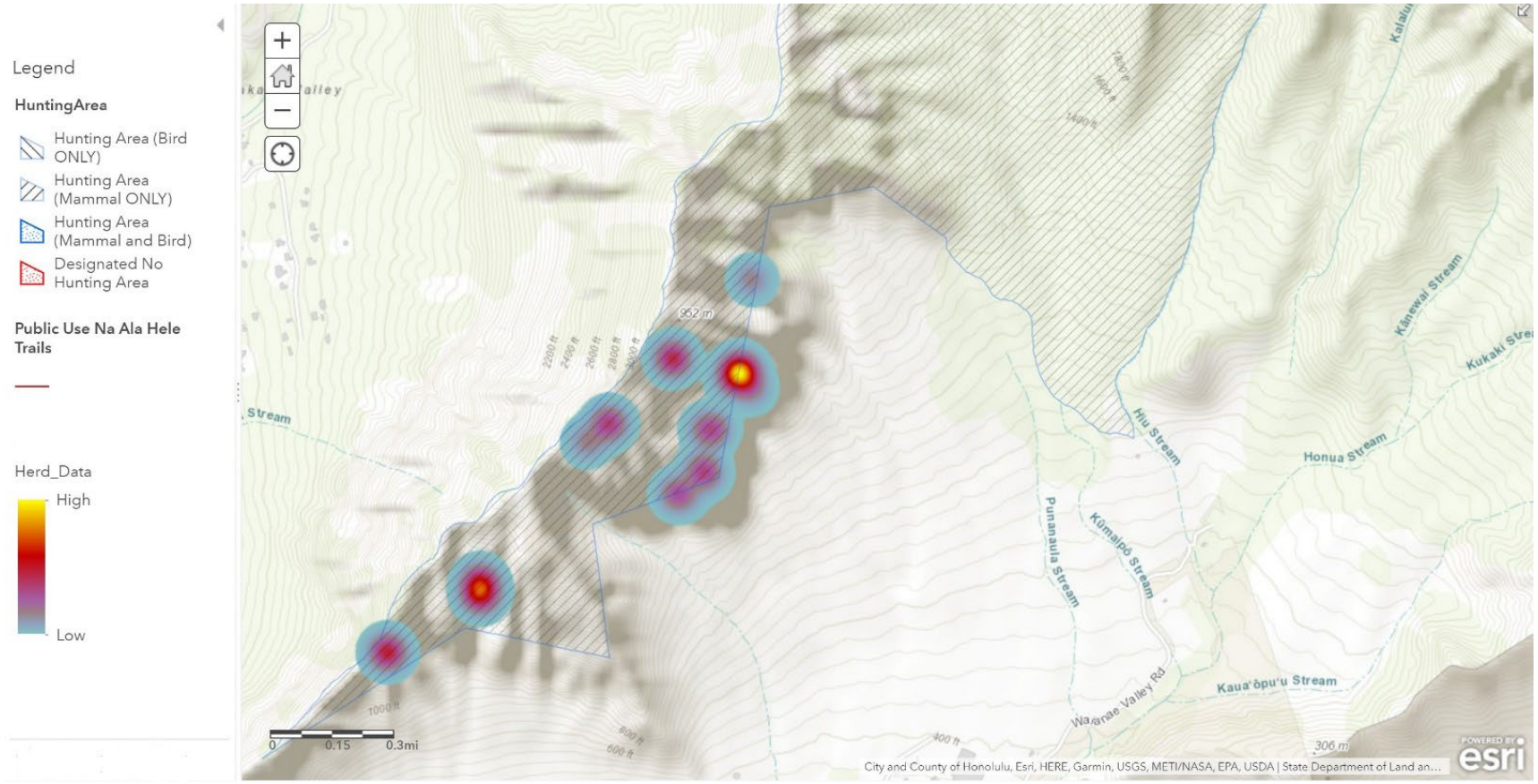


Figure 3. Wai‘anae Kai Aerial Goat Survey 2020.

Makua Kea‘au PHA

The survey site of Makua Kea‘au Valley began on the east side of the valley at 2600 feet and then descended to each elevation transect (Figure 4).

The image shows a close-up of the Makua Kea‘au portion of the 2020 Aerial Goat Survey. Orange circles correspond to the size of the herd that was spotted within the area located and marked. The herd locations can also be compared to the delineation of the Makua Kea‘au Public Hunting Area. The total amount of goats observed on 09/2020 was 134 individuals.

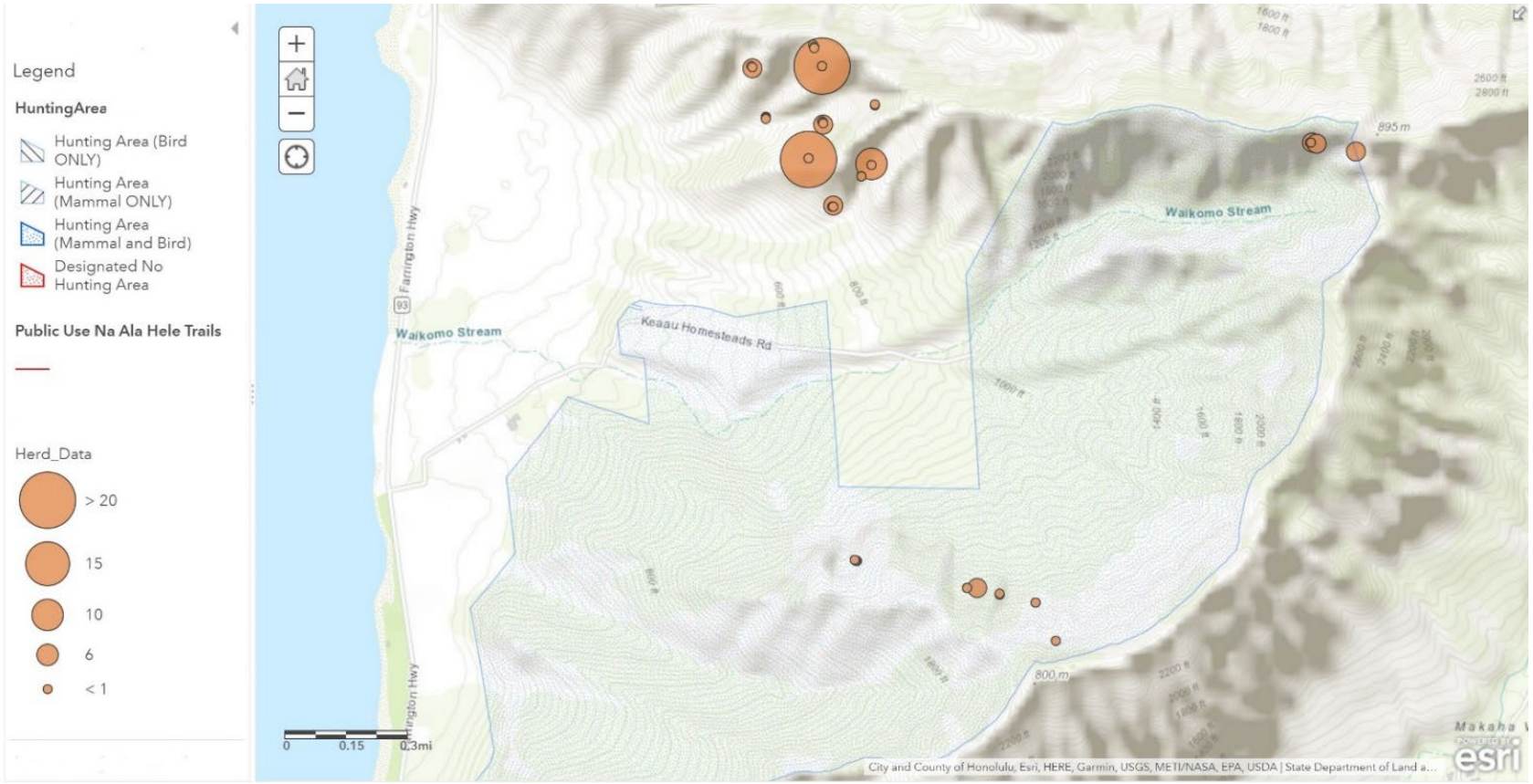


Figure 4. Makua Kea‘au Aerial Goat Survey 2020.

The image shows a close-up of the Makua Kea‘au portion of the 2020 Aerial Goat Survey. Orange circles correspond to the size of the herd that was spotted within the area located and marked. The heat density map provides a visual aid to where these game mammals were mostly spotted and possible preferred habitat within the hunting unit and areas outside of the unit. The total amount of goats observed on 09/2020 was 134 individuals.

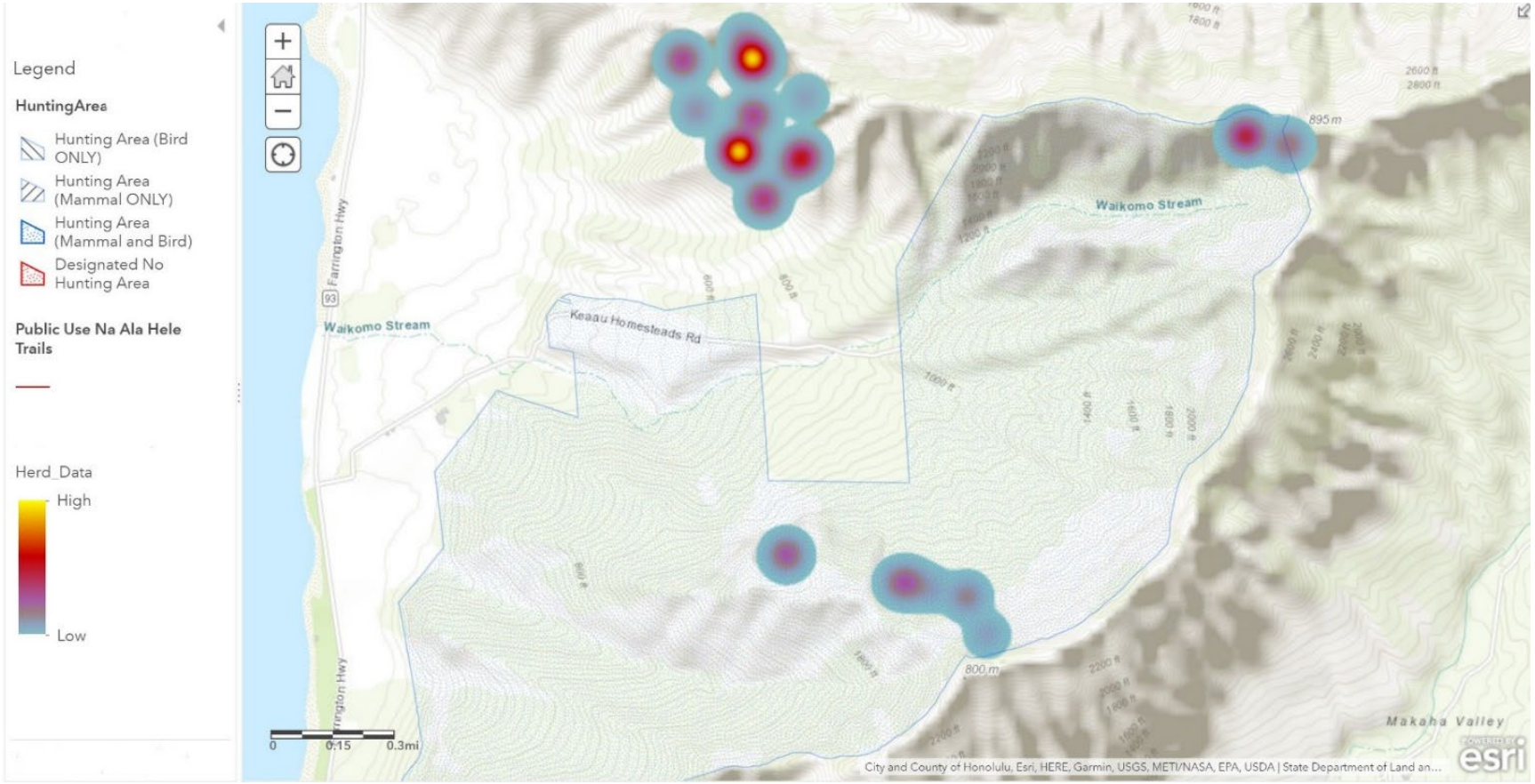


Figure 5. Makua Kea‘au Aerial Goat Survey 2020.

ArcGIS QuickCapture

The aerial goat survey data were collected on an iPad to quickly collect data on ArcGIS QuickCapture. The data collected on QuickCapture consisted of elevation transects, herd data or count habitat characteristics, and landscape characteristics (Figure 11). The survey was first created on the desktop via ArcGIS online to then be used on a handheld device in the future.

This image is a screenshot of the exact QuickCapture format that was used for the data collection.

Figure 6. ArcGIS QuickCapture Aerial Goat Survey 2020.

Elevation Transects

Elevation transects were categorized into four different transects; 1400 feet, 1800 feet, 2200 feet, and 2600 feet. Each transect was taken as a constant tracking line of our location, beginning at approximately the same starting point, and was the separating factor of each goat survey (Figure 6).

Herd Data

Herd data was taken as a point and numerically categorized into 1, 5, 10, 20, 50, and 100. This method was chosen to be a fast-paced way of inputting numerical data by using each button to add up to the herd count collected (Figure 6).

Habitat Characteristics

Habitat characteristics were taken as a point and categorized into the ridge, cliff, cave, tree cover, forest, and waterfall (Figure 6).

Landscape Characteristics

Landscape characteristics were taken as a point and were categorized into rocks/boulders, exposed soil, grass-short, grass-medium, grass-tall, native shrub-land, non-native shrub-land, native forest, and non-native forest (Figure 6).

Survey Procedure

Surveys began at each elevation transect roughly around the same area. For the Waiʻanae Kai PHA, the survey began on the East side of the ridge and continued counterclockwise (Figure 6). As for the Makua Keaʻau PHA, the survey began on the West point of the ridge and worked counterclockwise while including the Ohikilolo Valley (Figure 7). Each elevation transect was a separate survey taken; at each location, there were four surveys taken. During each survey, once a single goat or a herd was observed the total count was taken along with the habitat and landscape where it was identified. Throughout the entirety of the survey pictures and videos were being captured to ensure the data was correct.

This image shows the boundary of the Wai‘anae Kai PHA on the west side of O‘ahu.

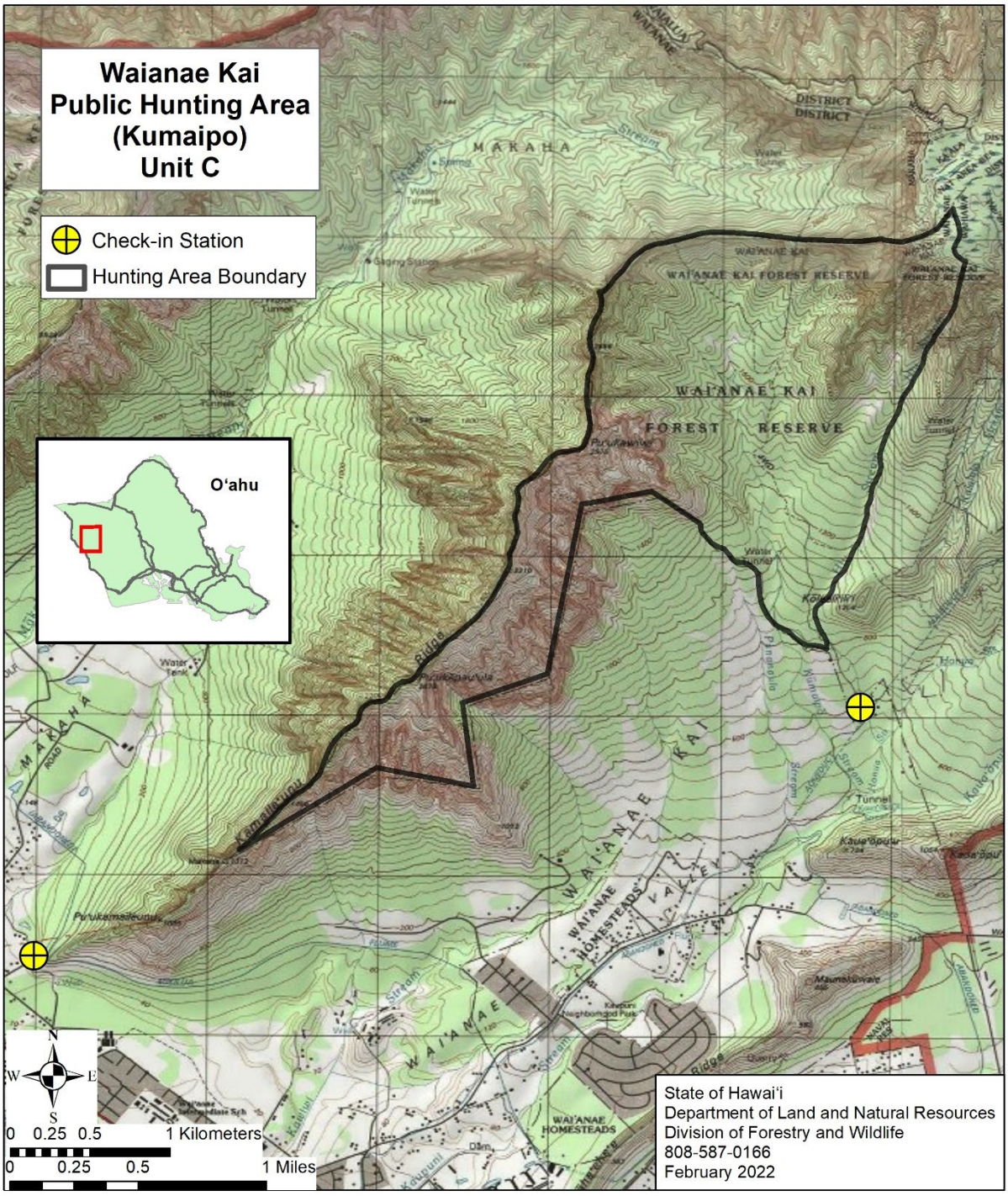


Figure 7. Wai‘anae Kai PHA Unit C.

This image shows the boundary of the Makua Kea‘au PHA on the west side of O‘ahu.

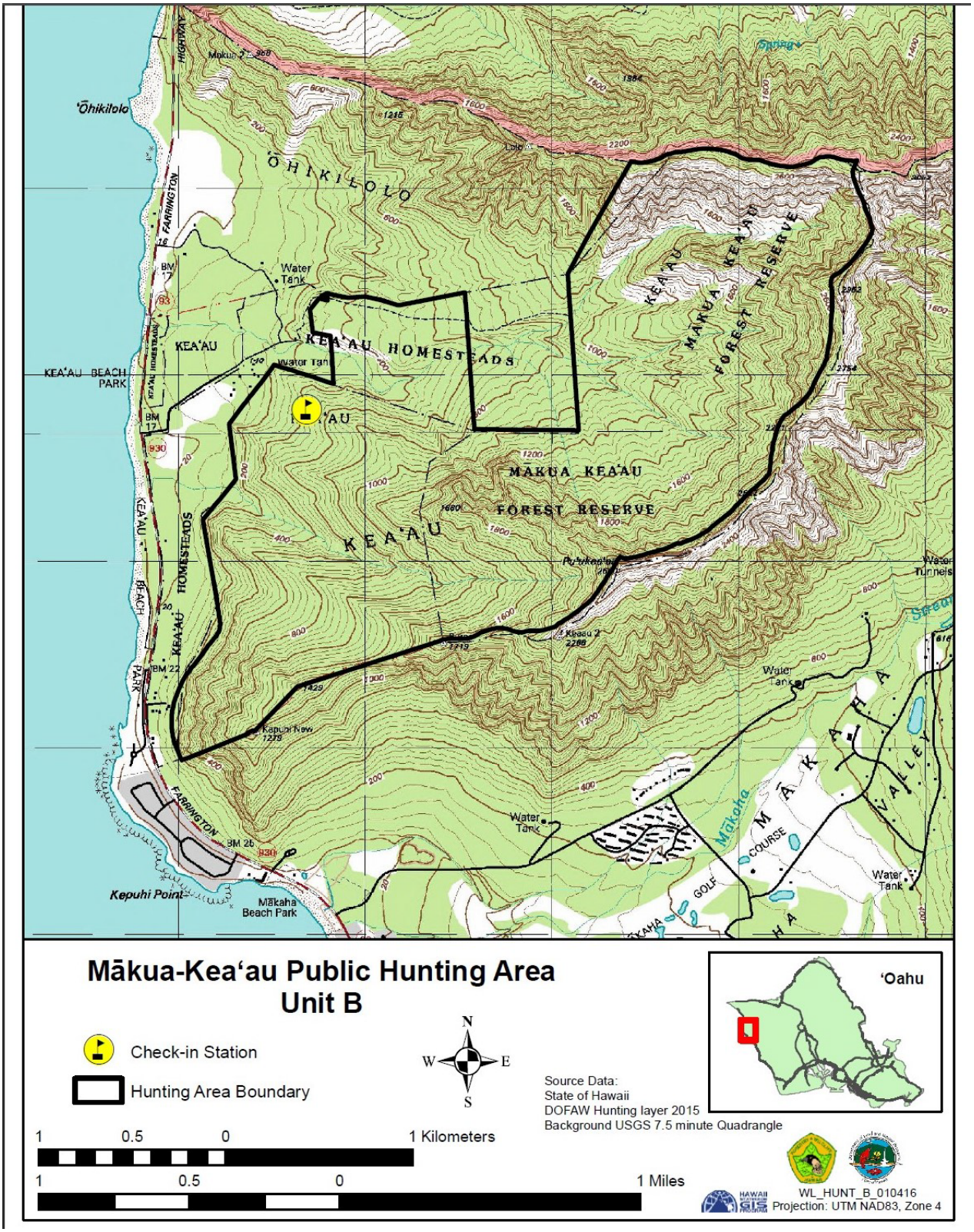


Figure 8. Makua Kea‘au PHA Unit B.

Survey Personnel Roles

The data recorder is the role in which the person is in charge of inputting data via QuickCapture. The other role consists of counting alongside the data recorder to ensure the total count was correct. The same role is in charge of capturing pictures and videos for future confirmation. During the survey, while in the helicopter, the data recorder is located behind the photo and video recorder. This positioning is so the pilot may position the aircraft in a way that both roles can observe and collect the same data.

Aerial Survey Counts Completed

Table 1. Summary of goat counts from WMWP aerial surveys

Location	February 9, 2017	November 9, 2017	October 18, 2018
Makua Keaʻau FR	n/a	30	5
Makaha	n/a	145	260
Waiʻanae Kai FR	31	53	120
Lualualei FR	21		
Nānākuli/Honoʻuliʻuli FR	0	0	0

Table 2. Waiʻanae Kai PHA Aerial Survey

Elevation Transect (Feet)	# of Goats (01/22/19)	# of Goats (09/29/20)
2600	36	25
2200	14	42
1800	19	39
1400	6	12
Total Observed	75	118

Table 3. Makua Keaʻau PHA Aerial Survey

Elevation Transect (Feet)	# of Goats (01/22/19)	# of Goats (09/29/20)
2600	87	17
2200	34	2
1800	41	17
1400	9	98
Total Observed	171	134

Total Number of Goats Observed for the entire operation of 09/29/20 aerial survey: 252 goats.

Total Number of Goats Observed for the entire operation of the 01/22/19 aerial survey: 245 goats.

Appendix 2 Hunter Check-In Data

Table 1. Kuaokalā GMA Check Station Data for all Game

	Boar	Sow	Total Pigs	Billy	Nanny	Total Goats	Total Ungulates	Total Hunters	Hunter Success Rate
2020-2021	2	4	6	1	0	1	7	122	0.06
2019-2020	4	7	11	0	0	0	11	107	0.10
2018-2019	7	5	12	0	0	0	12	127	0.09
2017-2018	13	7	20	0	0	0	20	279	0.07
2016-2017	0	0	0	0	0	0	0	39	0.00
2015-2016	9	4	13	1	1	2	15	258	0.06
2014-2015	1	0	1	0	0	0	1	191	0.01
2013-2014	0	0	0	0	0	0	0	0	0.00
2012-2013	0	0	0	0	0	0	0	0	0.00
2011-2012	0	0	0	0	0	0	0	0	0.00

Table 2. Makua Kea‘au PHA Check Station Data for all Game

	Boar	Sow	Total Pigs	Billy	Nanny	Total Goats	Total Ungulates	Total Hunters	Hunter Success Rate
2020-2021	7	1	8	45	19	64	72	388	0.19
2019-2020	5	9	14	36	23	59	73	298	0.24
2018-2019	1	1	2	41	20	61	63	283	0.22
2017-2018	3	3	6	34	15	49	55	282	0.20
2016-2017	1	1	2	47	25	72	74	361	0.20
2015-2016	11	4	15	53	39	92	107	533	0.20

2014-2015	1	0	1	37	29	66	67	252	0.27
2013-2014	0	0	0	0	0	0	0	0	0.00
2012-2013	0	0	0	0	0	0	0	0	0.00
2011-2012	0	0	0	0	0	0	0	0	0.00

Table 3. Waiʻanae Kai PHA Check Station Data for all Game

	Boar	Sow	Total Pigs	Billy	Nanny	Total Goats	Total Ungulates	Total Hunters	Hunter Success Rate
2020-2021	4	2	6	4	1	5	28	162	0.17
2019-2020	16	5	21	11	2	13	34	239	0.14
2018-2019	36	22	58	5	3	8	66	192	0.34
2017-2018	8	10	18	8	13	21	39	189	0.21
2016-2017	7	3	10	12	10	22	32	113	0.28
2015-2016	4	0	4	3	3	6	10	63	0.16
2014-2015	0	1	1	0	0	0	1	92	0.01
2013-2014	4	2	6	0	0	0	6	36	0.17
2012-2013	11	6	17	5	7	12	29	47	0.62
2011-2012	0	0	0	0	0	0	0	0	0.00

Table 4. Kamaileʻunu Access Check Station Data for all Game

	Boar	Sow	Total Pigs	Billy	Nanny	Total Goats	Total Ungulates	Total Hunters	Hunter Success Rate
2020-2021	0	0	0	30	23	53	53	88	0.60
2019-2020	6	9	15	68	69	137	152	116	1.31
2018-2019	10	11	21	62	66	128	149	91	1.64

Appendix 3 Goat Impact on Native Plant Studies

This exclosure classically illustrates the newfound ungulate control understanding of the early 1970s: 1) goats did not jump 4’ hog wire fences, even when malnourished and highly palatable plants visibly grew inside, and 2) rare native Hawaiian plants, safe from ungulates, sprouted and flourished inside the fence. Outside the fence, all were alien plants, browsed to the rootstalk.2

Figure 1. The Kukalauula Study Exclosure.

Figure 2. Makua, Oʻahu. Note: Goats present on right side of fenceline, not present on left side. Notice bare soil and lack of cover on right side

Figure 3. Goats present on cliffs unsafe for access on foot by public or staff ground control in Waiʻanae Kai FR, Oʻahu

Soil Erosion Examples

Figure 4. Makua, O‘ahu. Goats present on right side of fence, not present on left side. Notice erosion and lack of ground cover on right side.

Figure 5. Ohikilolo, O‘ahu.

Figure 6. Severe erosion on south slopes of Moloka‘i where goats are present.

Kawela Study Goat Removal & Revegetation

In the Kawela area, goat removal occured and changes in vegetation was tracked over time. The figures below show that vegetation cover increased, and erosion also decreased 10-fold from 6+ tons per year in the ocean (2007) to <2 tons per year (2013).

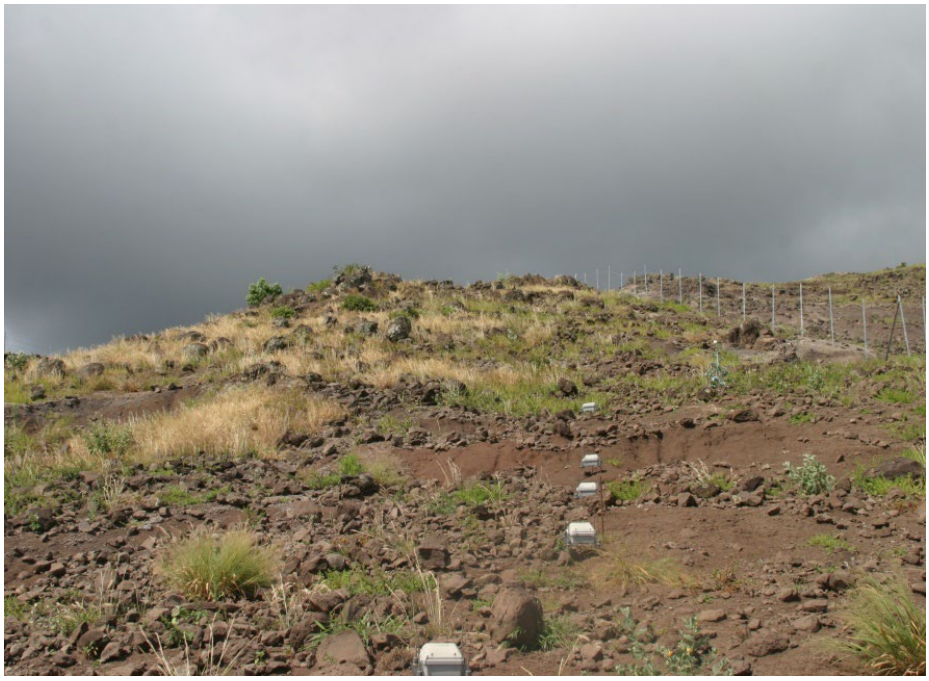


Figure 7. Kawela Fenced Goats Present – 2007 (1% ground cover)

Figure 8. Kawela Fenced Post Goat Removal –2014 (55% ground cover)

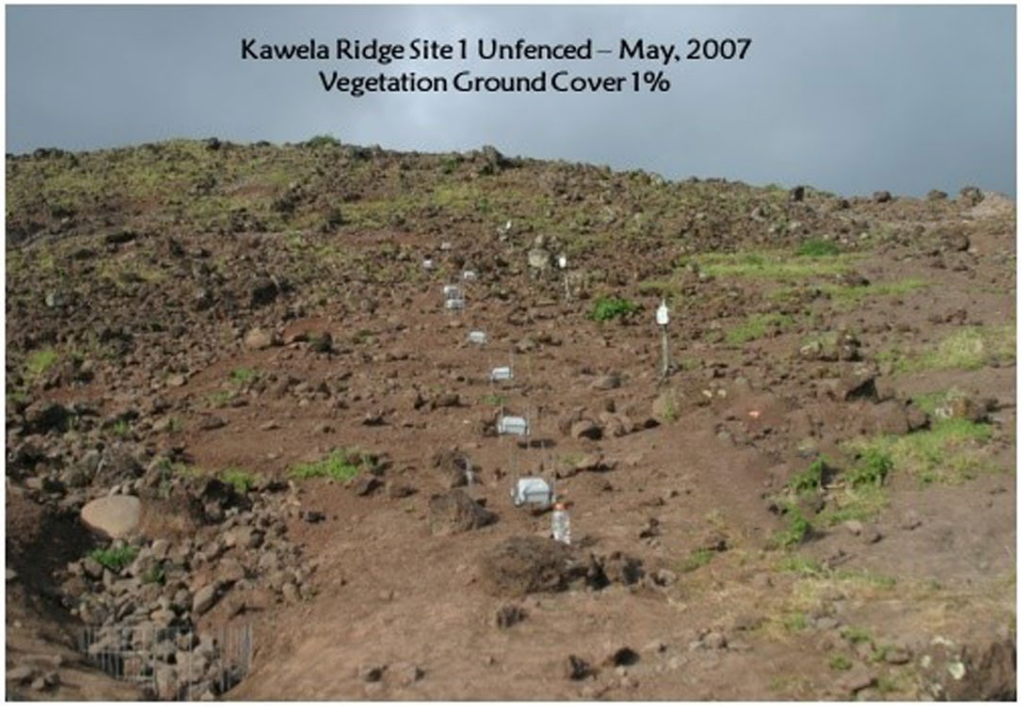


Figure 9. Kawela Unfenced Goats Present – 2007 (1% ground cover)

Figure 10. Kawela Unfenced Post Goat Removal –2014 (75% ground cover)

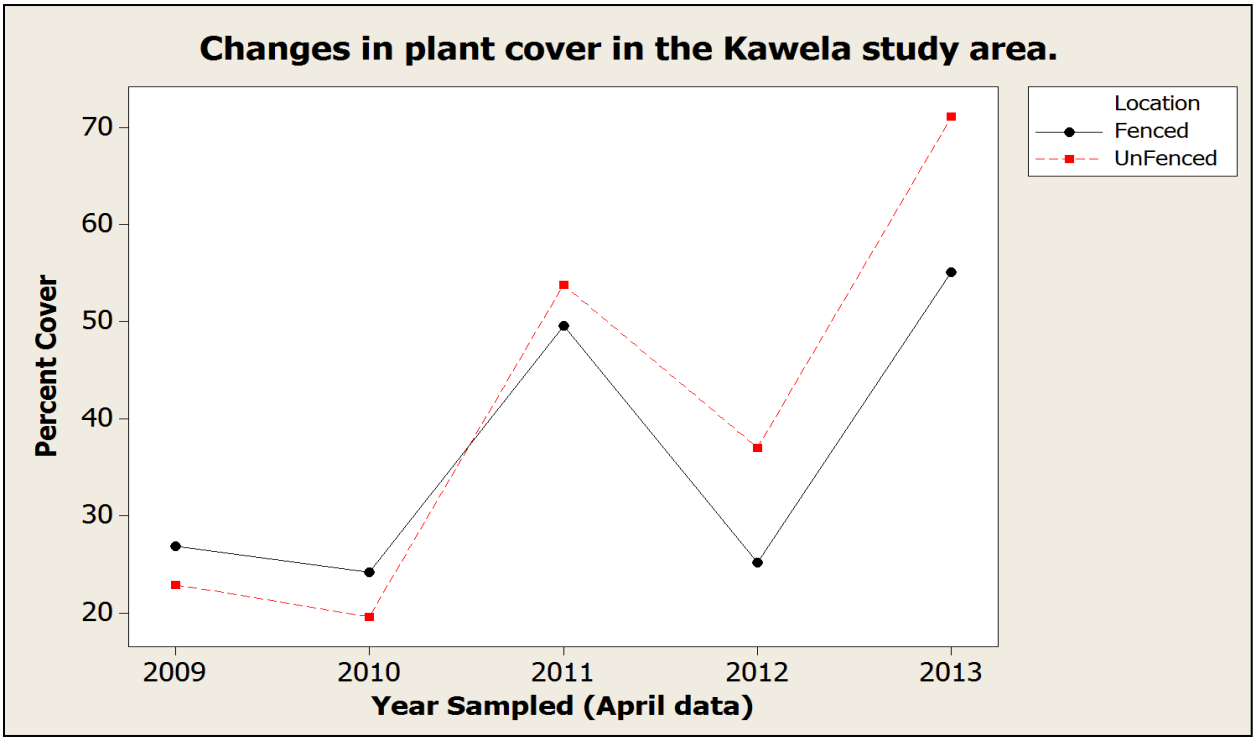


Figure 11. Changes in plant cover in the Kawela study area

Appendix 4. Spatial Analysis of Environmental Sensitivity to Goat Presence

1. Purpose of the analysis

The purpose of this analysis is to identify which determine which areas may be more environmentally sensitive to the presence of goats by considering multiple environmental and regulatory factors.

2. Analysis Area

The analysis area includes: Kuaokalā GMA, Kuaokalā FR, Mokulē‘ia FR, Pahole NAR, Ka‘ala NAR, Makua Kea‘au FR, Wai‘anae Kai FR, Hono‘uli‘uli FR, Lualualei FR, and Nānākuli FR.

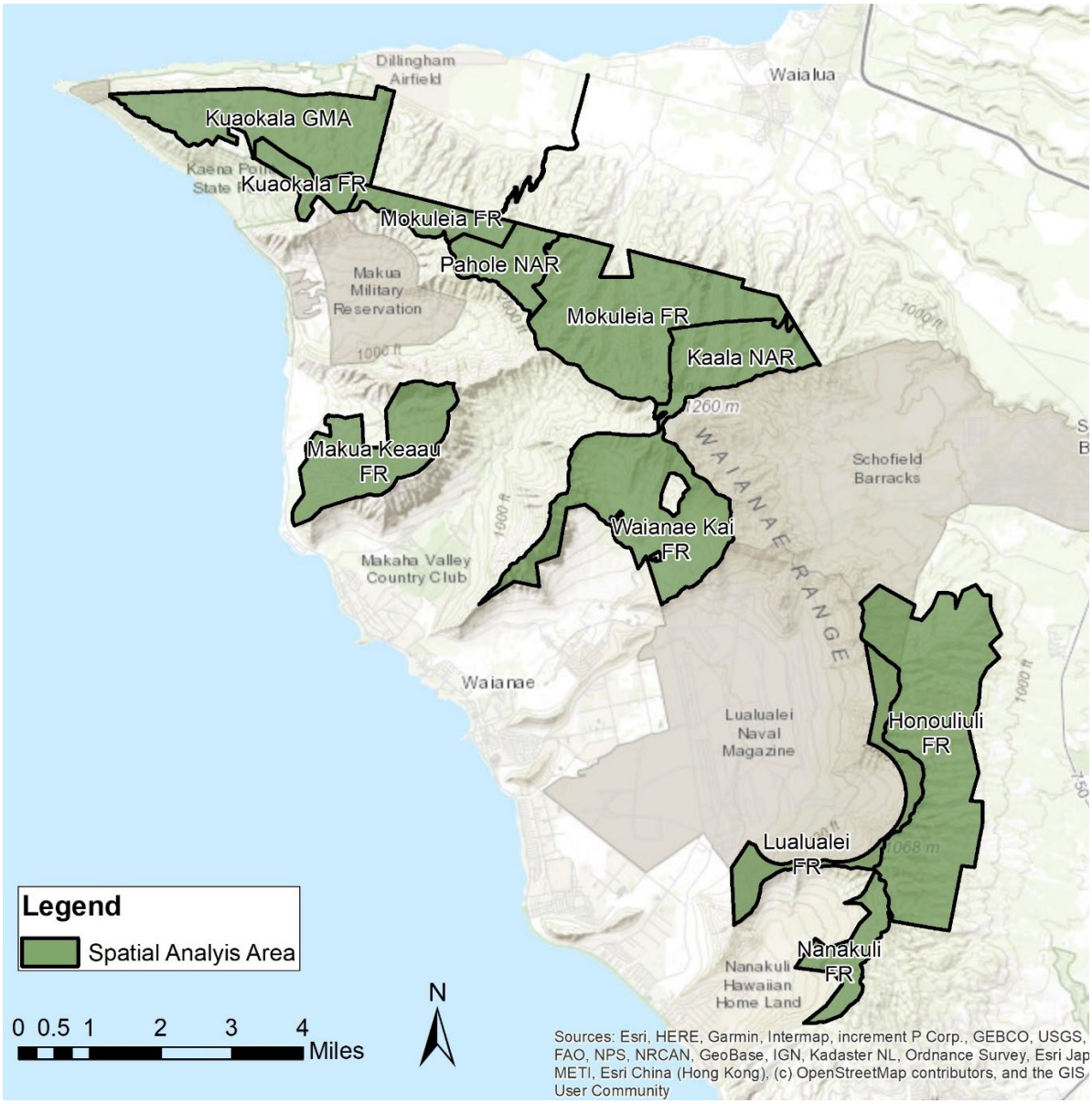


Figure 23. Spatial Analysis Area

3. Environmental Sensitivity Criteria

Nine different environmental and regulatory categories were factored into the analysis. For each category, criteria were established for areas that are potentially more environmentally sensitive to goat presence versus areas that are potentially less environmentally sensitive to goat presence, based on the potential impacts of goats.

Category	Criteria	
	Less Environmentally Sensitive	More Environmentally Sensitive
1. Landcover	Non-native vegetation	Native vegetation
2. Groundwater recharge	Low groundwater recharge	High groundwater recharge
3. Distance from rare species	Far distance from rare species	Near rare species
4. Soil erodibility	Low soil erodibility	High soil erodibility
5. Distance from fenced areas	Outside of fenced areas	Within fenced areas
6. Distance from water infrastructure	At least 1000 feet away from water infrastructure	Within 1000 feet from water infrastructure
7. Slope	Low percent slope	High percent slope
8. Critical habitat designation	Areas not designated critical habitat	Areas designated critical habitat
9. Board of Water Supply priority watershed designation	Areas not designated as priority watershed by the Board of Water Supply	Areas designated as priority watershed by the Board of Water Supply

4. Datasets and Reclassification

Based on the categories listed above, nine datasets were used for the spatial analysis. Each dataset was reclassified and assigned values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence.

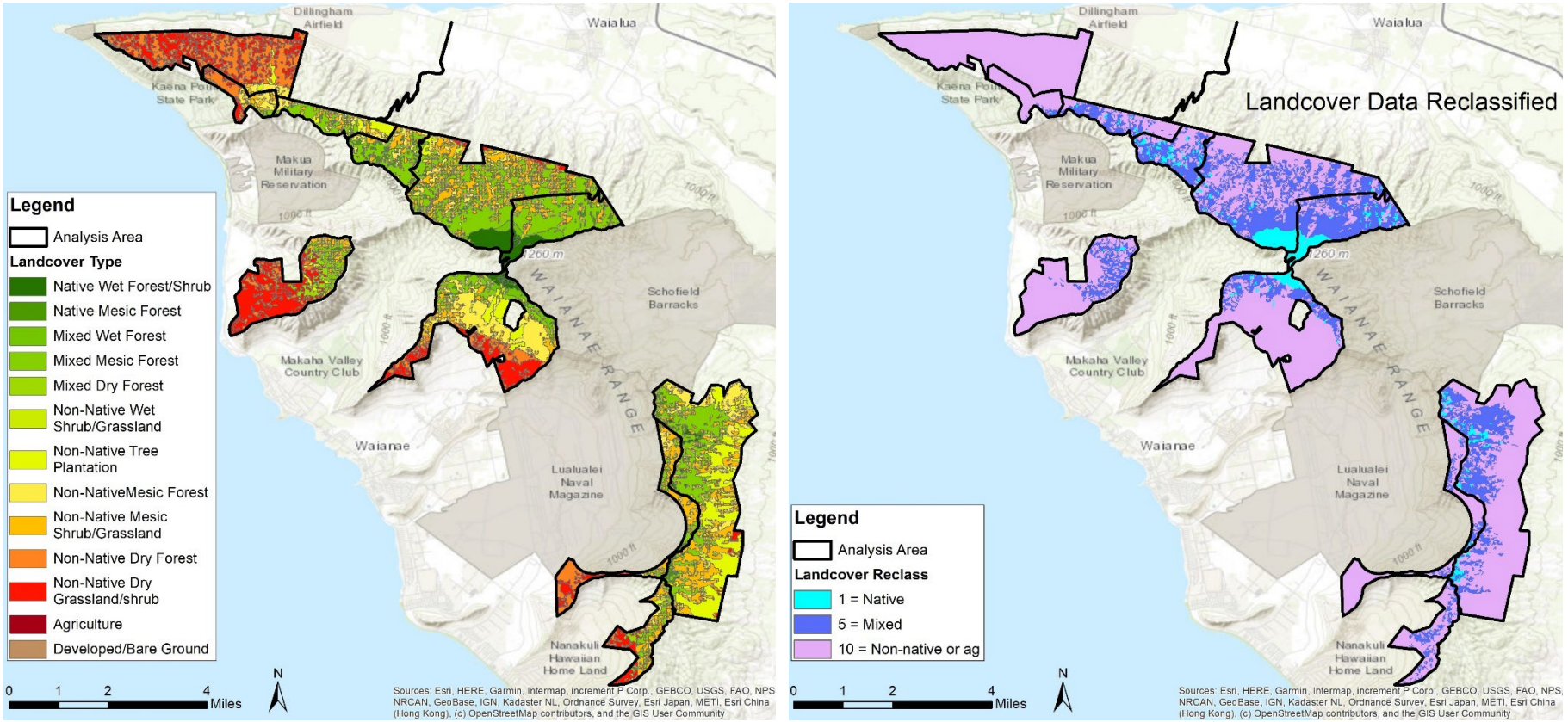


Figure 24. Spatial Analysis – Land Cover (Dataset source: Carbon Assessment of Hawai‘i Land Cover - Biome Unit)

The map on the left shows 13 distinct landcover types ranging from native wet forest/shrub to developed/bare ground. The landcover types were reclassified into three groups: native vegetation, mixed vegetation, and non-native vegetation or agriculture. These three groups were then assigned values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. The map on the right shows the three groups and their assigned values. Native vegetation (light blue) was assigned a 1 because it is more environmentally sensitive to goat presence than non-native vegetation (purple) or agriculture which scored a 10. Native vegetation was determined to be more sensitive to the presence of goats because goats can impact vegetation through browsing/grazing, trampling roots and seedlings, stripping tree bark, and altering plant communities by spreading non-native plant species.

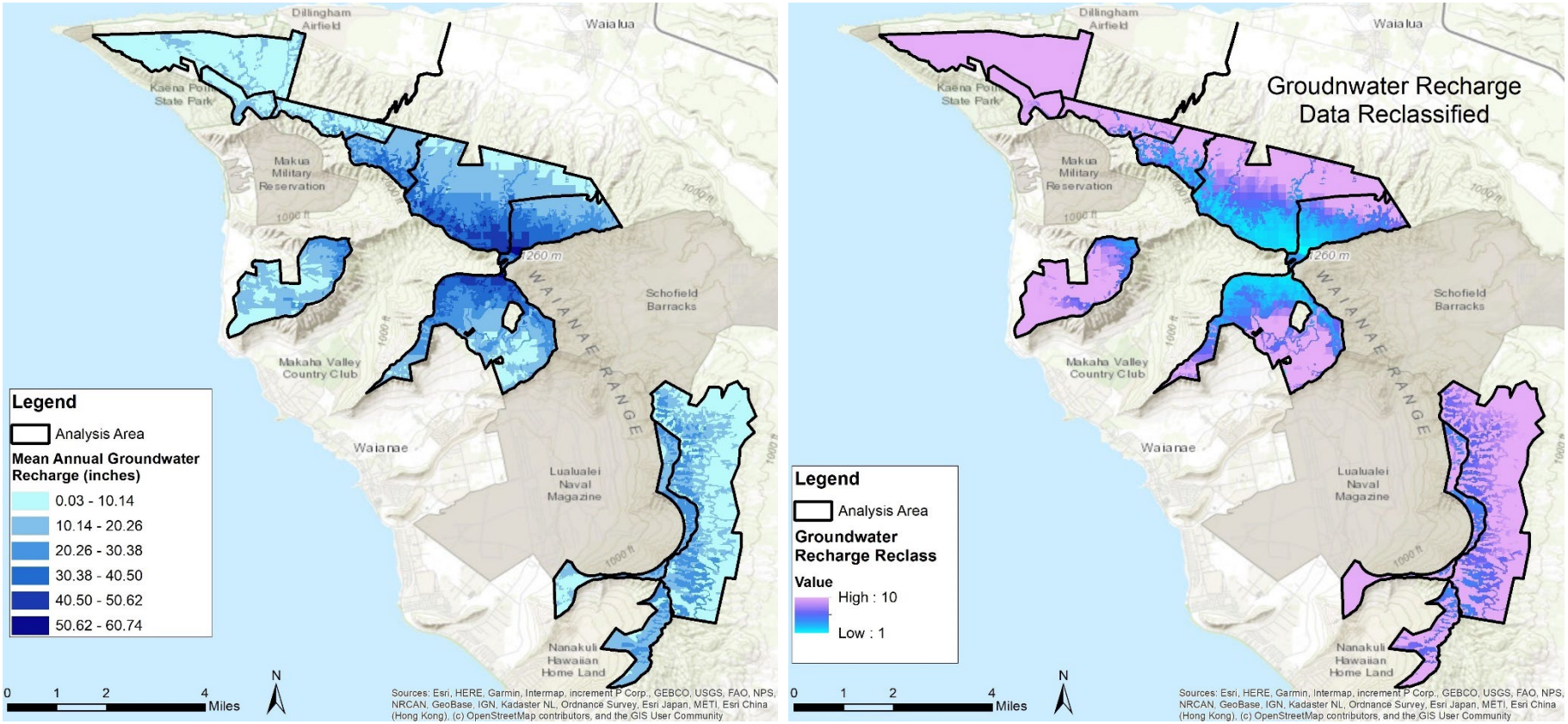


Figure 25. Spatial Analysis – Groundwater Recharge (Dateset source: 2015 United States Geological Survey Investigations Report)

The map on the left shows groundwater recharge data as mean annual recharge in inches. The recharge data was reclassified and given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. Areas where annual recharge is high were assigned lower scores because they are more environmentally sensitive to goat presence (light blue). Goats can impair watershed function by decreasing tree cover. Areas where annual recharge is low were scored higher because they are less environmentally sensitive to goat presence (purple).

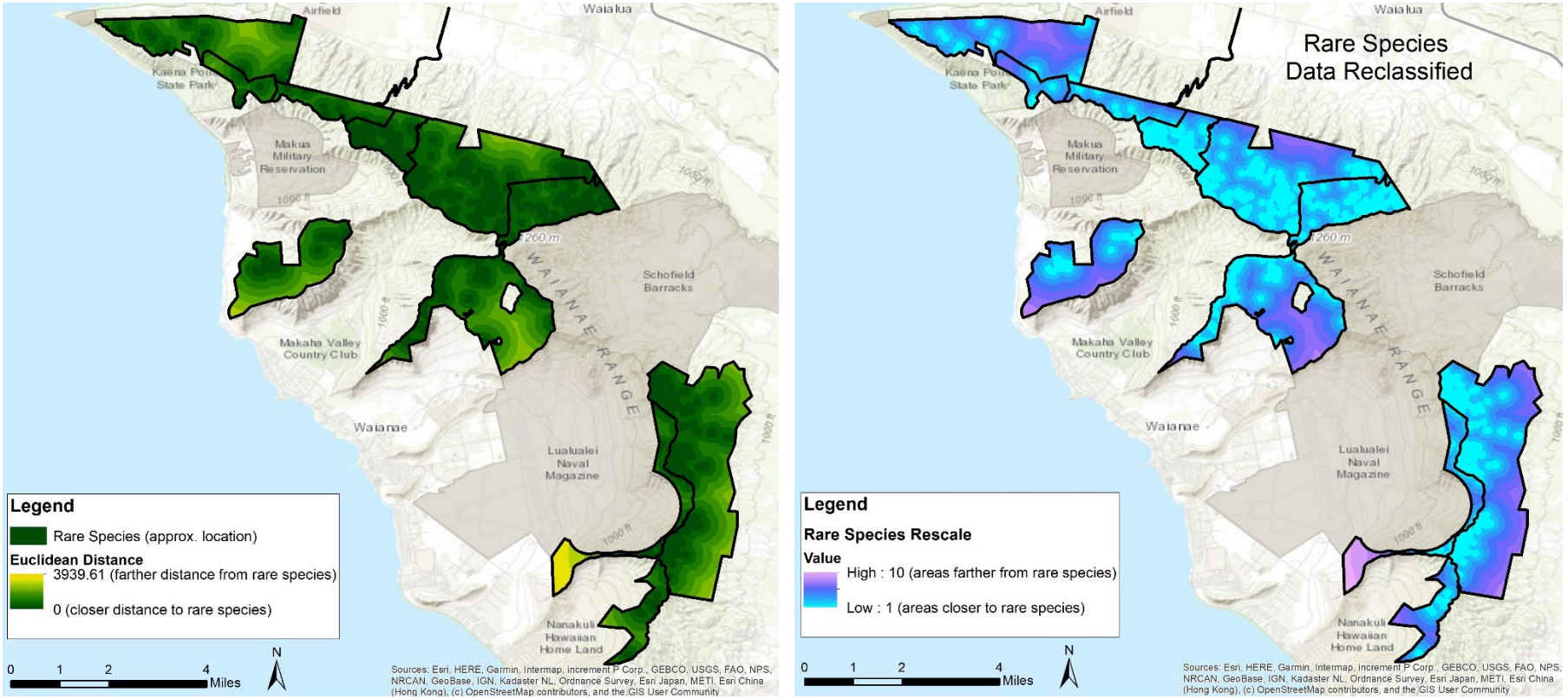


Figure 26. Spatial Analysis – Rare Species Dateset sources: Hawai‘i Biodiversity Mapping Program (2008), Army Natural Resources Program O‘ahu, US Fish and Wildlife Service, and Forestry and Wildlife

To avoid disclosing exact species locations, the approximate location of rare species is displayed on the map on the left. The euclidean distance (measured distance from every pixel to the nearest rare species) is displayed in green (closer to rare species) and yellow (farther from rare species). The euclidean distance was reclassified and given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence, and 10 being less environmentally sensitive to goat presence. Areas farther away from rare species are less environmentally sensitive to goat presence (purple), compared to areas that are closer to rare species (blue). Areas closer to rare species are more environmentally sensitive to goat presence because goats can negatively impact rare species through browsing, trampling, and altering plant communities by spreading non-native plant species.

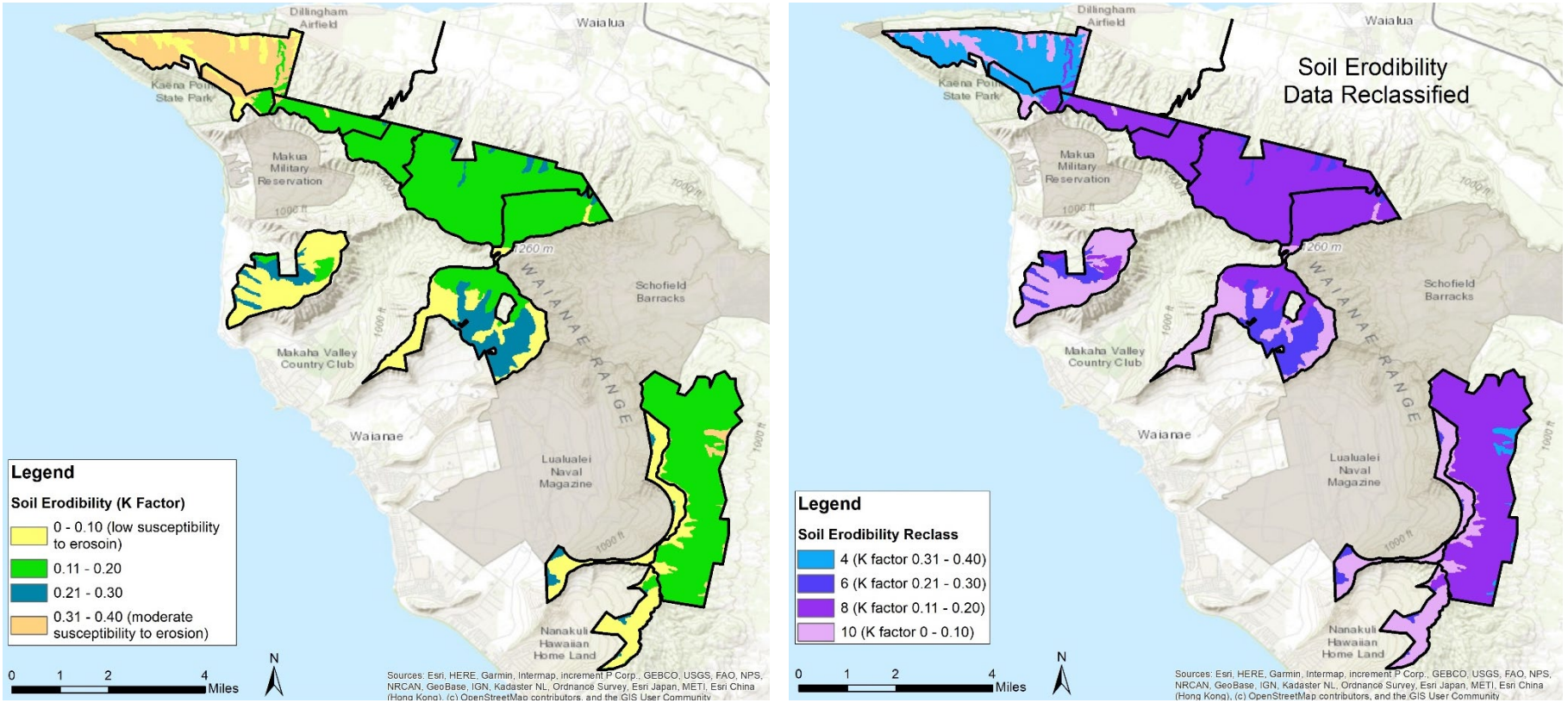


Figure 27. Spatial Analysis – Soil Dateset source: United States Natural Resources Conservation Service

The map on the left shows the soil erodibility factor, or K factor, which quantifies the susceptibility of soil particles to detachment and movement by water. A low K factor of 0.1 indicates less susceptibility to soil erosion, while a K factor of 0.4 indicates moderate susceptibility to soil erosion. The soil erodibility data was reclassified and given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. Areas where soil erodibility is moderate (K factor of 0.31-0.4) were assigned moderate scores because they are more environmentally sensitive to goat presence (blue). Areas where soil erodibility is low (K factor of 0.1-0.10) were scored higher because they are less environmentally sensitive to goat presence (purple). Goats have the potential to accelerate soil erosion in areas that are more susceptible to erosion by exposing soils through browsing/grazing, creating trails, and destabilizing substrate.

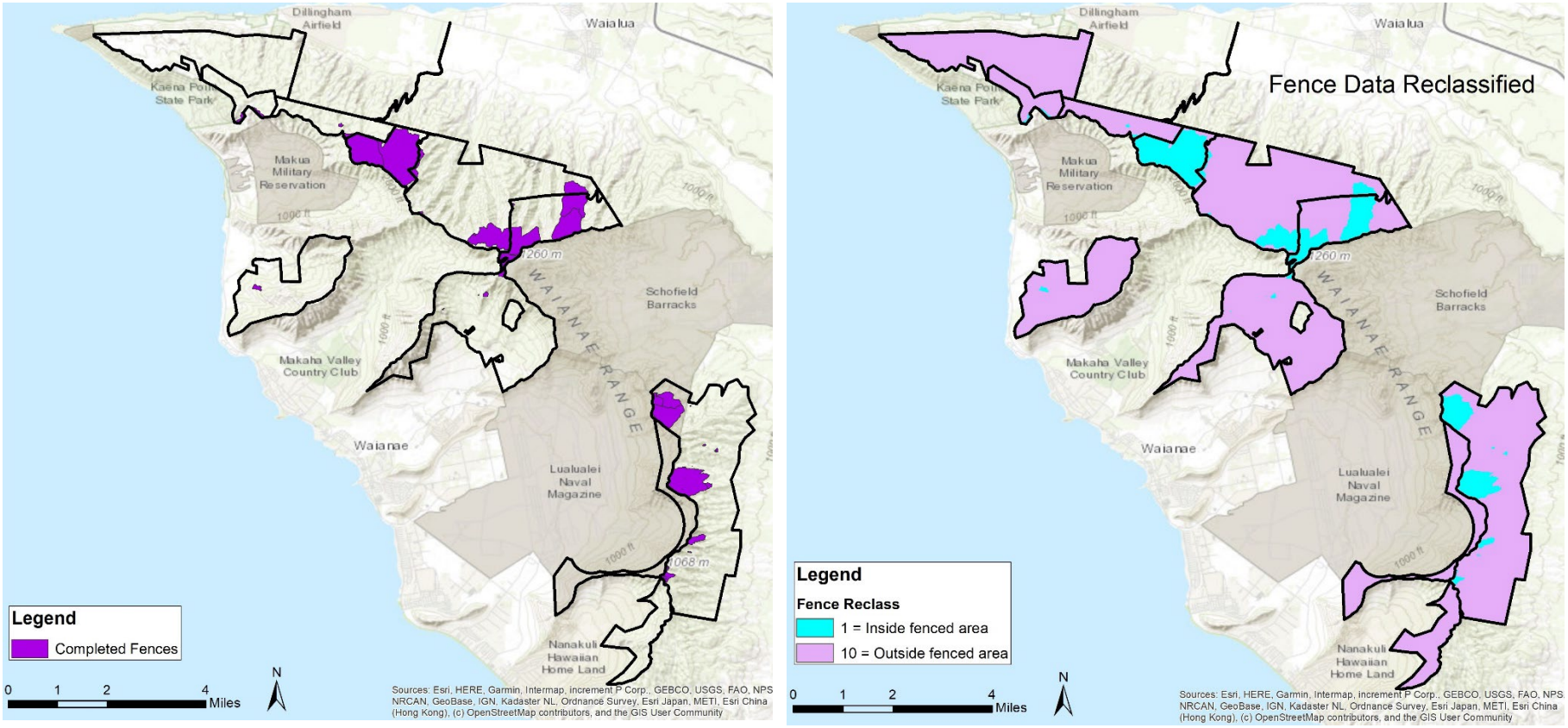


Figure 28. Spatial Analysis – Fenced Areas Dateset source: DOFAW

The map on the left shows existing completed fenced areas. These fences are protecting valuable resources such as native ecosystems and rare species. The fence data was reclassified into two groups: areas inside fences and areas outside fences. These groups were given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. Areas inside the fences were given a score of 1 because the resources being protected within the fenced areas are more environmentally sensitive to goat presence (light blue). Areas outside the fenced were given a score of 10 because they are less environmentally sensitive to goat presence (purple).

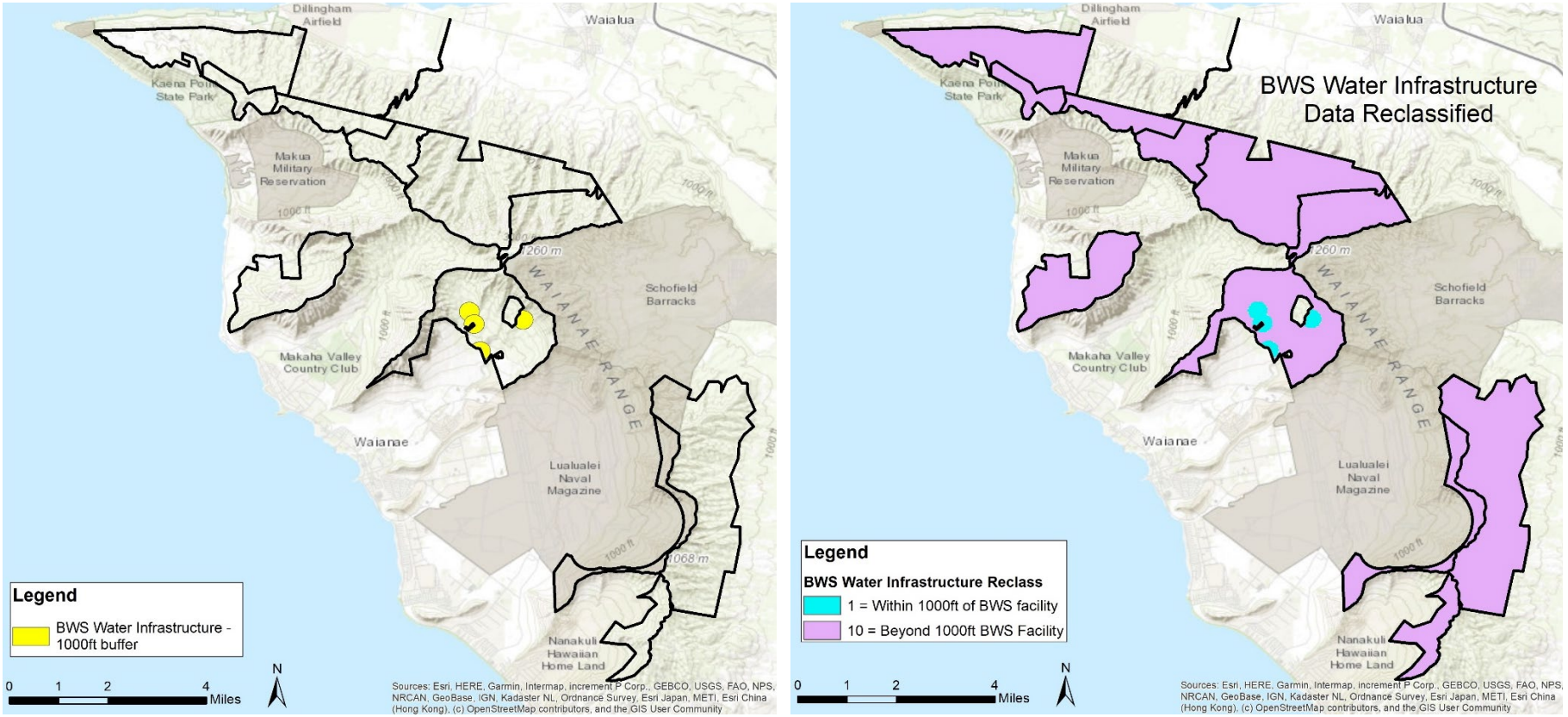


Figure 29. Spatial Analysis – BWS Infrastructure Dataset source: Honolulu Board of Water Supply

Several BWS water infrastructure are present in Wai‘anae Kai FR. The map on the left shows the infrastructure locations with 1,000 foot buffers. Animal carcasses are not allowed within 1,000 feet of BWS infrastructure to prevent biological contamination. The BWS infrastructure data was reclassified into two groups: areas within 1,000 feet of the infrastructure, and areas beyond 1,000 feet of the infrastructure. These groups were given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. Areas within 1,000 of BWS infrastructure were given a score of 1 because they are more environmentally sensitive to goat presence (light blue). Goat carcasses within 1,000 feet of BWS infrastructure may cause biological contamination. Areas beyond 1,000 feet of BWS infrastructure were given a score of 10 because they are less environmentally sensitive to goat presence (purple).

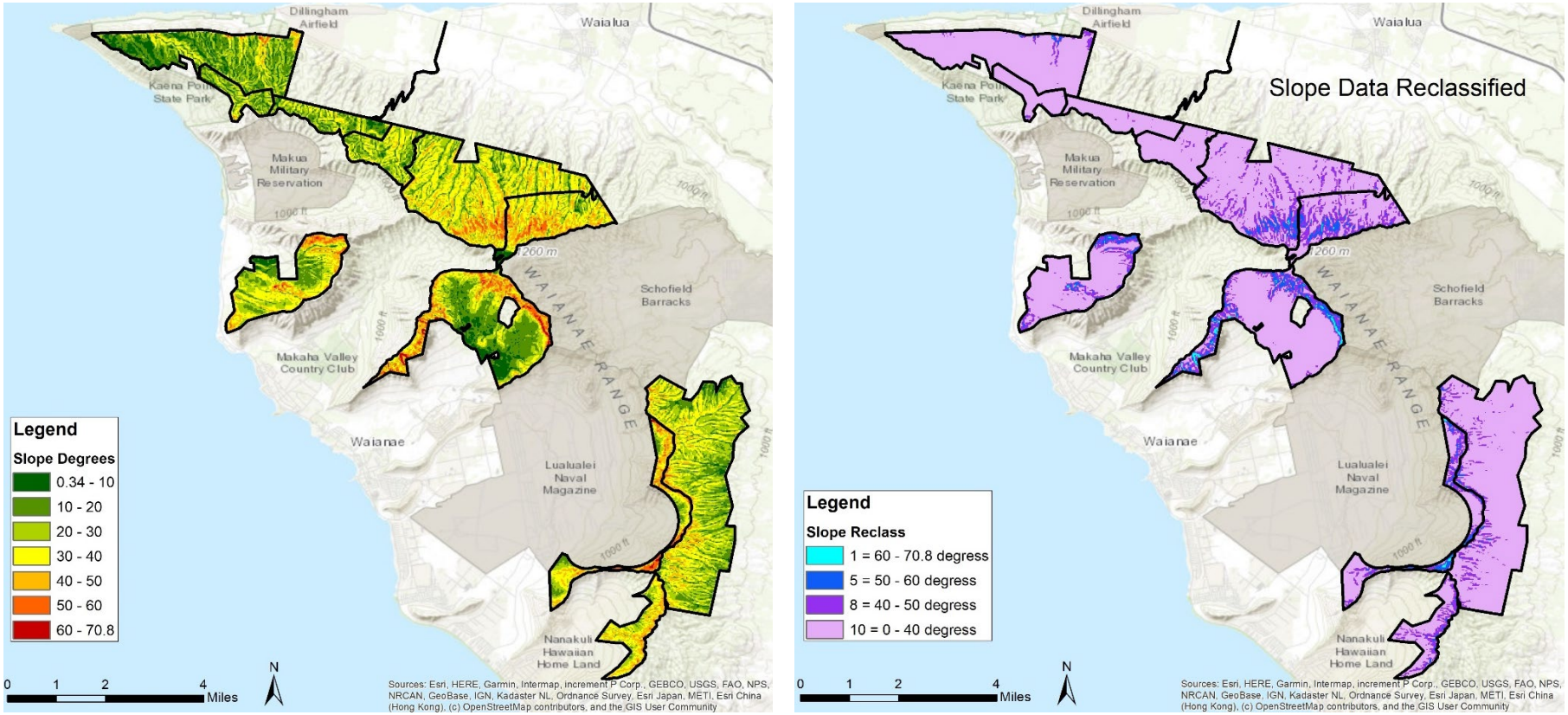


Figure 30. Slope Dateset source: 10-meter resolution land surface digital elevation model for the island of O‘ahu from the U.S. Geological Survey

The map on the left displays slope as degrees. The slope data was reclassified into four groups: 0-40 degrees, 40-50 degrees, 50-60 degrees, and 60-70.8 degrees. These groups were given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. Areas where slope is 0-40 degrees were given a score of 10 because they are less environmentally sensitive to goat presence (purple) and more accessible for public hunting. Areas with moderate slope of 40-60 degrees were given scores of 5 and 8 because they are moderately environmentally sensitive to goat presence. Areas with slope above 60 degrees were given a score of 1 (light blue) because they are more environmentally sensitive to goat presence and accessibility is limited due to the steep topography.

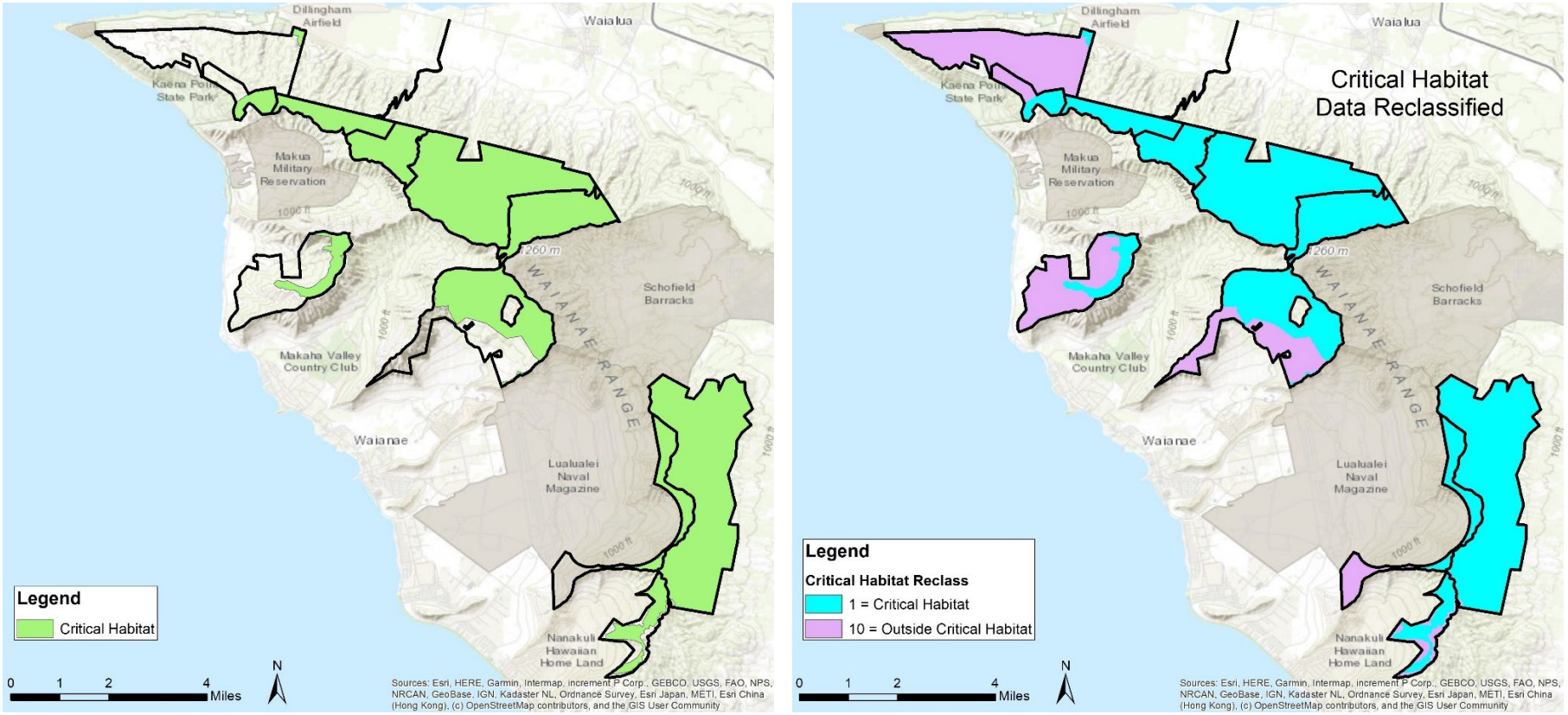


Figure 32. Spatial Analysis – Critical Habitat Dataset source: U.S. Fish and Wildlife Service

The map on the left shows areas that are designated critical habitat, which are specific areas that contain physical or biological features essential to conservation of federally listed endangered species and that may require special management considerations or protection. The critical habitat data was reclassified into two groups: within critical habitat, and outside critical habitat. These groups were given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. Areas outside critical habitat were given a score of 10 because they are less environmentally sensitive to goat presence (purple). Because critical habitat is essential to the conservation of federally listed endangered species, goats may negatively impact these areas through habitat degradation. Therefore, areas within critical habitat were given a score of 1 because they are more environmentally sensitive to goat presence.

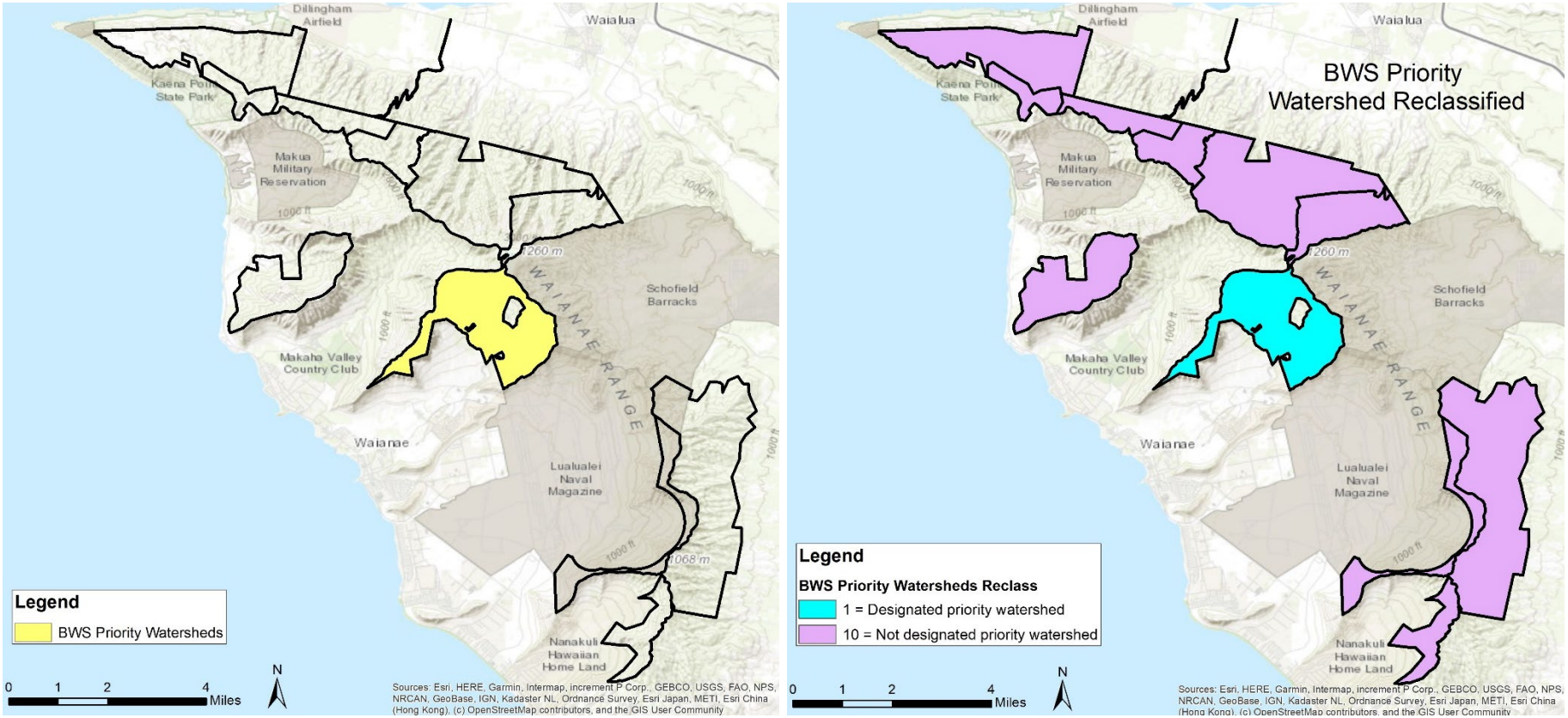


Figure 33. Spatial Analysis – Priority Watershed Data source: Honolulu Board of Water Supply

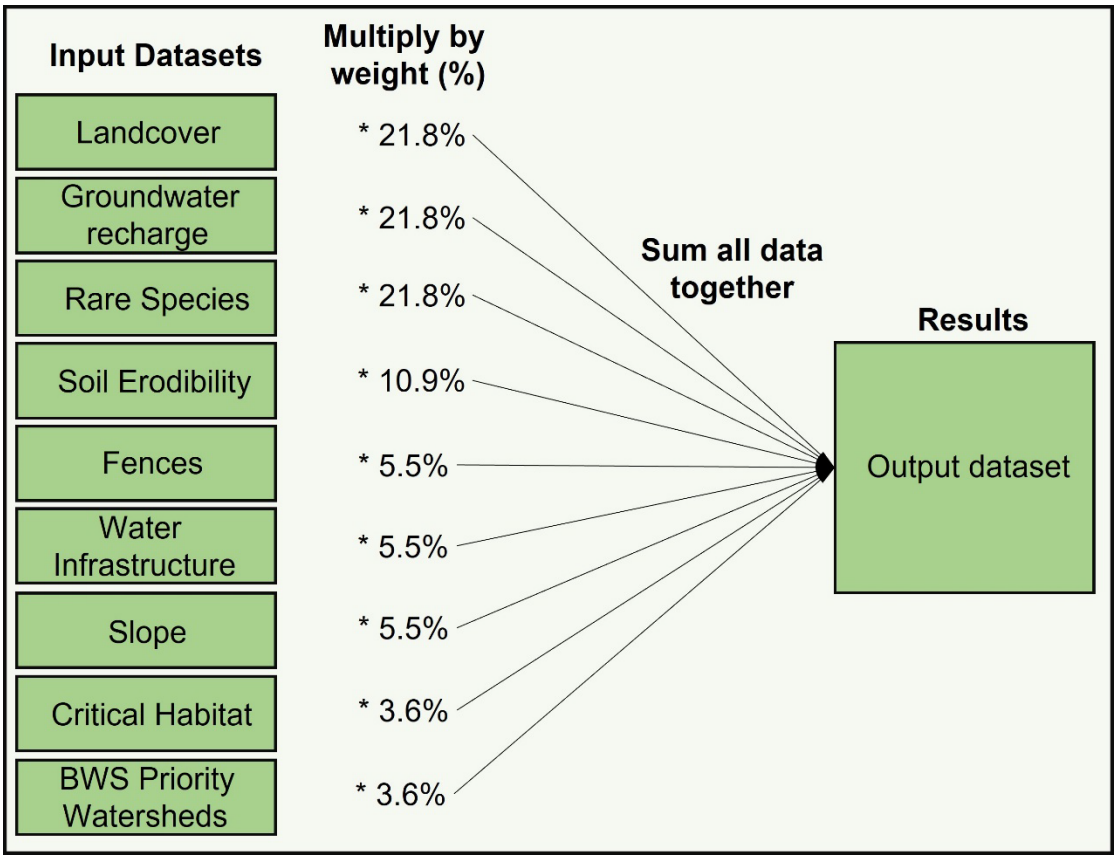
The map on the left shows BWS designated priority watersheds. Priority watersheds are watersheds have most of the district's groundwater supply and flowing streams, high potential recharge and production, the most groundwater and surface water use, available agricultural lands, and important cultural significance. The priority watershed data was reclassified into two groups: within priority watershed, and outside priority watershed. These groups were given values based on a common scale of 1-10, with 1 being more environmentally sensitive to goat presence and 10 being less environmentally sensitive to goat presence. Areas outside priority watershed were given a score of 10 because they are less environmentally sensitive to goat presence (purple). Goats can negatively impact priority watersheds through habitat degradation and acceleration of soil erosion. Therefore, areas within priority watersheds were given a score of 1 because they are more environmentally sensitive to goat presence.

5. Weighted Sum Analysis

After each dataset was reclassified, Forestry and Wildlife biologists conducted a ranking process that assigned each dataset a weight based on the data's importance in the analysis.

Criteria	Weight (%)
Land cover	21.8%
Groundwater recharge	21.8%
Rare species points	21.8%
Soil erodibility	10.9%
Fences	5.5%
Water infrastructure	5.5%
Slope	5.5%
Critical habitat	3.6%
BWS priority watersheds	3.6%

The reclassified values of each dataset were then multiplied by the weights specified in the table. All 11 data sets were then added together to create an output dataset that combined all of the input data.



6. Results

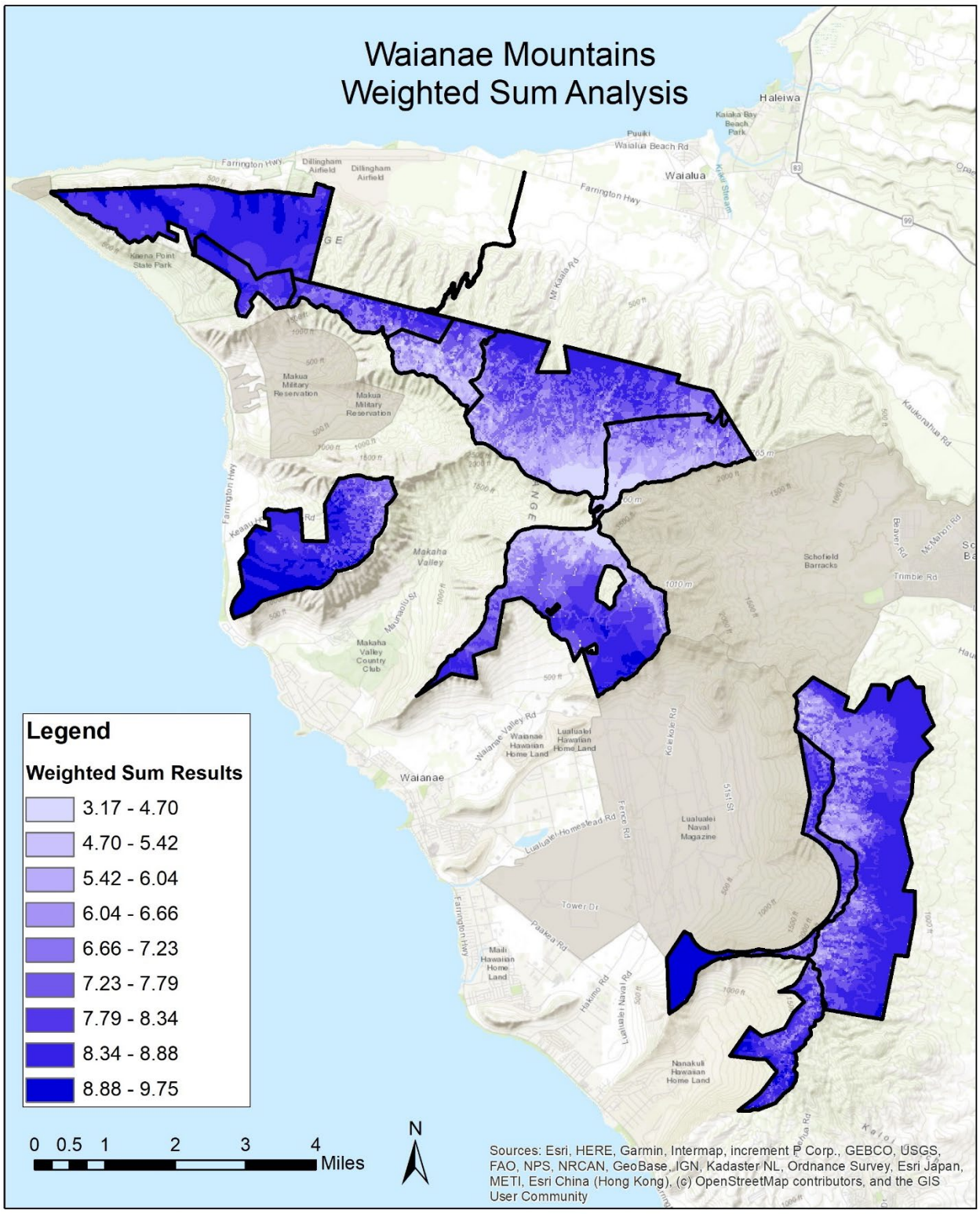


Figure 36. Spatial Analysis – Weighted Sum Results

The results were divided into three natural break classes that were based on natural groupings inherent in the data. Red areas have a lower score indicating higher environmental sensitivity to goat presence. Yellow areas have a moderate score indicating moderate environmental sensitivity to goat presence. Green areas have a high score, indicating low environmental sensitivity to goat presence.

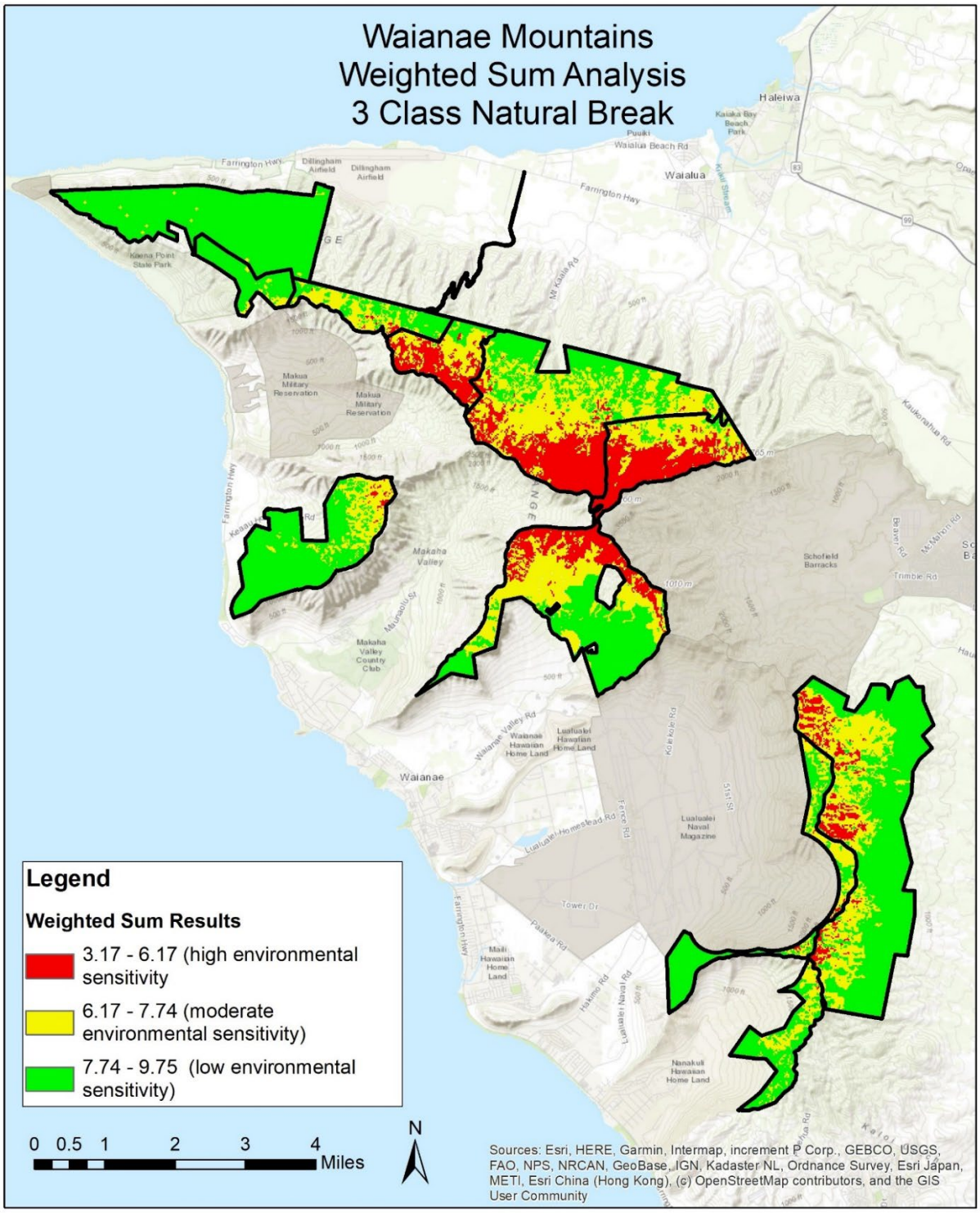


Figure 37. Spatial Analysis – How Output Relates to the Goals

Appendix 5 Aerial Shoot Protocol

Forestry and Wildlife Policy

Agency policies concerning the use of firearms and helicopters, as well as training, background checks, and position descriptions shall be adhered to.

Table 13. Communication/Notification Plan for Aerial Shooting Missions

Document	Approval	Content	Distribution Requirements
Email	Branch manager	Notification: Dates shooting will take place (as well as alternate dates) and a description of the area it will occur in.	NBS, area Legislators, community members
Legal Notice	Branch manager	Notification: Dates shooting will take place (as well as alternate dates) and a description of the area it will occur in.	Publish in local newspapers by Branch Manager at least 15 calendar days before the aerial shooting.
Letter	Branch manager	Notification: Dates shooting will take place (as well as alternate dates) and a description of the area it will occur in.	Dated letter to cooperating and adjacent landowners at least one week in advance of the mission.
Written Notice	Branch manager	Notification: Dates shooting will take place (as well as alternate dates) and a description of the area it will occur in.	Place written notice at entry points into the designated area before or on the day of the shoot.