Technical Report HCSU-020

BASELINE SURVEY FOR RARE PLANT SPECIES AND NATIVE PLANT COMMUNITIES WITHIN THE KAMEHAMEHA SCHOOLS' LUPEA SAFE HARBOR PLANNING PROJECT AREA, NORTH KONA DISTRICT, ISLAND OF HAWAI'I

James D. Jacobi[1]
Frederick R. Warshauer[2]
Jonathan Price[2]

[1]U.S. Geological Survey, Pacific Island Ecosystems Research Center, Kilauea Field Station, P.O. Box 44, Hawaii National Park, HI 96718
[2]Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo, Pacific Aquaculture and Coastal Resources Center, P.O. Box 44, Hawai'i National Park, HI 96718

Hawai'i Cooperative Studies Unit
University of Hawai'i at Hilo
Pacific Aquaculture and Coastal Resources Center (PACRC)
200 W. Kawili St.
Hilo, HI 96720
(808) 933-0706

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James D. Jacobi[1]
Frederick R. Warshauer[2]
Jonathan Price[2]

[1]U.S. Geological Survey
Pacific Island Ecosystems Research Center
Honolulu, HI 96813

[2]Hawai,,i Cooperative Studies Unit
University of Hawai,,i at Hilo
Hilo, HI 96720

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Hawai,,i Cooperative Studies Unit
University of Hawai,,i at Hilo
Pacific Aquaculture and Coastal Resources Center (PACRC)
200 W. Kawili St.
Hilo, Hawai,,i 96720
808-933-0706

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ABSTRACT

Kamehameha Schools, in conjunction with several federal, state, and private organizations, has proposed to conduct conservation management on approximately 5,340 ha (~13,200 acres) of land they own in the vicinity of Kīpukalupea in the North Kona District on the island of Hawai„i. The goal of this program is to restore and enhance the habitat to benefit native plant and animal populations that are currently, or were formerly, found in this site. The initial phase of this project has been focused on various activities including conducting baseline surveys for bird and plant species so Kamehameha Schools could develop a Safe Harbor Agreement (SHA) for the proposed project lands relative to the habitat management and species reintroduction efforts they would like to conduct in the Lupea Project area. This report summarizes methods that were used to collect field data on plant species and communities within the project area, and the results of that initial survey. The information was used to calculate baseline values for all listed threatened or endangered plant species found, or expected to be found, within the project area, and to design a monitoring program to assess changes in plant communities and rare plant species relative to management activities over the duration of the SHA.

The Lupea Project area contains excellent examples of several high elevation native plant communities including montane dry forest and woodland, native subalpine shrubland, and native grassland. Between November 2003 and January 2004 we sampled plant communities and species along seven transects established through the project area. A total of 109 plant species were found during this survey, within the transect grid and in nearby areas. Forty-four of these plants are endemic species, 21 are indigenous species, 43 are introduced, and one species is believed to have been introduced to Hawai„i by early Polynesian settlers. Only one federally listed Endangered plant, *Asplenium peruvianum* var. *insulare*, was found within the survey area. Additionally, we found one immature plant that may be *Sicyos macrophyllus*, a candidate species for listing. However, we were not able to make a definite determination of this species' identity since it did not have fruits or flowers. Finally, we documented four plant species within the survey area that have no official status designation but are considered to be rare and informally recognized as "species of concern" (SOC) as they appear to be declining in distribution and abundance statewide. These included *Chamaesyce olowaluana*,

Eragrostis deflexa, *Sisyrinchium acre*, and *Tetramolopium consanguineum*. In addition to conducting field surveys, we performed a query on a spatial database developed by Dr. Jonathan Price of the University of Hawai,i at Hilo which models the potential range of all native Hawaiian plant species based on historic observations and a set of environmental parameters. The potential species list for the Lupea Project area includes 47 taxa that we did not find during our surveys, as well as three other listed species that were not modeled by Price, but known from historic records in adjacent habitats. Some of these species are extremely rare or, in some cases have been locally extirpated. However, most of the plants that were predicted but not found during our surveys are expected to be located with additional searching, or may potentially recolonize the area following the elimination of ungulates and initiation of other restoration efforts. Forty-four introduced plant species were found within the survey area, seven of which are considered to be highly invasive. These include the grasses *Pennisetum clandestinum* and *Pennisetum setaceum*, vines *Delairea odorata* and *Passiflora tarminiana*, herbs *Senecio madagascariensis* and *Verbascum thapsus*, and the shrub *Rubus niveus*.

Non-zero baseline values are proposed for the one listed plant species found within the Lupea Project area, one species that is a candidate for listing, and the four other rare species we found that may be considered for listing in the future. Additionally, a zero baseline is proposed for 23 other species that were predicted, but not found within the project area. These include 14 Endangered species, one Threatened species, two candidates for listing, and six species of concern. Subsequent monitoring of the site will be necessary to determine if the populations of these species have increased or decreased relative to their baseline values. It is presumed that the management activities Kamehameha Schools has proposed for this area, particularly removal of the ungulates and weed control, will provide a benefit to the habitat as a whole and allow for natural regeneration and maintenance of the all elements of the plant communities found there.

INTRODUCTION

Kamehameha Schools, in conjunction with the U.S. Fish and Wildlife Service, Hawai,,i Division of Forestry and Wildlife, The Hawaiian Silversword Foundation, the Zoological Society of San Diego, and the Three Mountain Alliance, has proposed to conduct several conservation management actions on approximately 5,340 ha (~13,200 acres) of land they own in the vicinity of Kīpukalupea in the North Kona District on the island of Hawai,,i. The goal of this program is to restore and enhance the habitat to benefit native plant and animal populations that are currently, or were formerly, found in this site. Anticipated management actions for the Lupea Project area are aimed at significantly reducing or eliminating the impacts of introduced plant and animal species (particularly feral ungulates, rats, cats, mongooses, and several invasive plant species) on the habitat, and, if needed, to reintroduce or supplement populations of rare or extirpated species that were historically known from this area. One such species, the endangered Palila (*Loxioides bailleui*), a member of the Hawaiian Honeycreeper subfamily of birds, was regularly found in the lower section of the project area until the early 1900's after which it became extinct on the Kona side of the island of Hawai,,i (van Riper III et al. 1978, Scott et al. 1984, Banko 1986, Banko et al. 2002). One objective of the Kamehameha Schools Lupea Project is to manage the habitat in the area above Pu,,ulehua so it becomes suitable for the reintroduction of Palila within the next several decades. Similar restoration efforts are also planned for some of the rare native plant species that are currently or formerly known from this area.

The initial phase of this project has been focused on conducting baseline surveys for bird and plant species so Kamehameha Schools could develop a Safe Harbor Agreement (SHA) for the proposed project lands relative to the habitat management and species reintroduction efforts they would like to conduct in the Lupea Project area. Safe Harbor Agreements in Hawai,,i are under the jurisdiction of both the U.S. Fish and Wildlife Service and the State of Hawai,,i Department of Land and Natural Resources, and are developed in conjunction with the Hawai,,i Endangered Species Recovery Committee which advises both agencies on the biological aspects of SHA proposals (State of Hawai`i 1996, U.S. Fish and Wildlife Service 2004).

This report summarizes methods that were used to collect field data on plant species and communities within the project area, and the results of that survey. The information was used to calculate baseline values for all listed threatened or endangered plant species found, or expected to be found, within the project area, and to design a monitoring program to assess changes in plant communities and rare plant species relative to management activities over the duration of the Agreement.

METHODS

Description of the Project Area

The Kamehameha Schools Lupea Project area is located above Pu,,ulehua in the *ahupua'a* (land division) of Keauhou 2 (Figure 1). The site ranges in elevation from 1,500 m to 2,000 m (4,920 ft to 6,560 ft), and receives approximately 600 mm (24 in) of rainfall per year (Giambelluca et al. 1986). This area falls within the moderately dry moisture zone as mapped by Price et al. (2007) (Figure 2), in the montane dry vegetation zone (Figure 3) (Price and Jacobi, U.S. Geological Survey, unpublished data). Most of the area is covered by either ,,a,,āor pāhoehoe lava flows erupted from Mauna Loa volcano between 200 and 3,000 years ago (Wolfe and Morris 1996, Sherrod et al. 2007). However, a few small sites within the project area have lava or ash substrates between 5,000 and 11,000 years old.

Sampling Design

The sampling frame for this survey was developed using a systematic design with a random starting point. A base transect, running east to west through the potential project area, was established using ArcMap GIS version 9.3. A set of potential transect starting points was then calculated at 200 m intervals along this base line. One of these points was selected randomly as the first transect location and other transect points were then established both east and west of the base transect at 1,000 m intervals. Finally, eight

potential transects were set up on the GIS running northeast and southwest of the baseline starting points, with stations (sampling points) located at 200 m intervals along each transect. One hundred seventy-five potential stations were identified for the entire project area. Using UTM coordinates generated with the GIS, field crews first navigated to the starting points for each transect, then systematically established stations along the transect by following the specified compass heading (30° T, 19.5° magnetic), and measuring distance on the ground between stations with a meter tape. These transects and stations were used as the framework to survey bird and plant communities for the area.

Between November 2003 and January 2004 we sampled the plant species and communities at a total of 143 locations along the transects (Figure 4). Some potential sampling points (e.g., proposed Transect 8) were eliminated because they were primarily in the relatively unvegetated subalpine zone, which was not a main focus for the survey. Other points (e.g., portions of Transects 2 and 4), were not sampled due to time limitations during the survey. However, the 143 locations that were sampled are believed to provide an adequate sample of the plant species and forest or woodland communities found within the project area as a whole since they are dispersed across all major vegetation types found within the area. The location of each station along the transects was documented using a GPS unit with an accuracy of ≤5 m. All GPS and GIS data were recorded using UTM Zone 5 and NAD83 datum base.

Data Collection

At each station we collected data on the composition and structure of the plant community, as well as information on ungulate presence and abundance, and substrate characteristics. Presence and abundance of rare plants, and presence of a selected set of invasive plant species were recorded in 10 x 200 m plots that extended between station points along each of the transects.

Plant Community Characterization

Vegetation was characterized at each station using a rapid assessment format developed during the U.S. Fish and Wildlife Service's Hawai,,i Forest Bird Survey (Scott et al. 1981). The vegetation type descriptive code includes categories and semi-quantitative cover assessments for tree crown cover, tree height, tree species composition, and ground cover or understory type. Tree cover at a station was recorded in the following classes: closed (>60% cover), open (>25-60 % cover), scattered (5-25% cover), and very scattered but present (<5% cover). Tree height was recorded in three classes: >2 – 5 m, >5 – 10 m, and >10 m tall. Additionally, the species that comprise the tree and understory plant groups were identified and their abundance noted using a modified Braun-Blanquet cover/abundance scale (<5%, 5 – 25%, >25 – 50%, >50 – 75%, >75 cover). The field vegetation type codes are directly related to vegetation map symbols that have previously been used in mapping the vegetation of the island of Hawai,,i (Jacobi 1989, 1990).

Lists of vascular plant species were compiled for all plant communities as the observer walked along each transect. Species taxonomy follows Wagner *et al*. (1990), and Wagner *et al*. (2009) for flowering plants, and Palmer (2002) for ferns. Species status was based on the list of Endangered, Threatened, and candidate taxa compiled by the U.S. Fish and Wildlife Service (2009).

Rare Native and Invasive Plant Species

We recorded presence and abundance of rare native plant species, as well as a selected number of invasive plants in the 10 x 200 m plots that extended between each of the stations. The rare native plants included listed Endangered (E) or Threatened (T) species, candidate species (C) for listing, and other rare "species of concern" (SOC). Rare native and invasive plants were also documented with digital photos as much as possible. These images were used to help with the identification of the plant species as needed, and to provide reference material for other field personnel working in this area.

Ungulate Presence and Damage

The presence and abundance of ungulates (sheep, pigs, goats, *etc.*), or signs of their activity were documented at each station. We recorded data on species seen, number of individuals, browsing sign on plants, droppings, tracks, or trails.

Substrate Type

Substrate type was identified at each station to aid identifying habitat associations with the plant communities of the project area. The area characterized was within a 5 m radius circle around the station. Substrate categories that were recorded included thin organic soils on ,,a,,ā lava or pāhoehoe lava, thicker soils on lava, or soils derived from ash deposits.

RESULTS

Plant Species

A total of 109 vascular plant species were found during this survey (Appendix 1). Forty-four of these are endemic species (*i.e.,* found only in Hawai,,i), 21 are indigenous species (naturally found in Hawai,,i but also known from elsewhere in the world), 43 are introduced, and one species (*Oxalis corniculata*) is believed to have been introduced to Hawai,,i by early Polynesian settlers (Wagner et al. 1990).

Native Plants

The dominant native plant species within the Lupea Project area were the trees koa (*Acacia koa*), māmane (*Sophora chrysophylla*), naio (*Myoporum sandwicense*), arborescent ,,a,,ali,,i (*Dodonaea viscose*), and ,,iliahi (*Santalum paniculatum*); and shrubs pūkiawe (*Leptocophylla tameiameiae*) and ,,a,,ali,,i. ,,Ōhi,,a (*Metrosideros polymorpha*) was the dominant tree on the few ,,a,,ā lava flows that run through the area, as well as at

upper elevations in the subalpine woodland. A total of 13 fern species were found, all of them native, but no one species in great abundance. Seven native grass species were also found – they were particularly common in the upper elevation areas of the survey area. This represents one of the most diverse and extensive areas for native grasses remaining in the Hawaiian Islands.

Only one Endangered plant, *Asplenium peruvianum* var. *insulare* (Photo 1), listed as *Asplenium fragile* var. *insulare* by the U.S. Fish and Wildlife Service (2009), was found within the survey area (Figure 5). This species is now generally found in the entrances to lava tubes or other similarly shaded and protected areas. However, in this case the single documented plant was found growing on rotting logs and soil on the surface of the lava, a seldom seen form of this taxon. Additionally, we found one immature plant that, based on leaf morphology, appeared to be *Sicyos macrophyllus* (Photo 2), a candidate species for listing (Figure 5). However, we were not able to make a definite determination of its identity since it did not have either fruits or flowers. Finally, we documented four plant species within the survey area that have no official status designation but are considered to be rare and informally recognized as "species of concern" (SOC) since they appear to be declining in distribution and abundance statewide. These included *Chamaesyce olowaluana* (Photo 3) (Figure 5), *Eragrostis deflexa* (Figure 6), *Sisyrinchium acre* (Photo 4), and *Tetramolopium consanguineum* (Figure 7). Of these species, *Eragrostis deflexa* was the most abundant as it was found on ten (7%) of the sampled plots and at numerous locations between transects. The rest of the SOC species were quite rare. Individual *Chamaesyce olowaluana* trees were found in three plots and the other two species had less than five plants in one plot each.

We also found several other notable native species including the relatively uncommon fern *Polystichum hillebrandii* in one plot, as well as very robust populations of ʻiliahi (*Santalum paniculatum* – sandalwood) (Photos 5 and 6) throughout the survey area. Hawaiian sandalwood trees were extensively logged during the early 1800s and shipped to China to be made into wooden chests or incense (Cuddihy and Stone 1990). The Lupea

population of *Santalum paniculatum* appears to be one of the largest and best preserved, mixed size-class stands of this species in the entire state.

Predicted Native Species Within the Survey Area

In addition to conducting field surveys, we performed a query on a spatial database developed by Dr. Jonathan Price (University of Hawai,,i at Hilo) which models the potential range of all native Hawaiian plant species based on historic locations and a set of environmental parameters (Price 2004, Price et al. 2007). This analysis produced a list of 105 vascular plant species (ferns, monocots, and dicots) that could be expected to be found within the Lupea Project area based on historical information and locations of these species in similar habitats on the island of Hawai,,i. Fifty-eight of the native species predicted by Price were found during the survey. His potential species list also includes 47 taxa that we did not find during our surveys (Table 1). Some of these species are extremely rare or, in some cases have been locally extirpated. However, most of the common plants that were predicted but not found in our surveys are expected to be located with additional searching, or may potentially recolonize the area following the elimination of ungulates and initiation of other restoration efforts. We found five species in the field that were not included on Price's list for the area (Table 2). All of these plants are known from slightly moister habitats elsewhere on the island and represent some inclusion of these conditions within the project area, even thought the area was mapped as montane dry habitat. Several other Endangered plant species, including *Argyroxiphium kauense*, *Neraudia ovata*, and *Nothocestrum breviflorum*, are known from habitats on the island of Hawai,,i similar to the Lupea Project area, but were not predicted by Price's modeling since he had no documented records for these species close to this site in his database.

Introduced Plants

Forty-four introduced plant species were recorded within the survey area. Smith (1985) recognized seven of them to be highly invasive. These included the grasses *Pennisetum*

clandestinum and *Pennisetum setaceum* (Photo 7); vines *Delairea odorata* (Photo 8) and *Passiflora tarminiana* (formerly called *Passiflora mollissima*) (Photo 9); herbs *Senecio madagascariensis* (Photo 10) and *Verbascum thapsus* (Photo 11); and the shrub *Rubus niveus* (Photo 12) (Table 3) (Figures 8 - 12). Five of these plants are recognized by the State of Hawai„i as "Invasive and Noxious Weeds" (Hawaii Division of Plant Industry 2003). *Delairea odorata*, *Pennisetum clandestinum*, *Pennisetum setaceum*, and *Senecio madagascariensis* have been evaluated through the Hawai„i Weed Risk Assessment project and all are ranked as high threats to native ecosystems (Daehler et al. 2004, Daehler and Denslow 2009).

Verbascum thapsus was the most widespread of the invasive weeds, documented on over 29% (42) of the plots sampled (Figure 12). *Pennisetum clandestinum* is an upland pasture grass and was found distributed on 38 (27%) of the plots surveyed (Figure 9), primarily in the more moist lower and middle sections of the site, except on recent „a„ālava flows. *Pennisetum setaceum* has been expanding its distribution into upper elevation dry habitats on the island of Hawai„i. It was found on 29 (20%) of the plots sampled (Figure 10). This invasive species is of particular concern as it enhances the spread and intensity of fire in areas that it becomes abundant (Smith 1985, Jacobi and Warshauer 1986). *Delairea odorata* was the other species we found widespread across the area. It was found on 27 plots (19%), mostly in the lower and mid-elevation areas (Figure 8).

Three invasive plants (*Rubus niveus*, *Senecio madagascariensis*, and *Passiflora tarminiana*) were extremely rare within the survey area, but do pose a threat to management of the native plant communities found there if they increase in distribution and abundance. *Rubus niveus* was found at only two plots in the lower, southern portion of the area (Figure 11), and at numerous other locations in this general vicinity. This species was probably introduced here as an ornamental and is generally scattered across the mesic habitats immediately below the survey area. It has the potential to form dense bramble patches in the lower, moister sections of the Lupea Project area. If unchecked, this species will likely spread much further through these habitats and become a much bigger problem in the future.

Only two *Senecio madagascariensis* plants were found during this survey (Figure 11). Over the past decade, *Senecio madagascariensis* has been increasing in both distribution and abundance in open dry and mesic habitats on the islands of Hawai,,i and Maui (Culliney et al. 2003). Besides its potential competitive impacts with native understory vegetation, *Senecio madagascariensis* is toxic to cattle and poses a serious threat to cattle ranching. *Passiflora tarminiana* was also recorded in very few plots (2) (Figure 8). This species is a serious pest in native montane wet and mesic forests, but appears to be less of a problem in montane dry habitats like the Lupea Project area (Smith 1985, Jacobi and Warshauer 1986). It is not clear if its limited distribution in this area is a result of habitat features or if it has been controlled by browsing by cattle, sheep, and goats. This is definitely a species to watch and possibly actively control following removal of the ungulates.

Plant Communities

At a general scale, the plant communities within the project area fall under the montane dry vegetation zone, as mapped by Price and Jacobi (U.S Geological Survey, unpublished data). However, most of the plant communities found in large portions of the project area have been highly altered by logging, cattle grazing, feral ungulates, fire, and alien plant invasion over the past 200 years (Cuddihy and Stone 1990). Evidence for past logging was seen throughout the area up to approximately 1,830 m (6,000 ft) elevation.

The major plant communities within the Lupea Project area include:

- Mixed māmane-naio-koa-,,a,,ali,,i-'iliahi woodland with native shrubs and/or grasses. Found on 81% (116) of the stations sampled. (Photos 13 – 16)
    - Closed/open māmane-naio-koa-,,a,,ali,,i-'iliahi forest with native shrub and grass understory (generally at upper elevations of the survey area)
    - Closed/open māmane-naio-koa-,,a,,ali,,i-'iliahi forest with alien grass understory (generally at the lower elevation portion of the survey area)

- ʻŌhiʻa dominated forest or woodland on ʻaʻā lava or at upper elevations. This community also includes scattered individuals of other tree species, including koa, māmane, naio, ʻiliahi, and ʻakoko. Found on 15% (22) of the stations sampled. (Photo 17)
    - Open/closed tall ʻōhiʻa with native shrubs (on ʻaʻā lava flows)
    - Scattered tall ʻōhiʻa with native shrubs (on ʻaʻālava flows)
    - Open/scattered low-stature ʻōhiʻa above 1,830 m (6,000 ft) elevation on both ʻaʻā and pāhoehoe lava flows

- Pūkiawe-ʻaʻali ʻi shrubland. Found on 3% (5) of the stations sampled. (Photo 18)
    - Native shrubland dominated by pūkiawe and ʻaʻali ʻi
    - Native shrubland dominated by pūkiawe and ʻaʻali ʻi but with scattered koa, ʻiliahi, māmane, and other tree species

- Grassland communities with very few trees (may include koa, māmane, naio, ʻiliahi, ʻaʻali ʻi) (not sampled on the stations but recorded along the transects). (Photos 19 – 21)
    - Native grassland patches above 1,830 m (6,000 ft) elevation
    - Pasture grassland dominated by alien species

Introduced Ungulates

Some type of ungulate sign (e.g., tracks, droppings, evidence of browsing, live animals) was seen on virtually every station sampled and in most areas between the stations and transects. Feral ungulates, primarily sheep (*Ovis aries*) and some feral goats (*Capra hircus*) (Photo 22) were seen throughout the entire area and a few Mouflon (*Ovis gmelini musimon*) sheep have been previously recorded here (Dale Fergerstrom, Kamehameha Schools, Personal communication). Cattle currently range up to the *mauka* (upper elevation) wall of Mizota's Kīpuka but are mostly concentrated in the lower pasture areas on the makai (lower elevation) side of the survey area.

DISCUSSION

Significance of the Region

The region including and surrounding the proposed Lupea Project area harbors the second largest area of māmane-containing communities on the island of Hawai,,i. Only the upper slopes of Mauna Kea support a larger extent of māmane in the state, but does not have the great plant species diversity found in the Pu,,ulehua to Lupea landscape. These forests originally were even more structurally variable and diverse in plant species (Rock 1913). They also supported a unique community of four finch-billed honeycreepers (Perkins 1903, 1913, Munro 1960), of which only the Palila survives, and now only in a population on Mauna Kea (Banko et al. 2002, Leonard et al. 2008).

This region is effectively a plateau formed by the gradual burying of the elongate Hualālai southeast rift zone by the northwest slope of Mauna Loa, the more active of the two volcanoes. This large area of gentle slopes is on a portion of Mauna Loa that is away from the rapidly covered regions of its two rift zones, and its surface is composed of older summit overflows that are interspersed with more recently erupted flows from radial vents such as at the "Honey Bee" site in the project area (Wolfe and Morris 1996, Sherrod et al. 2007). Ash that was ejected from some of these scattered vents has also contributed to local soil development.

The result is a large region with broad, well developed montane vegetation zones. As one looks south from the plateau, the māmane belt abruptly narrows in width as the slopes of the west flank become steeper, and māmane forest nearly disappears all together soon after entering into South Kona. Similarly, zones of koa and other forest types are also narrower to the south. Other māmane forest areas on the island (north and southwest Hualālai, the Pōhakuloa Training Area, east Kapāpala-Keauhou) are much smaller and in much poorer condition than the large portions of this region. Consequently, the upper Pu,,ulehua to Lupea region has the best potential to be restored into viable Palila habitat on Mauna Loa. Of this region, the proposed survey area includes much of the best preserved sections of māmane vegetation.

The most intact plant communities in this region are the native subalpine woodland/shrub/grassland units above approximately 1,830 m (6,000 ft) elevation. These include both the mixed tree communities and associated native shrub and grassland habitats, as well as the subalpine ʻōhiʻa forest on both ʻaʻā and pāhoehoe lava. This site is one of the most diverse areas for native grass species on the Big Island. It is notable that the Mauna Loa silversword (*Argyroxiphium kauense*) was reported in the early 1950s by David Woodside in the subalpine habitat above the Lupea Study area. The upper sections of the survey area are above the current and probably historic distribution of cattle. Additionally, the feral sheep and goat populations do not currently appear to be very large at these upper elevations. These factors may be why the native plant communities here are still in relatively good condition.

Significance of the Vegetation

The large area within and adjacent to the plateau has enough successional maturity and age heterogeneity to have harbored even more native species than recorded during our surveys. Originally, the area's climate was mesic to dry, and these zones on nearby similarly old substrates supported a rich collection of plant communities, especially in the lowermost parts of the region that are now so degraded. There, species such as *Melicope hawaiensis, Exocarpos gaudichaudii, Haplostachys haplostachya, Delissea undulata, Zanthoxylum hawaiiense, Neraudia ovata, Festuca hawaiiensis, Solanum incompletum, Nothocestrum breviflorum, Stenogyne angustifolia, Dubautia linearis, Eragrostis atropioides, Eragrostis grandis, Sicyos macrophyllus,* and *Kadua coriacea* are likely to have occurred. Past removal of the koa canopy by logging may well have precluded the persistence of some of these species. Similarly, the uplands may have harbored *Exocarpos menziesii, Portulaca sclerocarpa, Silene hawaiiensis, Argyroxiphium kauense,* and others. A few of these species may still persist in this plateau area, and most are predicted by Price's range modeling database. If the ungulates are eliminated from this area, it may be appropriate to consider reintroducing some of these species into the remaining areas of native vegetation if they do not recolonize naturally.

While portions of the area originally supported large stands of tall koa over a diversity of smaller trees and shrubs, the younger flows had significant areas of diverse shrublands, the uppermost of which are still of high quality. Also significant is that the region still supports seven species of native grasses and three native sedges; additional species are likely to be found with more searching. The native grasses are probably more abundant and diverse here than anywhere else in the Hawaiian Islands and their prominence in the understory and open shrubland communities is unique. Despite the presence of ungulates and alien grass species, most of the native grasses appear to be stable here at this time.

Proposed Baselines for Plant Species Within the Project Area

It is extremely difficult to develop rigorous population baselines for rare plant species such as those found within the Lupea Project area. The amount of field effort needed to provide precise density estimates for these species would be enormous and beyond the expectations for a Safe Harbor Agreement. However, for the Safe Harbor process it is required that some baseline value is determined for all listed species found, or expected to be found within the project area. Additionally, it is considered prudent to identify baseline levels for all species found, or predicted to be found, that may possibly be listed as Endangered or Threatened in the future. Therefore, baseline values are proposed for the one currently listed Endangered plant species, one species that is a candidate for listing, and four rare species (SOC species) that may be considered for listing in the future; as well as for 23 other listed or rare plants not currently found within the project area but predicted to occur there, based on Price's species database and distribution modeling. Two measures were used to calculate a species' baseline level for the Lupea Project area and should be used when assessing trends in these populations over time: 1) continued presence on the site if it was found there during the initial surveys, and 2) frequency of occurrence within the survey plots. It is presumed that the management activities Kamehameha Schools has proposed for this area, particularly removal of the ungulates and weed control, will provide a benefit to the habitat as a whole and allow for

natural regeneration and maintenance of the all elements of the plant communities found there.

Non-zero baseline values are proposed for the six listed, candidate, or SOC species that were observed in the field (Table 4). The only listed Endangered species documented from the survey area was *Asplenium peruvianum var. insulare*. We found just one plant of this species at only one location (Transect 7, near Station 8) (Figure 5). The most abundant of the non-zero baseline species was *Eragrostis deflexa*, found in 10 (7%) of the plots surveyed and at several locations between stations. Three individual trees of *Chamaesyce olowaluana* were found in each of three plots; all of the other species in this group were found in just one plot during the survey. Subsequent monitoring of the site will be necessary to determine if the populations of these plants have increased or decreased relative to their baseline values.

Table 4 also includes proposed zero baseline values for 23 other species that were predicted by Price, *et al*.'s (2007) modeling, or from other sources, but were not found within the project area during this survey. These include 14 Endangered species, one Threatened species, one candidate for listing, and six species of concern. Although most of the predicted species have never been documented within this specific site, it is possible that they may colonize the area from adjacent populations in similar habitat, or may be intentionally reintroduced into the Lupea Project area at a future date.

Recommendations for Subsequent Plant Species and Community Monitoring

For future surveys it will be important to monitor the specific sites that *Asplenium peruvianum var. insulare* and the other non-zero baseline species were located in 2003 - 2004, as well as repeat the surveys at the established stations and plots to document changes in these populations across the landscape. Changes in population status for these plant species would be recognized if their frequency of occurrence increased or decreased from the baseline values. For example, *Asplenium peruvianum var. insulare* would be considered to be at baseline if just one plant is recorded in a subsequent survey.

Observing it on more than one station would be considered to be an increase in the population for the area. Changes in numbers of individuals should also be recorded by size class to document trends in the population units. Individuals that have been out-planted to augment the existing populations, or reintroduced individuals of the baseline species that are predicted for the area but not found during the initial surveys, should be considered as new additions to the wild populations.

CONCLUSIONS

The area that Kamehameha Schools has proposed for conservation management in the Lupea Project area has a unique geography that contains excellent examples of several high elevation native plant communities including montane dry forest and woodland, native subalpine shrubland, and native grassland. Although only one Endangered species was found within the proposed project area, future management actions may lead to the restoration of several listed or otherwise rare plant species currently known from the area, as well as a number of other of other taxa that were formerly found in or near this habitat. The conservation management actions may also eventually result in a habitat suitable for reintroduction of the Endangered Palila to this area which it previously occupied. The baseline values proposed for the currently listed or otherwise rare plant species found during the 2003 - 2004 surveys will allow Kamehameha Schools and its cooperators to monitor the direction of change in these populations over time as a result of their habitat restoration management actions.

ACKNOWLEDGEMENTS

We particularly thank Tanya Rubenstein of the Three Mountain Alliance who helped with developing the survey concepts, as well as keeping the overall project moving forward. Additionally, this work could not have been completed without the close cooperation of many people from Kamehameha Schools, particularly Peter Simmons, Namaka Whitehead, Tonnie Casey, Dale Fergerstrom, and Robert Lindsey. Funding for this survey was provided by the Hawai„i Division of Forestry and Wildlife and the U.S. Fish and Wildlife Service's Pacific Islands Fish and Wildlife Office, Honolulu. Administrative support was provided through the U.S. Geological Survey's Hawai'i Cooperative Studies Unit, Pacific Aquaculture and Coastal Resources Center at the University of Hawai„i at Hilo; as well as the U.S. Geological Survey's Pacific Island Ecosystems Research Center. Linda Pratt, Chris Farmer, Marie Bruegmann, and Tanya Rubenstein reviewed the manuscript and provided many helpful comments that were incorporated into the final version of this report.

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Table 1. Additional plant species predicted for the Lupea Project area based on spatial modeling by Price et al. (2007).

Taxon	Common Name	[1]Status	Family	Category
Bidens campylotheca Sch.Bip.	ko,,oko,,olau, ko,,olau	SOC	Asteraceae	Dicot
Bidens micrantha Gaudich.	ko,,oko,,olau, ko,,olau		Asteraceae	Dicot
Carex macloviana d'Urv.			Cyperaceae	Monocot
Carex meyenii Nees			Cyperaceae	Monocot
Chamaesyce celastroides (Boiss.) Croizat & O.Deg.	,,akoko, koko, ,,ekoko, kōkōmālei		Euphorbiaceae	Dicot
Cyperus fauriei Kūk.		E	Cyperaceae	Monocot
Cyperus hillebrandii Boeck.			Cyperaceae	Monocot
Cystopteris douglasii Hook.		SOC	Athyriaceae	Fern
Delissea undulata Gaudich.		E	Campanulaceae	Dicot
Diplazium sandwichianum (C.Presl) Diels	hō,,i,o, pohole (Maui)		Athyriaceae	Fern
Dryopteris glabra (Brack.) Kuntze	kēlau, hohiu		Dryopteridaceae	Fern
Dubautia arborea (A.Gray) D.D.Keck	na,,ena,,e, kūpaoa	SOC	Asteraceae	Dicot
Dubautia linearis (Gaudich.) D.D.Keck	na,,ena,,e, kūpaoa		Asteraceae	Dicot
Eragrostis atropioides Hillebr.	lovegrass		Poaceae	Monocot
Eragrostis grandis Hillebr.	lovegrass		Poaceae	Monocot
Eragrostis monticola (Gaudich.) Hillebr.	kalamālō		Poaceae	Monocot
Eragrostis variabilis (Gaudich.) Steud.	kāwelu, ,,emoloa, kalamālō		Poaceae	Monocot
Exocarpos gaudichaudii A.DC.	hulumoa, kaumahana, heau, au	SOC	Santalaceae	Dicot
Exocarpos menziesii Stauffer	heau, au		Santalaceae	Dicot
Festuca hawaiiensis Hitchc.	fescue	C	Poaceae	Monocot
Haplostachys haplostachya (A.Gray) H.St.John	honohono	E	Lamiaceae	Dicot
Hesperocnide sandwicensis (Wedd.) Wedd.			Urticaceae	Dicot
Kadua coriacea (Sm.) W.L.Wagner & Lorence	kio,,ele	E	Rubiaceae	Dicot
Korthalsella complanata (Tiegh.) Engl.	hulumoa, kaumahana		Viscaceae	Dicot
Korthalsella cylindrica (Tiegh.) Engl.	hulumoa, kaumahana		Viscaceae	Dicot
Melanthera subcordata (A.Gray) W.L.Wagner & H.Rob.	nehe		Asteraceae	Dicot
Melicope hawaiensis (Wawra) T.G.Hartley & B.C.Stone	mokihana kūkae moa, manena, alani, alani kuahiwi	SOC	Rutaceae	Dicot
Panicum konaense Whitney & Hosaka			Poaceae	Monocot
Panicum pellitum Trin.	kāi,,oi,,o (Ni,,ihau)		Poaceae	Monocot
Peperomia blanda (Jacq.) Kunth	,,ala,,ala wai nui		Piperaceae	Dicot
Peperomia tetraphylla (G.Forst.) Hook. & Arn.	,,ala,,ala wai nui		Piperaceae	Dicot
Pittosporum confertiflorum A.Gray	hō,,awa, hā,,awa		Pittosporaceae	Dicot

Table 1. (Continued).

Taxon	Common Name	Status	Family	Category
Portulaca sclerocarpa A.Gray	po,,e, ,,ihi, ,,ihi mākole	E	Portulacaceae	Dicot
Pouteria sandwicensis (A.Gray) Baehni & O.Deg.	,,āla,,a, āulu, ,,ēla,,a,kaulu		Sapotaceae	Dicot
Ranunculus hawaiensis A.Gray	makou, ,,awa Kanaloa	C	Ranunculaceae	Dicot
Sadleria cyatheoides Kaulf.	,,ama,,u, ma,,u, ma,,uma,,u, pua,,a ,ehu,,ehu, ,,ama,,uma,,u		Blechnaceae	Fern
Schiedea hawaiiensis Hillebr.		SOC	Caryophyllaceae	Dicot
Sicyos anunu (H.St.John) I.Telford	,,ānunu		Cucurbitaceae	Dicot
Silene hawaiiensis Sherff		T	Caryophyllaceae	Dicot
Silene lanceolata A.Gray		E	Caryophyllaceae	Dicot
Smilax melastomifolia Sm.	hoi kuahiwi, aka,,awa, pi,,oi (Kaua,,i), uhi, ulehihi		Smilacaceae	Monocot
Solanum incompletum Dunal	pōpolo kū mai, pōpolo	E	Solanaceae	Dicot
Spermolepis hawaiiensis C.F.Wolff		E	Apiaceae	Dicot
Stenogyne angustifolia A.Gray		E	Lamiaceae	Dicot
Stenogyne rugosa Benth.	mā ,,ohi,,ohi		Lamiaceae	Dicot
Tetramolopium arenarium (A.Gray) Hillebr.		E	Asteraceae	Dicot
Zanthoxylum hawaiiense Hillebr.	a,,e, mānele, hea,,e	E	Rutaceae	Dicot

[1]STATUS: E = Endangered; T = Threatened; C = candidate for listing; SOC = rare "species of concern"

Table 2. Plant species observed in the field but not predicted for the Lupea Project area.

Taxon	Common Name	[1]Status	Family	Category
Asplenium polyodon G.Forst.	pūnana manu		Aspleniaceae	Fern
Cyrtomium caryotideum (Wall.) C.Presl	kā,,ape,,ape, ,,āhina kuahiwi		Dryopteridaceae	Fern
Pittosporum hosmeri Rock	hō,,awa, hā,,awa, ,,a,,awa, ,,a,,awa hua kukui		Pittosporaceae	Dicot
Polystichum hillebrandii Carruth.	ka,,upu, papa,,oi		Dryopteridaceae	Fern
Sisyrinchium acre Mann	mau,,u lā,,ili, mau,,u hō,,ula ,,ili	SOC	Iridaceae	Monocot

[1]STATUS: SOC = rare "species of concern"

Table 3. Invasive plant species found within the Lupea Project area.

Taxon	Common Name	Family	[1]Plot Freq	[2]Hawai'i Noxious	[3]WRA Rank	Comments
Delairea odorata Lem.	German ivy	Asteraceae	19%		High (14)	Syn: *Senecio mikanoides*
Passiflora tarminiana Coppens & Barney	banana poka	Passifloraceae	1%	Y		Syn: *Passiflora mollisima*
Pennisetum clandestinum Hochst. ex Chiov.	Kikuyu grass	Poaceae	27%		High (18)	
Pennisetum setaceum (Forssk.) Chiov.	fountain grass	Poaceae	20%	Y	High (26)	
Rubus niveus Thunb.	Mysore raspberry	Rosaceae	1%	Y		
Senecio madagascariensis Poir.	fireweed	Asteraceae	1%	Y	High (23)	
Verbascum thapsus L.	common mullein	Scrophulariaceae	29%	Y		Not always recorded

[1]Station Freq. = percent of plots surveyed that contained this species (n=143)
[2]Hawai,,i Noxious = Listed on the State of Hawai,,i Noxious Weed List (Hawai,,i Division of Plant Industry 2003)
[3]WRA Rank = Rank for this species from the Hawai,,i Weed Risk Assessment; actual score given in parentheses (Daehler and Denslow 2009)

Table 4. Proposed baseline levels for observed and predicted rare plant species in plots surveyed within the Lupea Project area.

Taxon	Status	Baseline		
		Observed	Count	Frequency
Observed during surveys				
Asplenium peruvianum Desv. var. *insulare* (C. V. Morton) D. D. Palmer	E	Y	1	0.7%
Chamaesyce olowaluana (Sherff) Croizat & O.Deg.	SOC	Y	3	2.1%
Eragrostis deflexa Hitchc.	SOC	Y	10	7.0%
Sicyos macrophyllus A.Gray	C	Y?	1	0.7%
Sisyrinchium acr e Mann	SOC	Y	1	0.7%
Tetramolopium consanguineum (A.Gray) Hillebr.	SOC	Y	1	0.7%
Predicted by Price et al. (2007) for project area but not observed during field survey		**Baseline**		
	Status	**Observed**	**Count**	**Frequency**
Bidens campylotheca Sch.Bip.	SOC	N	0	0%
Cyperus fauriei Kük.	E	N	0	0%
Cystopteris douglasii Hook.	SOC	N	0	0%
Delissea undulata Gaudich.	E	N	0	0%
Dubautia arborea (A.Gray) D.D.Keck	SOC	N	0	0%
Exocarpos gaudichaudii A.DC.	SOC	N	0	0%
Festuca hawaiiensis Hitchc.	C	N	0	0%
Haplostachys haplostachya (A.Gray) H.St.John	E	N	0	0%
Kadua coriacea (Sm.) W.L.Wagner & Lorence	E	N	0	0%
Melicope hawaiensis (Wawra) T.G.Hartley & B.C.Stone	SOC	N	0	0%
Portulaca sclerocarpa A.Gray	E	N	0	0%
Ranunculus hawaiensis A.Gray	C	N	0	0%
Schiedea hawaiiensis Hillebr.	SOC	N	0	0%
Silene hawaiiensis Sherff	T	N	0	0%
Silene lanceolata A.Gray	E	N	0	0%
Solanum incompletum Dunal	E	N	0	0%
Spermolepis hawaiiensis C.F.Wolff	E	N	0	0%
Stenogyne angustifolia A.Gray	E	N	0	0%
Tetramolopium arenarium (A.Gray) Hillebr.	E	N	0	0%
Zanthoxylum hawaiiense Hillebr.	E	N	0	0%
Other possible listed species for the project area but not predicted by Price		**Baseline**		
	Status	**Observed**	**Count**	**Frequency**
Argyroxiphium kauense (Rock & M. Neal) O. Deg. & I. Deg.	E	N	0	0%
Neraudia ovata Gaudich.	E	N	0	0%
Nothocestrum breviflorum A. Gray	E	N	0	0%

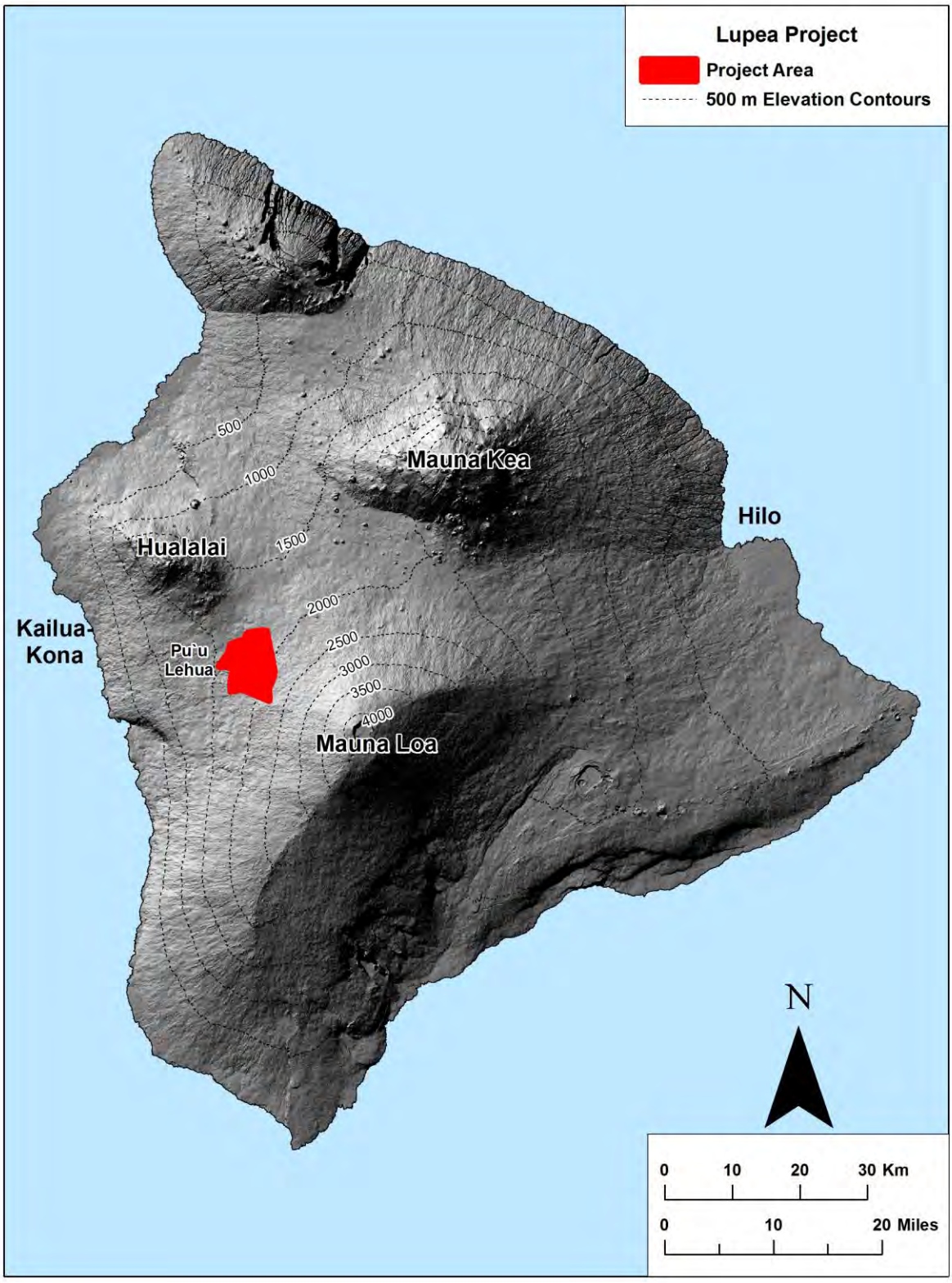

Figure 1. Location of the Lupea Project area on the island of Hawai,,i.

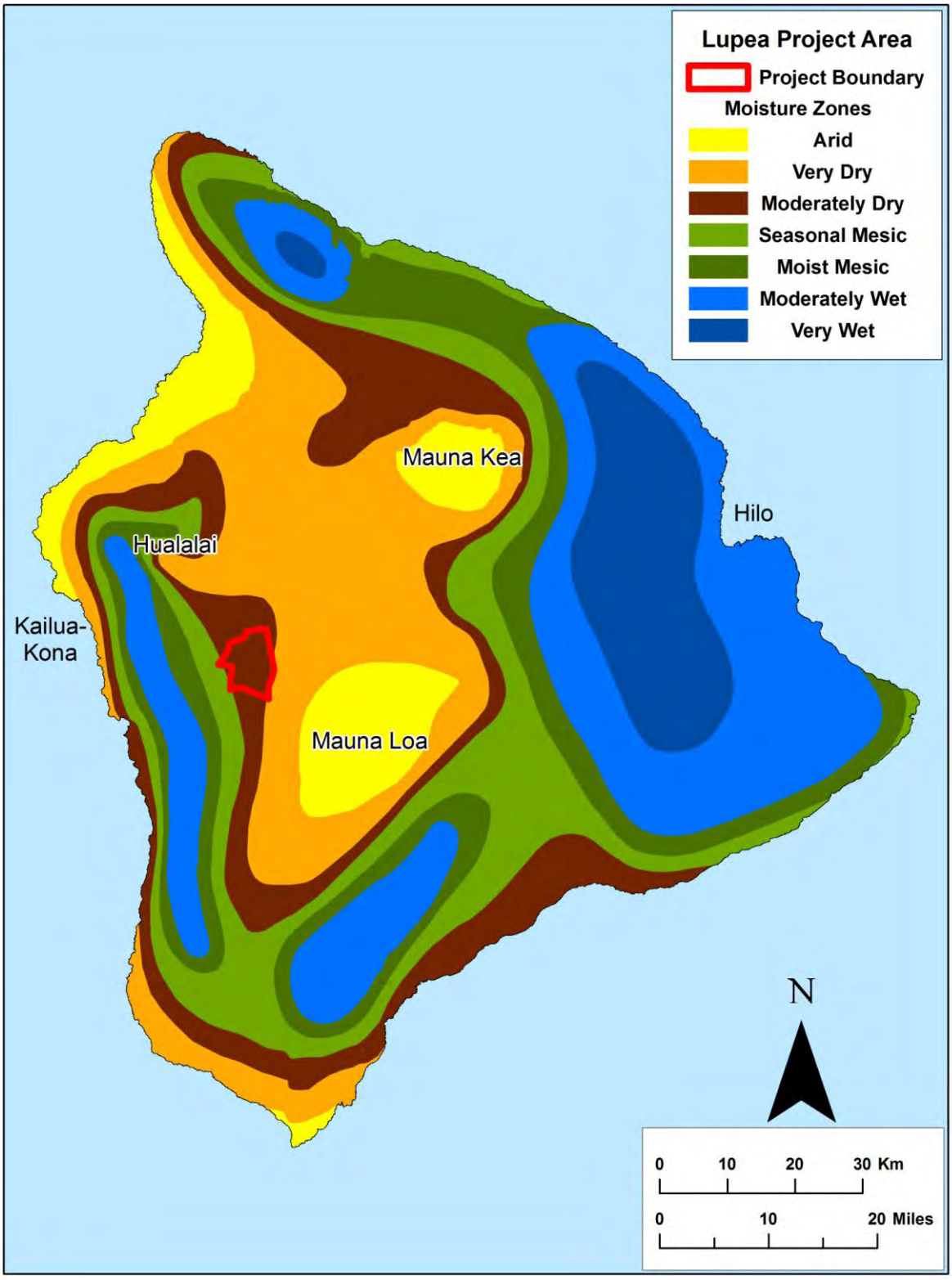

Figure 2. Relationship of the Lupea Project area to moisture zones on the island of Hawai„i mapped by Price et al. (2007).

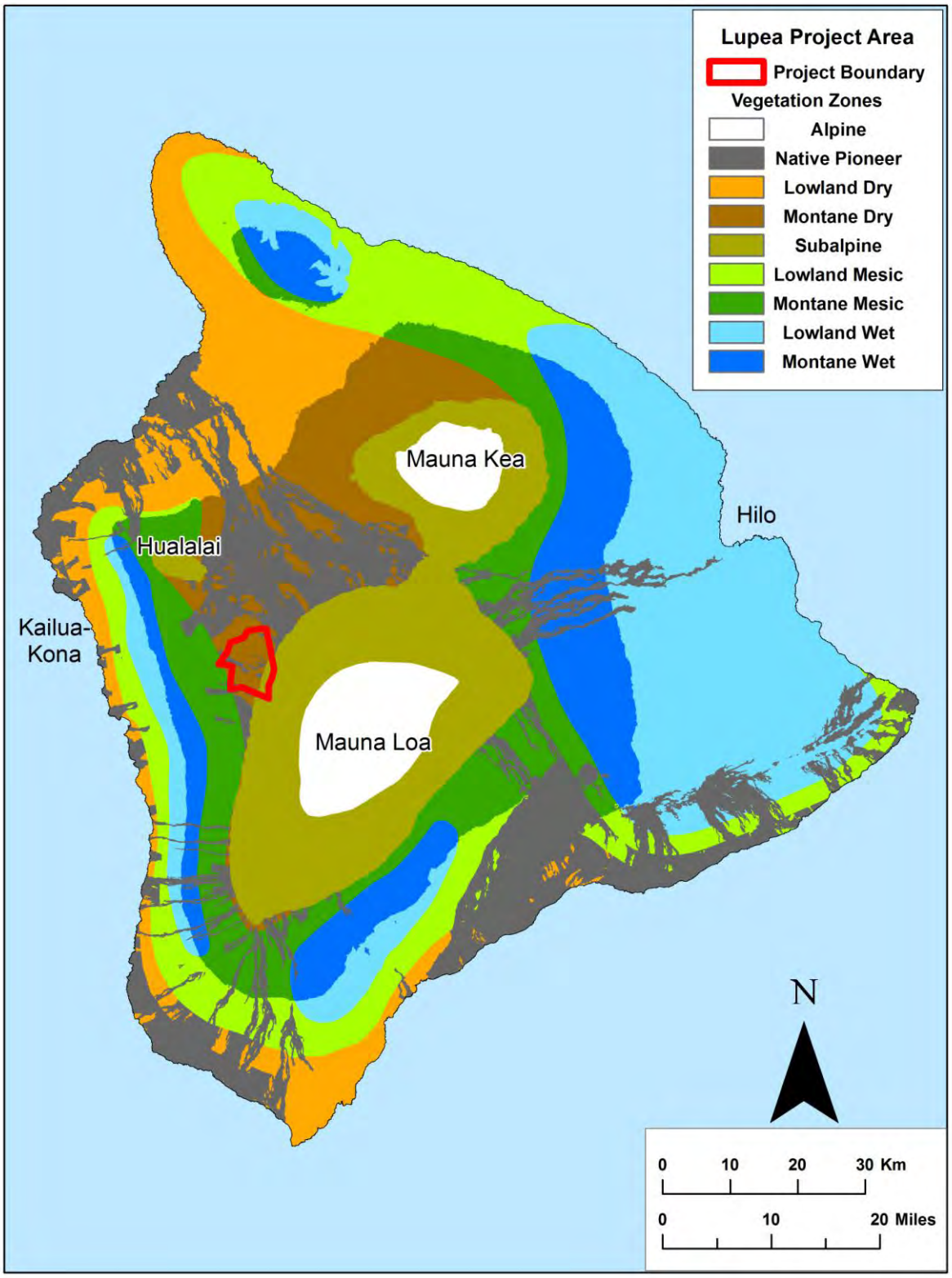

Figure 3. Relationship of the Lupea Project area to vegetation zones mapped by Price and Jacobi (U.S.Geological Survey, unpublished data).

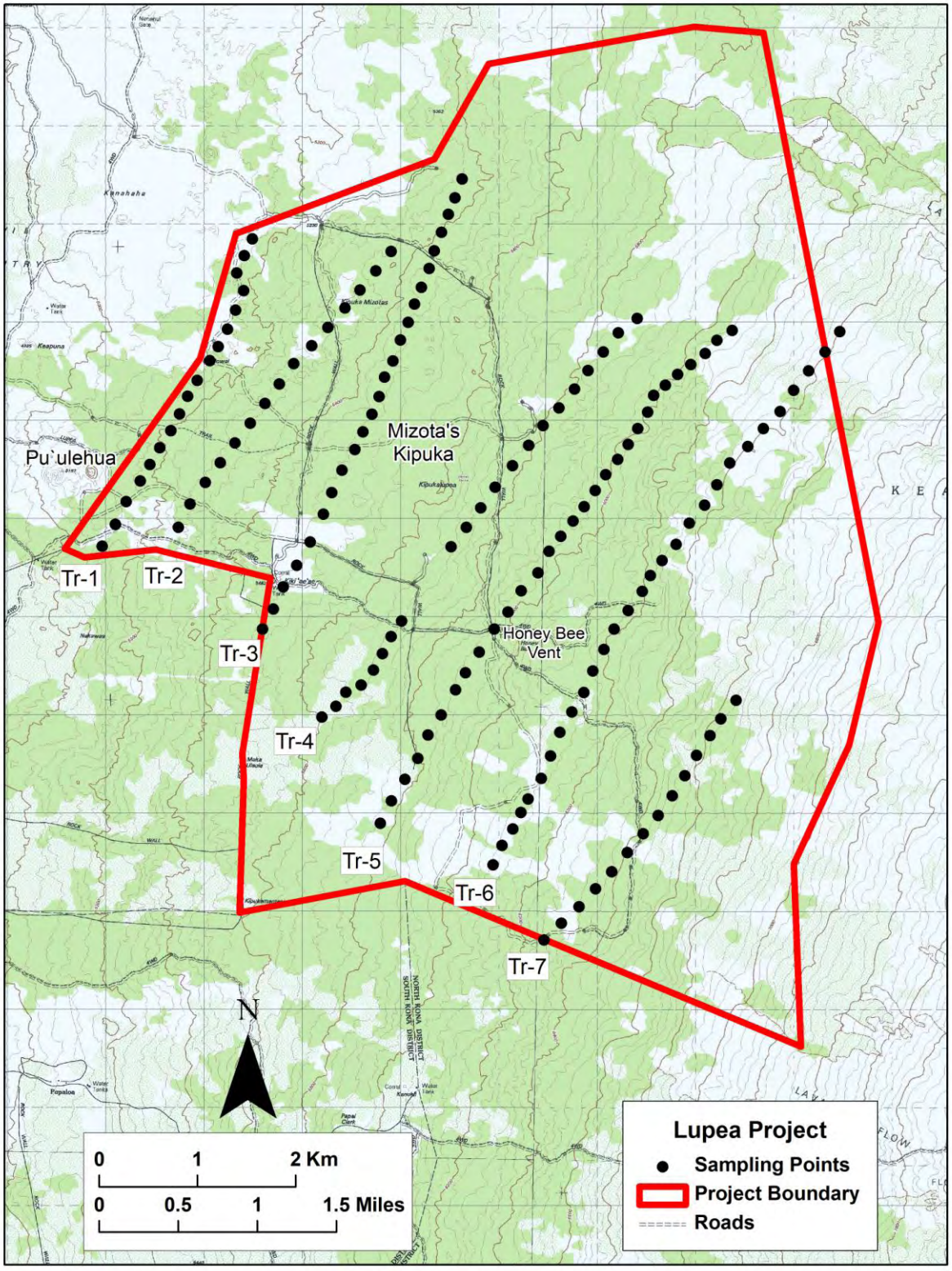

Figure 4. Transects and sampling points established within the Lupea Project area.

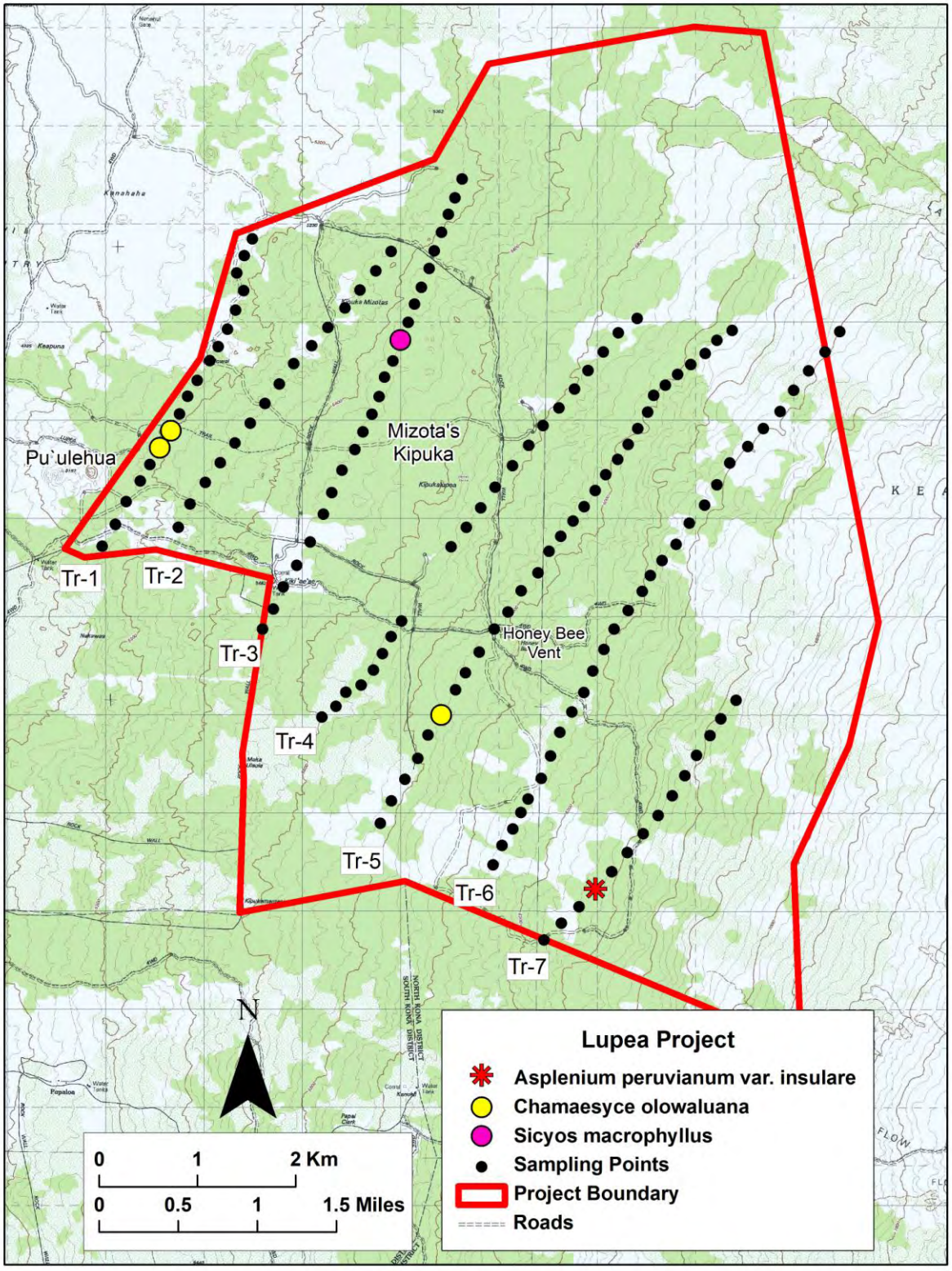

Figure 5. Location of *Asplenium peruvianum var. insulare*, *Chamaesyce olowaluana*, and *Sicyos macrophyllus* plants found during the 2003 - 2004 survey of the Lupea Project area.

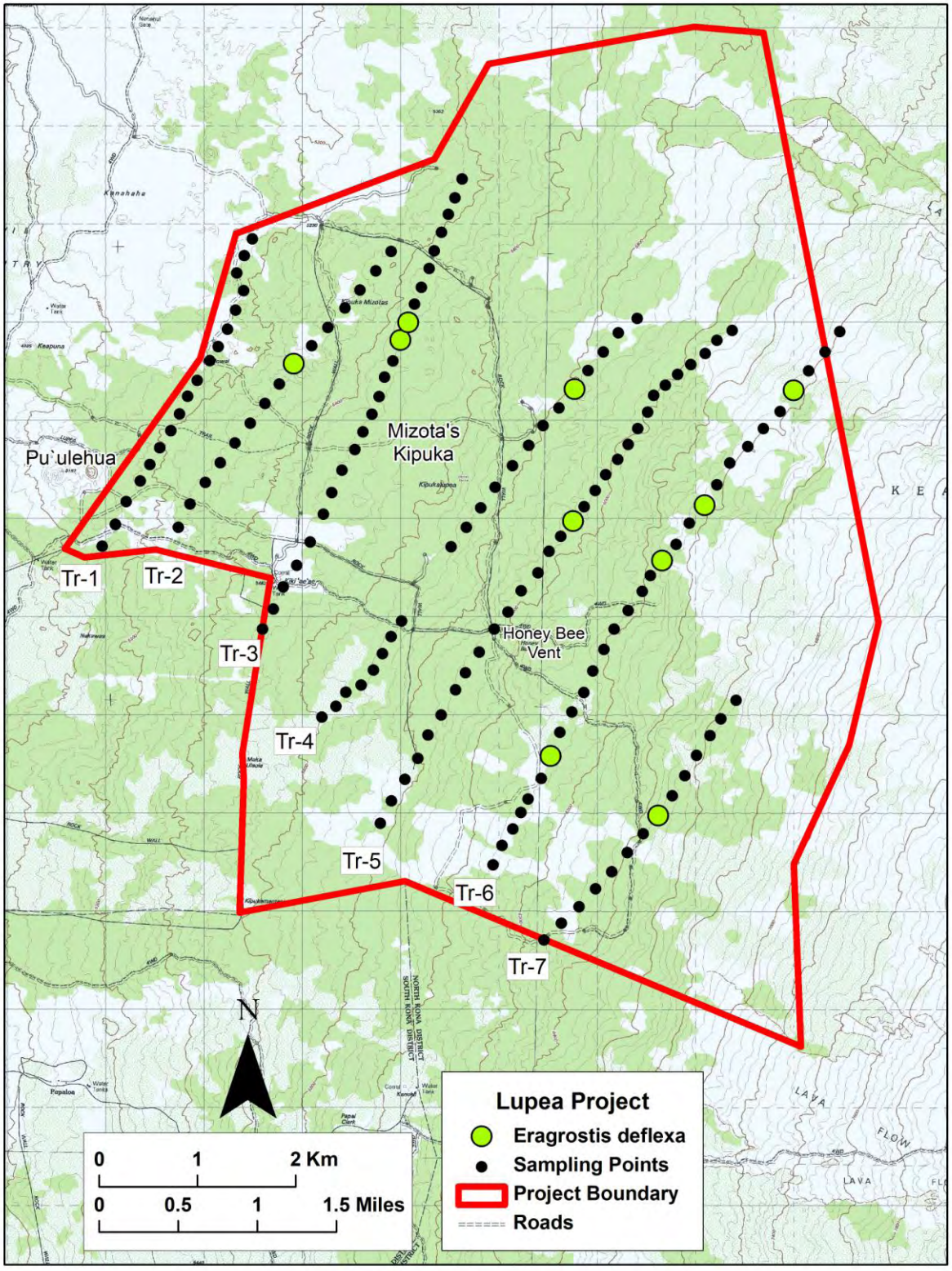

Figure 6. Location of *Eragrostis deflexa* plants found during the 2003 - 2004 survey of the Lupea Project area.

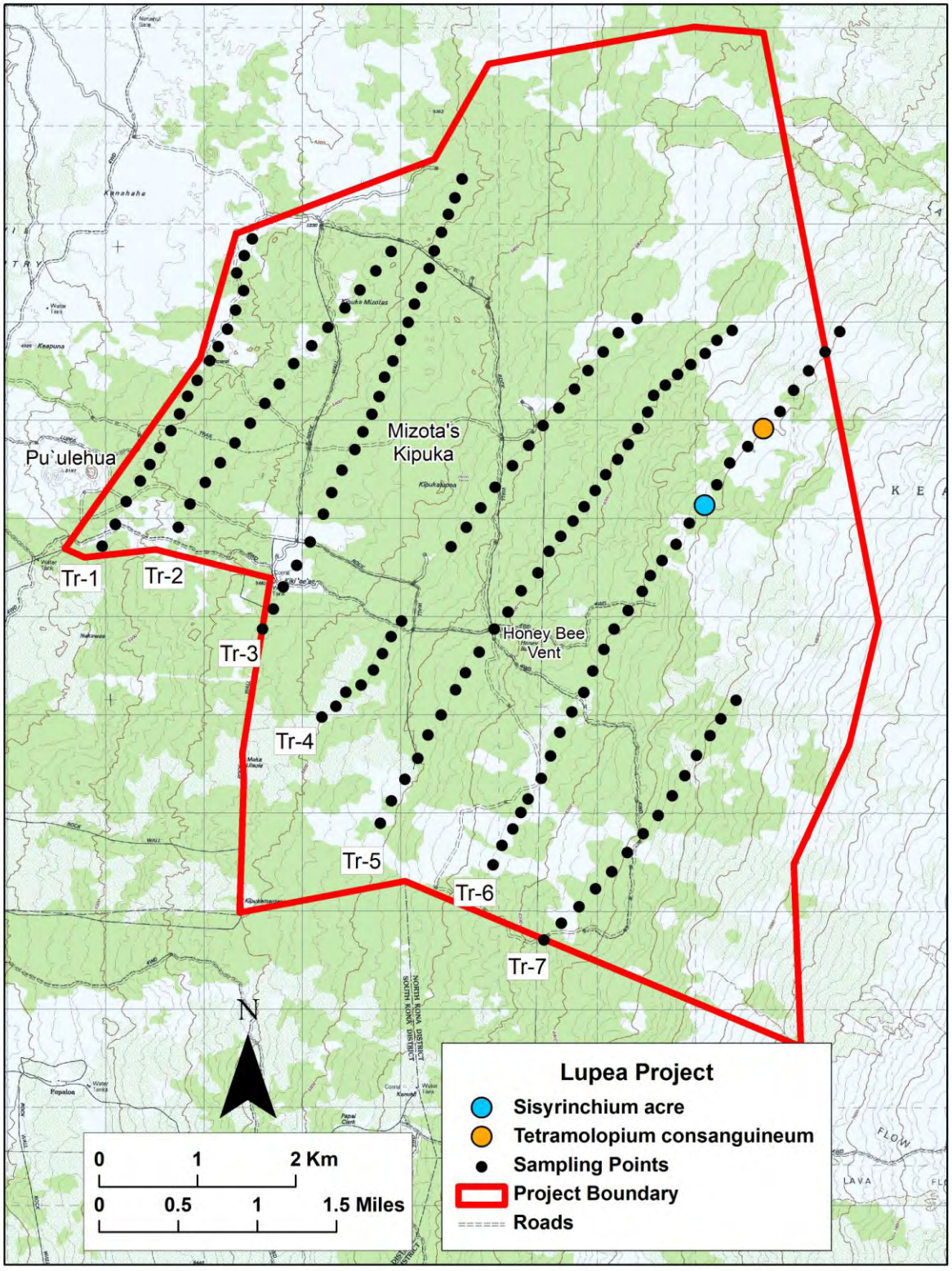

Figure 7. Location of *Sisyrinchium acre* and *Tetramolopium consanguineum* plants found during the 2003 - 2004 survey of the Lupea Project area.

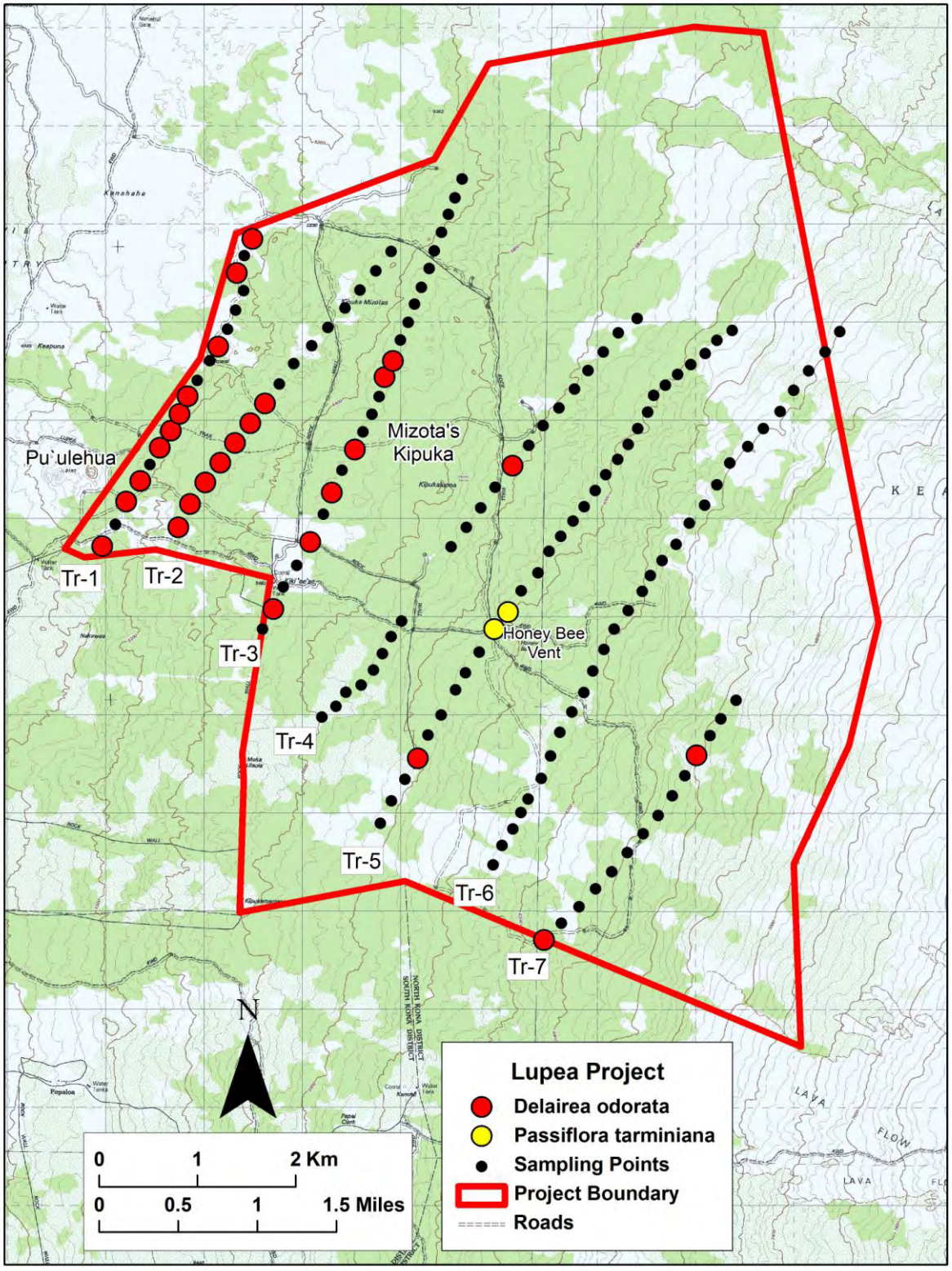

Figure 8. Location of *Delairea odorata* and *Passiflora tarminiana* plants found during the 2003 - 2004 survey of the Lupea Project area.

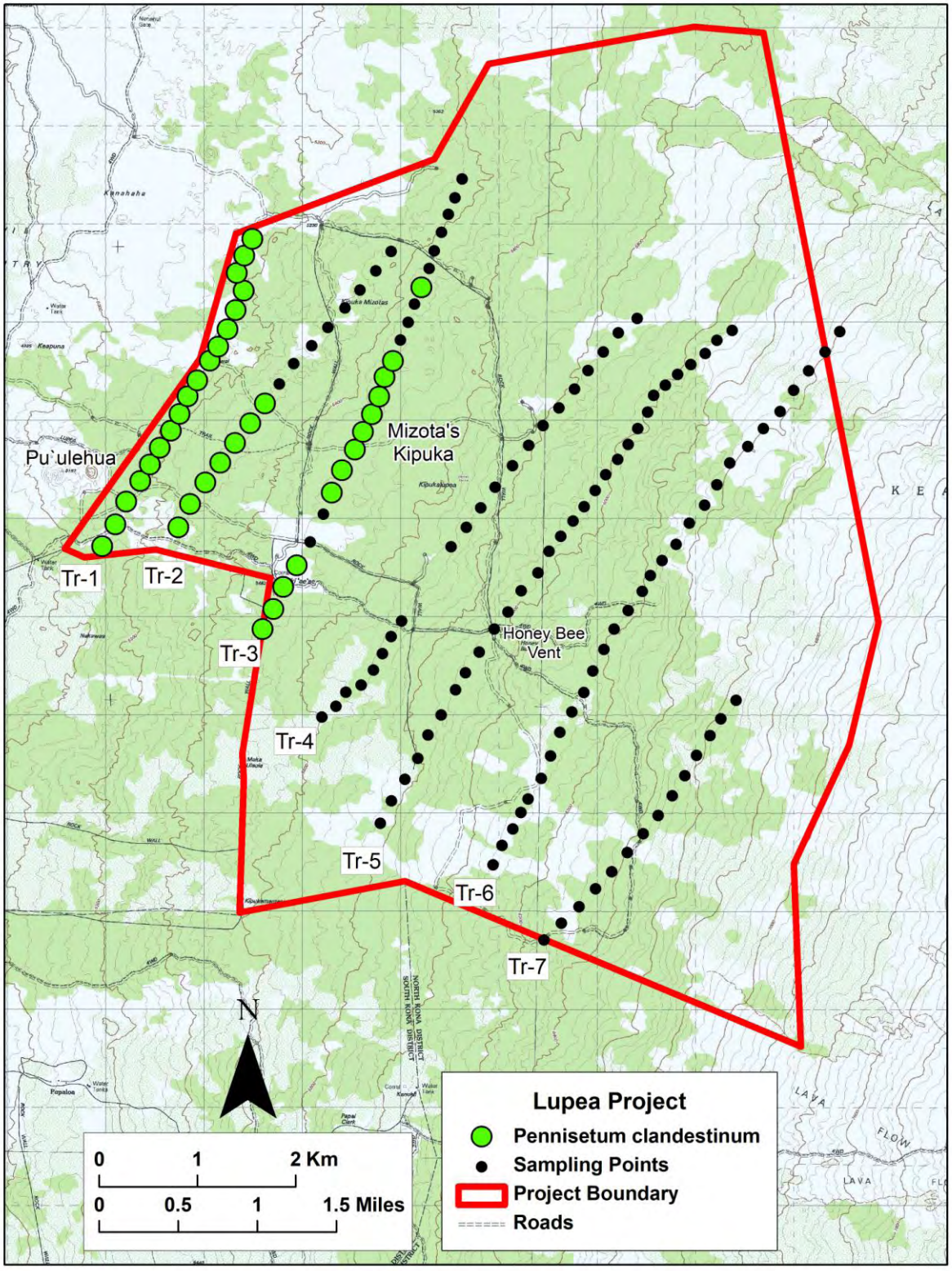

Figure 9. Location of *Pennisetum clandestinum* plants found during the 2003 - 2004 survey of the Lupea Project area.

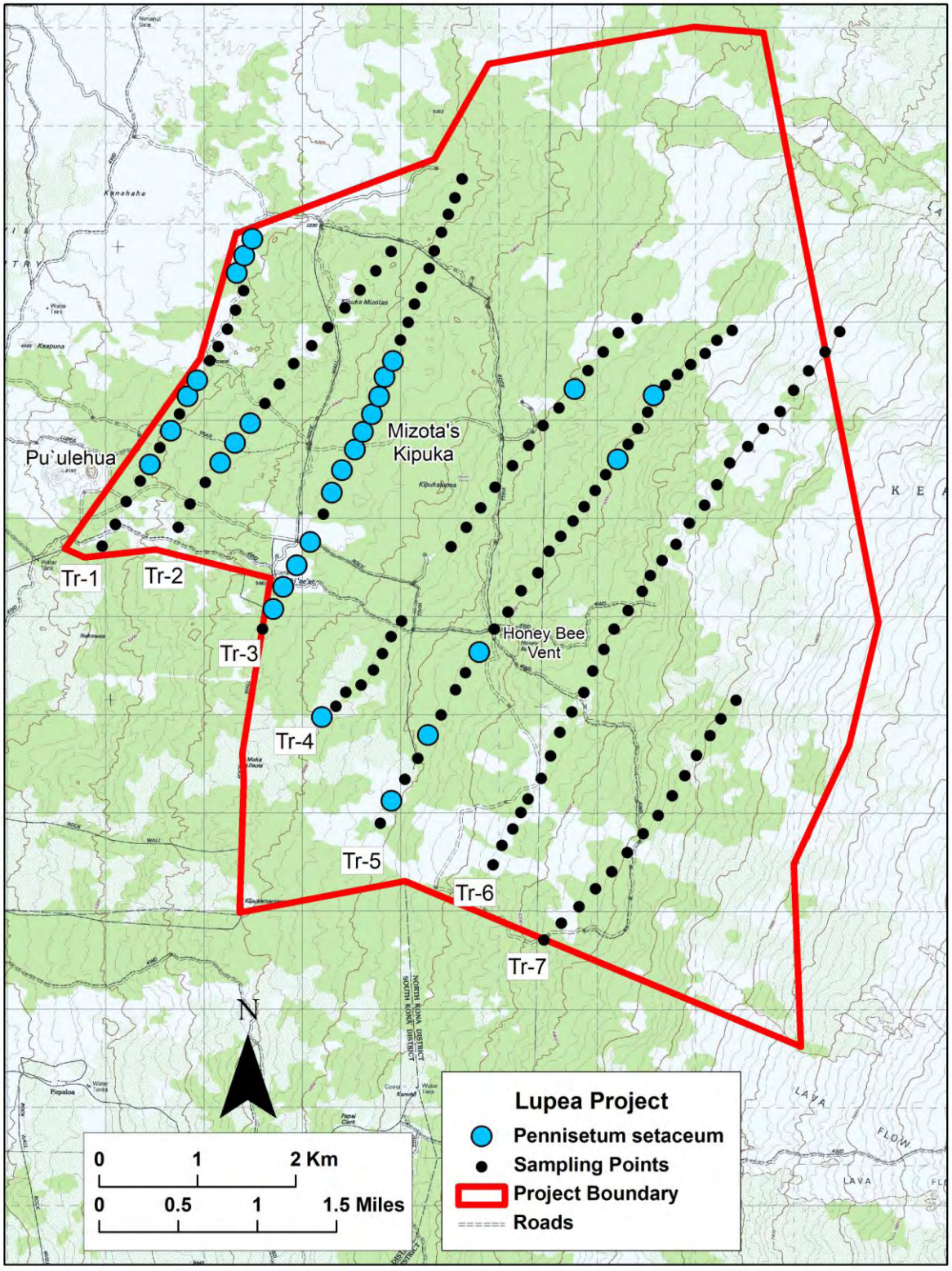

Figure 10. Location of *Pennisetum setaceum* plants found during the 2003 - 2004 survey of the Lupea Project area.

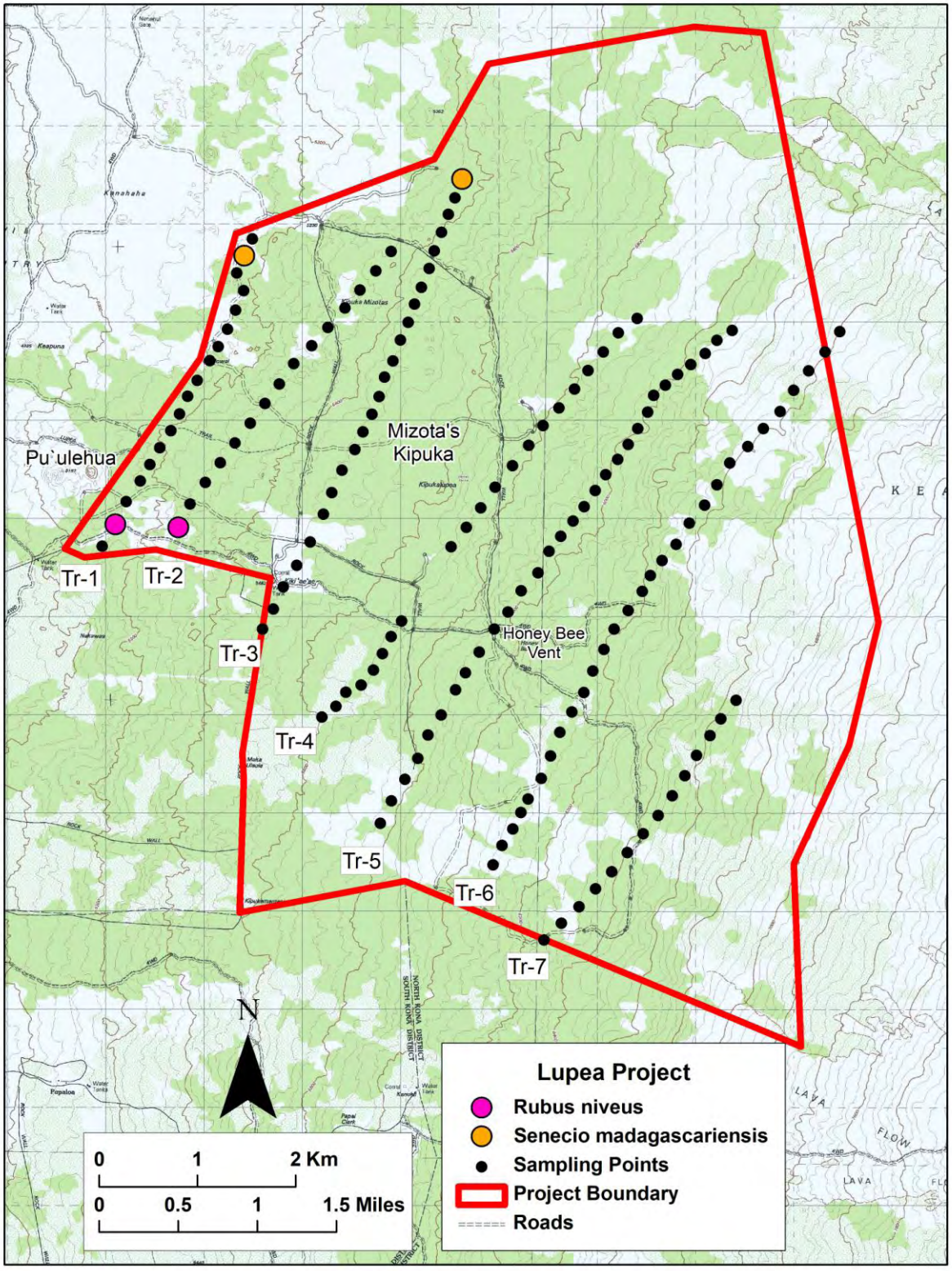

Figure 11. Location of *Rubus niveus* and *Senecio madagascariensis* plants found during the 2003 - 2004 survey of the Lupea Project area.

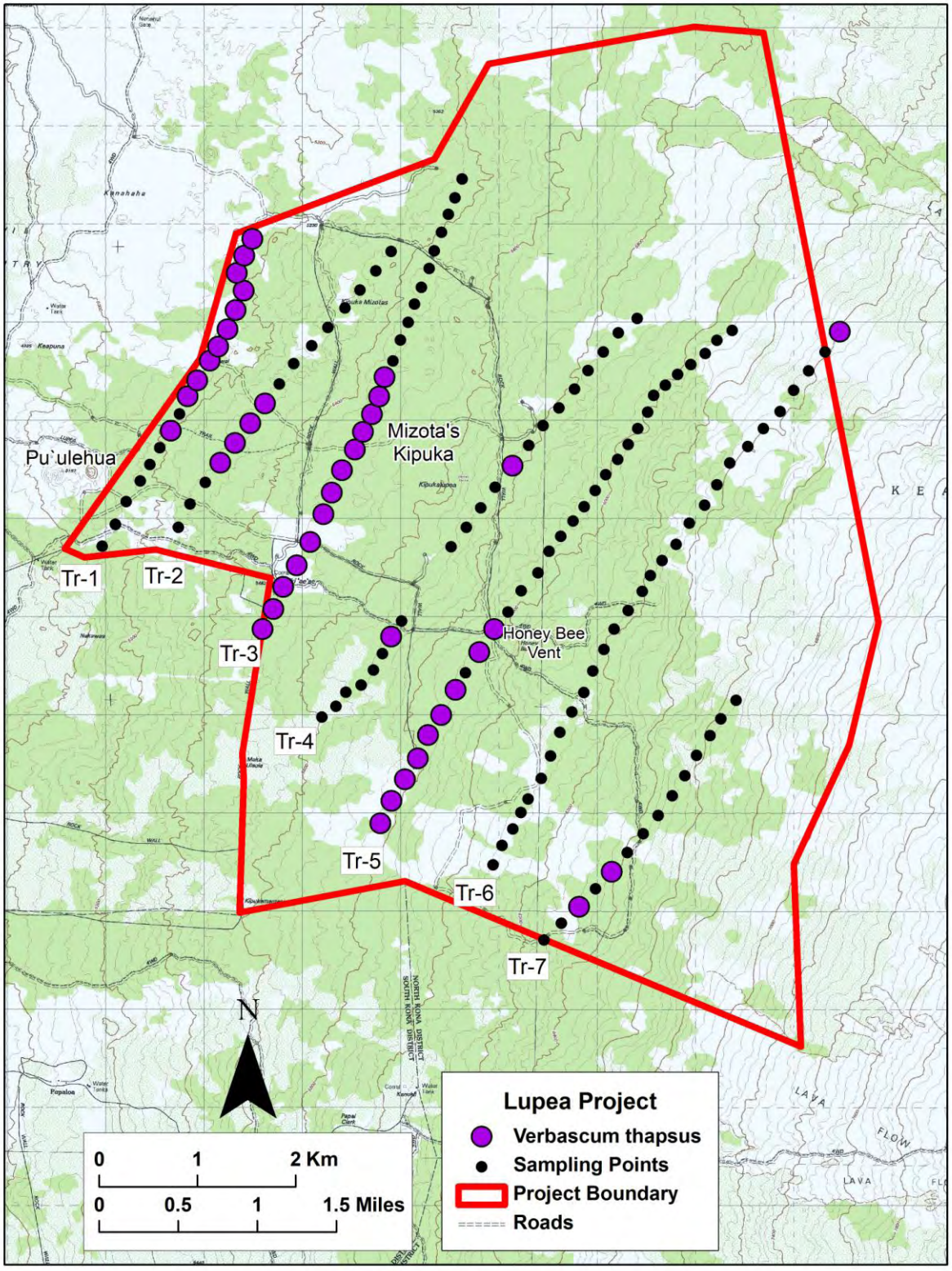

Figure 12. Location of *Verbascum thapsus* plants found during the 2003 - 2004 survey of the Lupea Project area.

Appendix 1. Plant species observed during the survey of the Lupea Project area in 2003 - 2004.

Taxon	Common Name	[1]Origin	[2]Status	Family	Notes
Ferns					
Asplenium adiantum-nigrum L.	,,iwa,,iwa	ind		Aspleniaceae	
Asplenium aethiopicum (Burm.f.) Bech.	,,iwa,,iwa a Kane	ind		Aspleniaceae	
Asplenium peruvianum Desv. var. *insulare* (C. V. Morton) D. D. Palmer		end	E	Aspleniaceae	Listed by U.S. FWS as *Asplenium fragile* var. *insulare*
Asplenium polyodon G.Forst.	pūnana manu	ind		Aspleniaceae	
Asplenium trichomanes L. subsp. densum (Brack.) W. H. Wagner	,,ōali,,i	end		Aspleniaceae	
Cyrtomium caryotideum (Wall.) C.Presl	ka,,ape,,ape, ,,ahina kuahiwi	ind		Dryopteridaceae	
Dryopteris wallichiana (Spreng.) Hyl.	,,i,,o nui,laukahi	ind		Dryopteridaceae	
Lepisorus thunbergianus (Kaulf.) *Ching*	pakahakaha, ,,ēkaha ,,akōlea, pua,,a kuhinia	ind		Polypodiaceae	
Pellaea ternifolia (Cav.) Link	kalamoho lau li,,i, laukahi, kalamoho	ind		Pteridaceae	
Polypodium pellucidum Kaulf.	,,ae, ,,ae lau nui	end		Polypodiaceae	
Polystichum hillebrandii Carruth.	ka,,upu, papa,,oi	end		Dryopteridaceae	
Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaudich.) R. M. Tryon	kīlau, kīlau pueo, pai,,a, bracken fern	end		Dennstaedtiaceae	
Pteris cretica L.	,,ōali, cretan brake	ind		Pteridaceae	
Monocots					
Agrostis sandwicensis Hillebr.		end		Poaceae	
Anthoxanthum odoratum L.	sweet vernalgrass	X		Poaceae	
Bromus catharticus Vahl	rescue grass	X		Poaceae	
Bulbostylis capillaris (L.) C.B.Clarke		X		Cyperaceae	
Carex wahuensis C.A.Mey.		end		Cyperaceae	
Deschampsia nubigena Hillebr.	hairgrass	end		Poaceae	
Dianella sandwicensis Hook. & Arn.	,,uki,,uki, ,,uki	ind		Liliaceae	
Ehrharta stipoides Labill.	meadow ricegrass	X		Poaceae	

Taxon	Common Name	Origin	Status	Family	Notes
Eragrostis brownei (Kunth) Nees ex Steud.	sheepgrass	X		Poaceae	
Eragrostis deflexa Hitchc.	lovegrass	end	SOC	Poaceae	
Eragrostis leptophylla Hitchc.	lovegrass	end		Poaceae	
Fimbristylis dichotoma (L.) Vahl		ind		Cyperaceae	
Lachnagrostis filiformis Trin.	he,,upueo	ind		Poaceae	Synonym: *Agrostis avenacea*
Luzula hawaiiensis Buchenau	wood rush	end		Juncaceae	
Melinis repens (Willd.) Zizka	natal redtop, natal grass	X		Poaceae	
Morelotia gahniiformis Gaudich.		end		Cyperaceae	
Panicum tenuifolium Hook. & Arn.	mountain pili	end		Poaceae	
Pennisetum clandestinum Hochst. ex Chiov.	Kikuyu grass	X		Poaceae	
Pennisetum setaceum (Forssk.) Chiov.	fountain grass	X		Poaceae	
Setaria parviflora (Poir.) Kerguélen	yellow foxtail, perennial foxtail, mau,, Kaleponi	X		Poaceae	
Sisyrinchium acre Mann	mau,,u la,,ili, mau,,u hō,,ula ,,ili	end	SOC	Iridaceae	
Sporobolus africanus (Poir.) Robyns & Tournay	smutgrass, African dropseed, rattail grass	X		Poaceae	
Trisetum glomeratum (Kunth) Trin.	pili uka, he,,upueo (Hawai,,i), mountain pili	end		Poaceae	
Vulpia myuros (L.) C.C.Gmel.	rattail fescue	X		Poaceae	
Dicots					
Acacia koa A.Gray	koa	end		Fabaceae	
Achillea millefolium L.	common yarrow, milfoil	X		Asteraceae	
Ageratina riparia (Regel) R.M.King & H.Rob.	Hamakua pamakani, spreading mist flower	X		Asteraceae	
Alyxia stellata (J.R.Forst. & G.Forst.) Roem. & Schult.	maile	ind		Apocynaceae	
Anagallis arvensis L.	scarlet pimpernel, poor man's weatherglass	X		Primulaceae	
Argemone glauca (Nutt. ex Prain) Pope	pua kala, kala, naule, pōkalakala	end		Papaveraceae	
Bidens menziesii (A.Gray) Sherff	ko,,oko,,olau, ko,,olau	end		Asteraceae	

Taxon	Common Name	Origin	Status	Family	Notes
Bidens pilosa L.	Spanish needle, beggartick, kī, kī nehe, kī pipili, nehe	X		Asteraceae	
Cardamine flexuosa With.	bittercress	X		Brassicaceae	
Centaurium erythraea Raf.	bitter herb, European centaury	X		Gentianaceae	
Chamaesyce olowaluana (Sherff) Croizat & O.Deg.	,,akoko, koko, ,,ekoko, kōkōmalei	end	SOC	Euphorbiaceae	
Chenopodium murale L.	goosefoot, pigweed, lamb's quarters, ,,aheahea	X		Chenopodiaceae	
Chenopodium oahuense (Meyen) Aellen	,,aheahea, ,,ahea, ,,ahewahewa, alaweo, alaweo huna (Ni,,ihau), ,,aweoweo, kaha,,iha,i	end		Chenopodiaceae	
Cirsium vulgare (Savi) Ten.	bull thistle, pua kala	X		Asteraceae	
Cocculus orbiculatus (L.) DC.	huehue, hue, hue,,ie, ,,inalua	ind		Menispermaceae	
Conyza canadensis (L.) Cronquist	horseweed, lani wela, ilioha, ,,awī,,awī, pua mana	X		Asteraceae	
Coprosma ernodeoides A.Gray	,,aiakanēnē, kūkaenēnē, leponēnē, nēnē, pūnēnē, pilo, hupilo	end		Rubiaceae	
Coprosma menziesii A.Gray	pilo, hupilo	end		Rubiaceae	
Coprosma montana Hillebr.	pilo, hupilo	end		Rubiaceae	
Daucus pusillus Michx.	American carrot	X?		Apiaceae	
Delairea odorata Lem.	German ivy, Italian ivy	X		Asteraceae	
Dodonaea viscosa Jacq.	,,a,,ali,,i, ,,a,,ali,,i kū makani, ,,a,,ali,,i kū ma kua, kūmakani	ind		Sapindaceae	
Dubautia ciliolata (DC.) D.D.Keck	na,,ena,,e, kūpaoa	end		Asteraceae	
Dubautia scabra (DC.) D.D.Keck	na,,ena,,e, kūpaoa	end		Asteraceae	
Emilia fosbergii Nicolson	pualele (Ni,,ihau)	X		Asteraceae	
Gamochaeta purpurea (L.) Cabr.	purple cudweed	X		Asteraceae	
Geranium cuneatum Hook. subsp. cuneatum	nohoanu, hinahina	end		Geraniaceae	
Geranium homeanum Turcz.		X		Geraniaceae	
Heterotheca grandiflora Nutt.	telegraph weed	X		Asteraceae	
Hypericum mutilum L.	St. John's wort	X		Clusiaceae	
Leptecophylla tameiameiae (Cham. & Schlecht.) C.M.Weiller	pūkiawe, ,,a,,ali,,i mahu, kanehoa, kawa,,u (Lana,,i, Maui), maiele, maieli, puakeawe, puakiawe, pukeawe, pūpūkiawe	ind		Ericaceae	Synonym: *Styphelia tameiameiae*

Taxon	Common Name	Origin	Status	Family	Notes
Lythrum maritimum Kunth	loosestrife, pūkamole, nīnika, pūkamole lau li,,i, pūkamole lau nui	X		Lythraceae	
Marrubium vulgare L.	common horehound, white horehound	X		Lamiaceae	
Metrosideros polymorpha Gaudich.	,,ōhi,,a,,,ōhi,,a lehua, lehua	end		Myrtaceae	
Myoporum sandwicense A.Gray	naio, naeo, naieo, bastard sandalwood	ind		Myoporaceae	
Myrsine lanaiensis Hillebr.	kōlea	end		Myrsinaceae	
Myrsine lessertiana A.DC.	kōlea lau nui, kōlea	end		Myrsinaceae	
Opuntia ficus-indica (L.) Mill.	panini, papipi	X		Cactaceae	
Osteomeles anthyllidifolia (Sm.) Lindl.	,,ūlei, eluehe (Moloka,,i), u,,ulei	ind		Rosaceae	
Oxalis corniculata L.	yellow wood sorrel, ,,ihi ,,ai, ,,ihi ,,awa, ,,ihi maka ,,ula, ,,ihi makole	Pol?		Oxalidaceae	
Passiflora tarminiana Coppens & Barney	banana poka	X		Passifloraceae	
Peperomia cookiana C.DC.	,,ala,,ala wai nui	end		Piperaceae	
Physalis peruviana L.	Cape gooseberry, poha, pa,,ina (Hawai,,i)	X		Solanaceae	
Picris hieracioides L.	hawkweed	X		Asteraceae	
Pittosporum hosmeri Rock	hō,,awa, ha,,awa, ,,a,,awa, ,,a,,awa hua kukui	end		Pittosporaceae	
Pittosporum terminalioides Planch. ex A.Gray	hō,,awa, ha,,awa	end		Pittosporaceae	
Plectranthus parviflorus Willd.	,,ala,,ala wai nui, ,,ala,,ala wai nui pua kī, ,,ala,,ala wai nui wahine, spurflower	ind		Lamiaceae	
Pluchea carolinensis (Jacq.) G.Don	sourbush, marsh fleabane	X		Asteraceae	
Polycarpon tetraphyllum (L.) L.		X		Caryophyllaceae	
Pseudognaphalium sandwicensium (Gaudich.) A.Anderb.	,,ena,,ena, pūheu (Ni,,ihau)	end		Asteraceae	
Rubus hawaiensis A.Gray	,,akala, ,,akalakala, kala	end		Rosaceae	
Rubus niveus Thunb.	hill raspberry, Mysore raspberry	X		Rosaceae	
Rumex acetosella L.	sheep sorrel	X		Polygonaceae	

Taxon	Common Name	Origin	Status	Family	Notes
Rumex giganteus W.T.Aiton	pawale, uhauhakō	end		Polygonaceae	
Santalum paniculatum Hook. & Arn.	ʻiliahi, sandalwood	end		Santalaceae	
Senecio madagascariensis Poir.		X		Asteraceae	
Sicyos macrophyllus A.Gray	ʻanunu	end	C	Cucurbitaceae	Tentative ID
Sida fallax Walp.	ʻilima	ind		Malvaceae	
Solanum americanum Mill.	glossy nightshade, pōpolo, ʻōlohua, polopolo, pōpolohua	ind?		Solanaceae	
Sophora chrysophylla (Salisb.) Seem.	mamane, mamani	end		Fabaceae	
Stenogyne microphylla Benth.		end		Lamiaceae	
Stenogyne rugosa Benth.	maʻohiʻohi	end		Lamiaceae	
Tagetes minuta L.	stinkweed, ʻōkoleʻoiʻoi	X		Asteraceae	
Tetramolopium consanguineum (A.Gray) Hillebr.		end	SOC	Asteraceae	
Tetramolopium humile (A.Gray) Hillebr. subsp. *humile* Lowrey		end		Asteraceae	
Trifolium glomeratum L.		X		Fabaceae	
Vaccinium reticulatum Sm.	ʻōhelo, ʻōhelo ʻai	end		Ericaceae	
Verbascum thapsus L.	woolly mullein, common mullein, flannel plant, velvet plant	X		Scrophulariaceae	
Verbena litoralis Kunth	vervain, ōwī, oī, haʻuoi (Niʻihau), haʻuōwī (Niʻihau)	X		Verbenaceae	
Veronica plebeia R.Br.	trailing speedwell, common	X		Scrophulariaceae	
Wahlenbergia gracilis (G.Forst.) A.DC.		X		Campanulaceae	
Wikstroemia phillyreifolia A.Gray	ʻakia, kauhi	end		Thymelaeaceae	

[1]**Origin**: end = endemic; ind = indigenous; pol = Polynesian introduction; X = alien species; ? = uncertain
[2]**Status**: E = Endangered; C = Candidate; SOC = rare, species of concern

Photo 1. The Endangered fern *Asplenium peruvianum* var. *insulare*, the only listed species found within the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 2. A young plant, similar to the native vine *Sicyos macrophyllus* (shown here), was found within the Lupea Project area. (Photo by Forest and Kim Starr)

Photo 3. Three individuals of the native tree, *Chamaesyce olowaluana*, were found within the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 4. A few individuals of *Sisyrinchium acre* were found on Transect 6 within the Lupea Project area. (Photo by Derral R. Herbst © Smithsonian Institution)

Photo 5. Two large *Santalum paniculatum* trees, growing in Mizota's Kipuka within the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 6. Close-up of leaves and fruit of *Santalum paniculatum*. (Photo by J. Jacobi, USGS).

Photo 7. Fountaingrass (*Pennisetum setaceum*), an invasive grass species found throughout the Lupea Project area, except on the upper elevation transects. (Photo by J. Jacobi, USGS).

Photo 8. Dense foliage of the invasive vine Cape Ivy or German Ivy (*Delairea odorata*), found occasionally throughout the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 9. A few individuals of banana poka (*Passiflora tarminiana*) were found within the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 10. Although currently rare within the Lupea Project area, *Senecio madagascariensis*, has the potential to become much more widespread within these habatats. (Photo by J. Jacobi, USGS).

Photo 11. Mullein (*Verbascum thapsus*) was the most widespread of the invasive plant species found within the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 12. A few individuals of mysore raspberry (*Rubus niveus*) were found in the lower, slightly wetter habitat at the start of Transects 1 and 2 within the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 13. Example of mixed māmane-naio-koa-„a„alį-’iliahi woodland with native shrub understory within the Lupea Project area. (Photo by J. Jacobi, USGS).

Photo 14. Heavily disturbed example of mixed māmane-naio-koa-,,a,,ali‚i-’iliahi woodland; damage caused by cattle and sheep browsing. (Photo by J. Jacobi, USGS).

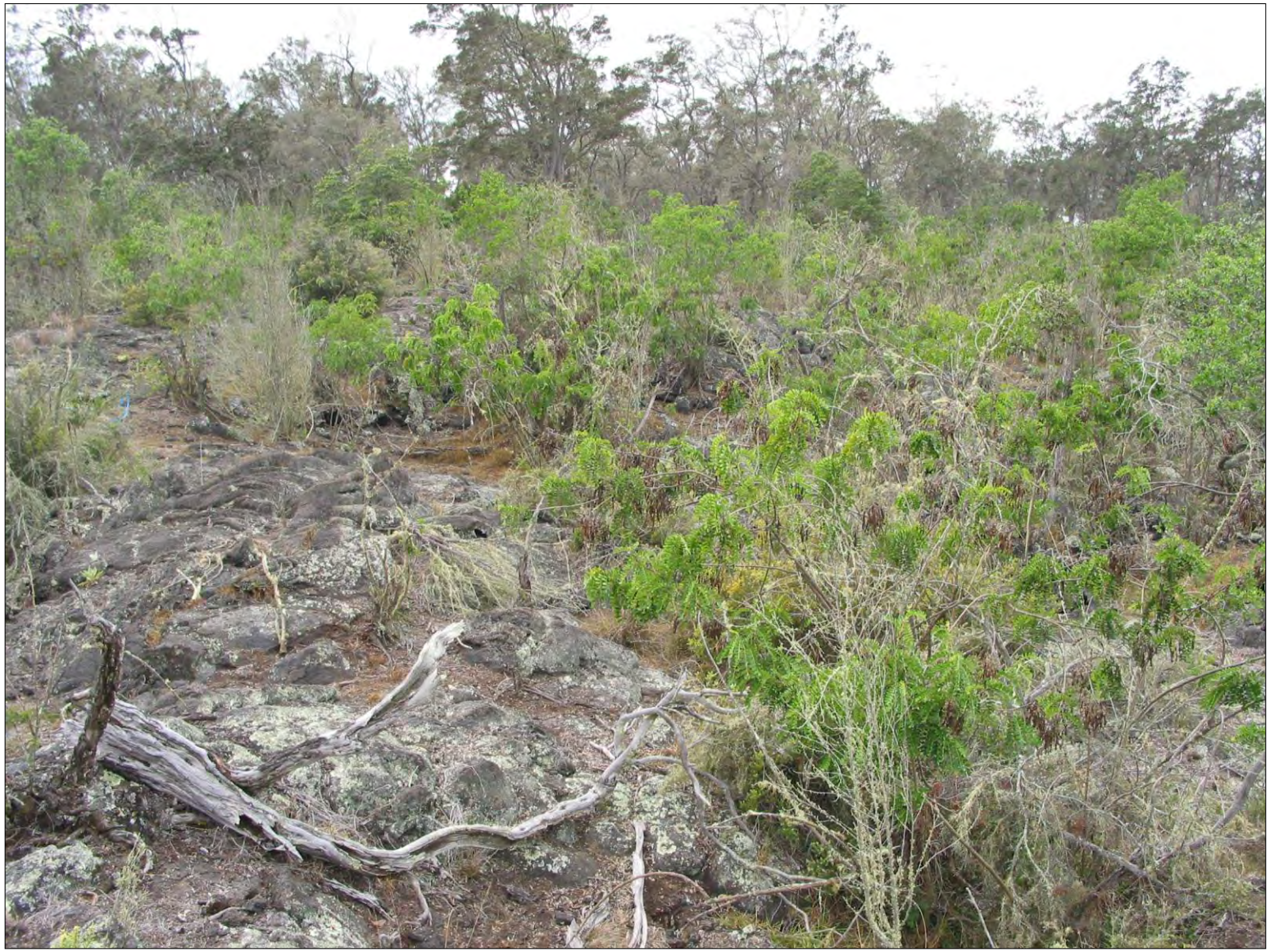

Photo 15. Very low-statured and open māmane-naio-koa-,,a,a̧li,,i-’iliahi woodland community on pāhoehoe lava. (Photo by J. Jacobi, USGS).

Photo 16. Heavily altered example of what was originally a tall, closed canopy māmane-naio-koa-,,a,,ali,,i-'iliahi forest; this area is currently a cattle pasture. (Photo by J. Jacobi, USGS).

Photo 17. Open ʻōhiʻa dominated forest on ʻaʻā lava. (Photo by J. Jacobi, USGS).

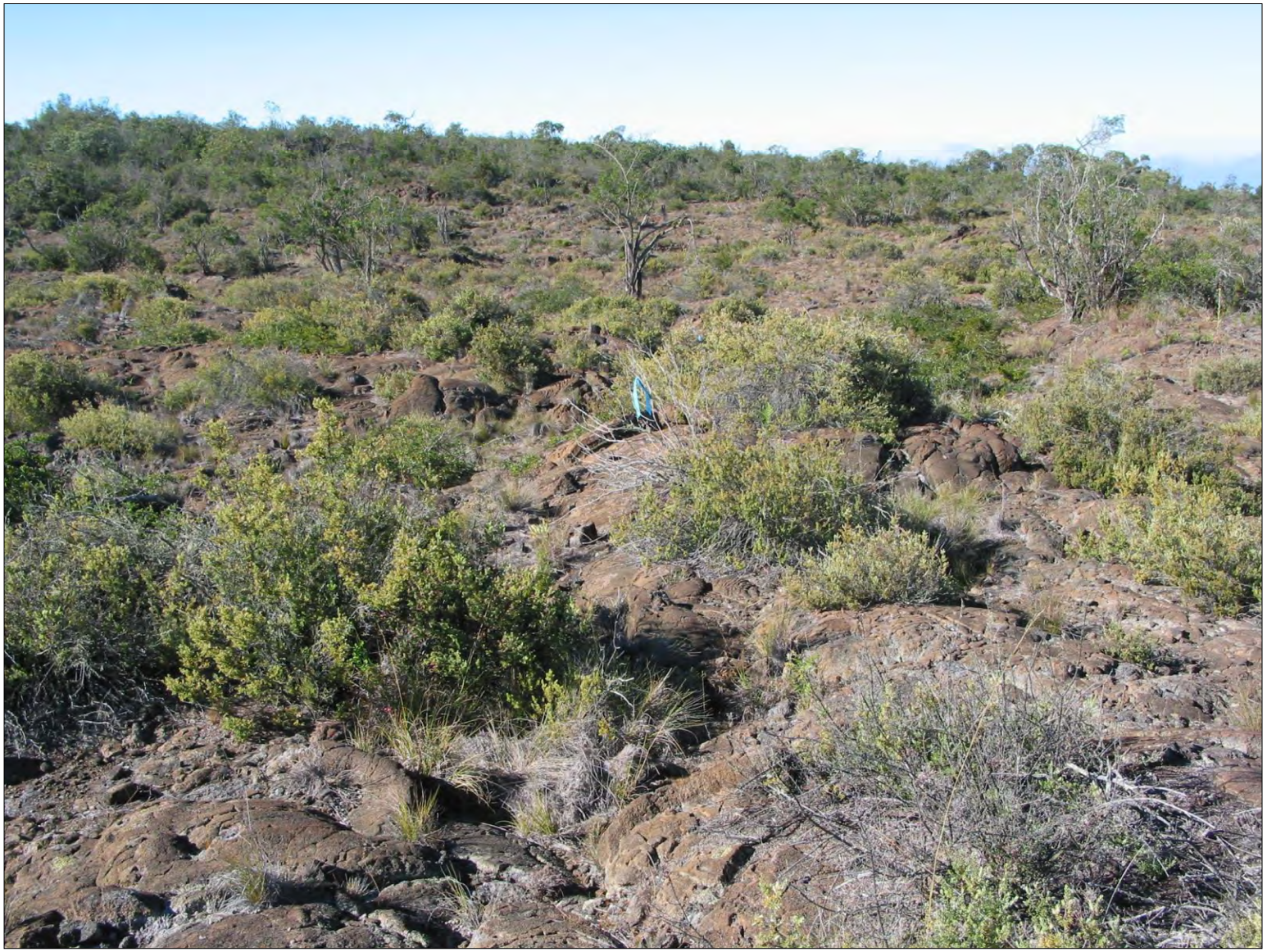

Photo 18. Subalpine Pūkiawe-,a,,ali,,i shrubland on a pāhoehoe lava flow near the end of Transect 5. (Photo by J. Jacobi, USGS).

Photo 19. Native grassland patch dominated by *Deschampsia nubigena*, *Eragrostis* spp., and *Panicum tenuifolium* in the subalpine shrub/woodland community near the end of Transect 5. (Photo by J. Jacobi, USGS).

Photo 20. Close-up of *Eragrostis leptophylla* and *Deschampsia nubigena*, two native grass species commonly found in the subalpine community. (Photo by J. Jacobi, USGS).

Photo 21. Heavily grazed, open pasture community dominated by alien grasses including *Pennnisetum clandestinum* on Transect 1. (Photo by J. Jacobi, USGS).

Photo 22. Herd of feral goats (*Capra hircus*) on a pāhoehoe lava flow above the Lupea Project area. (Photo by J. Jacobi, USGS).