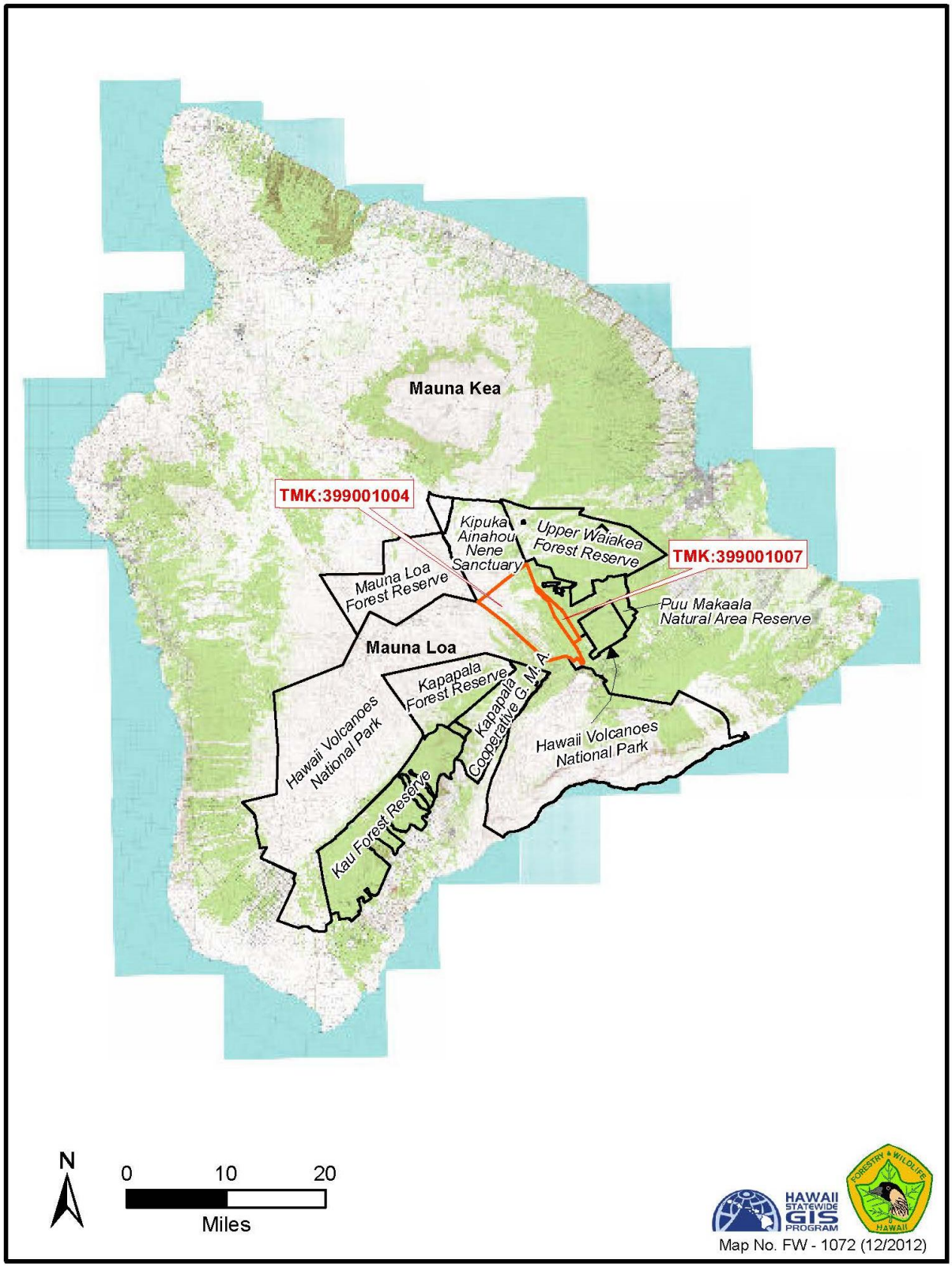
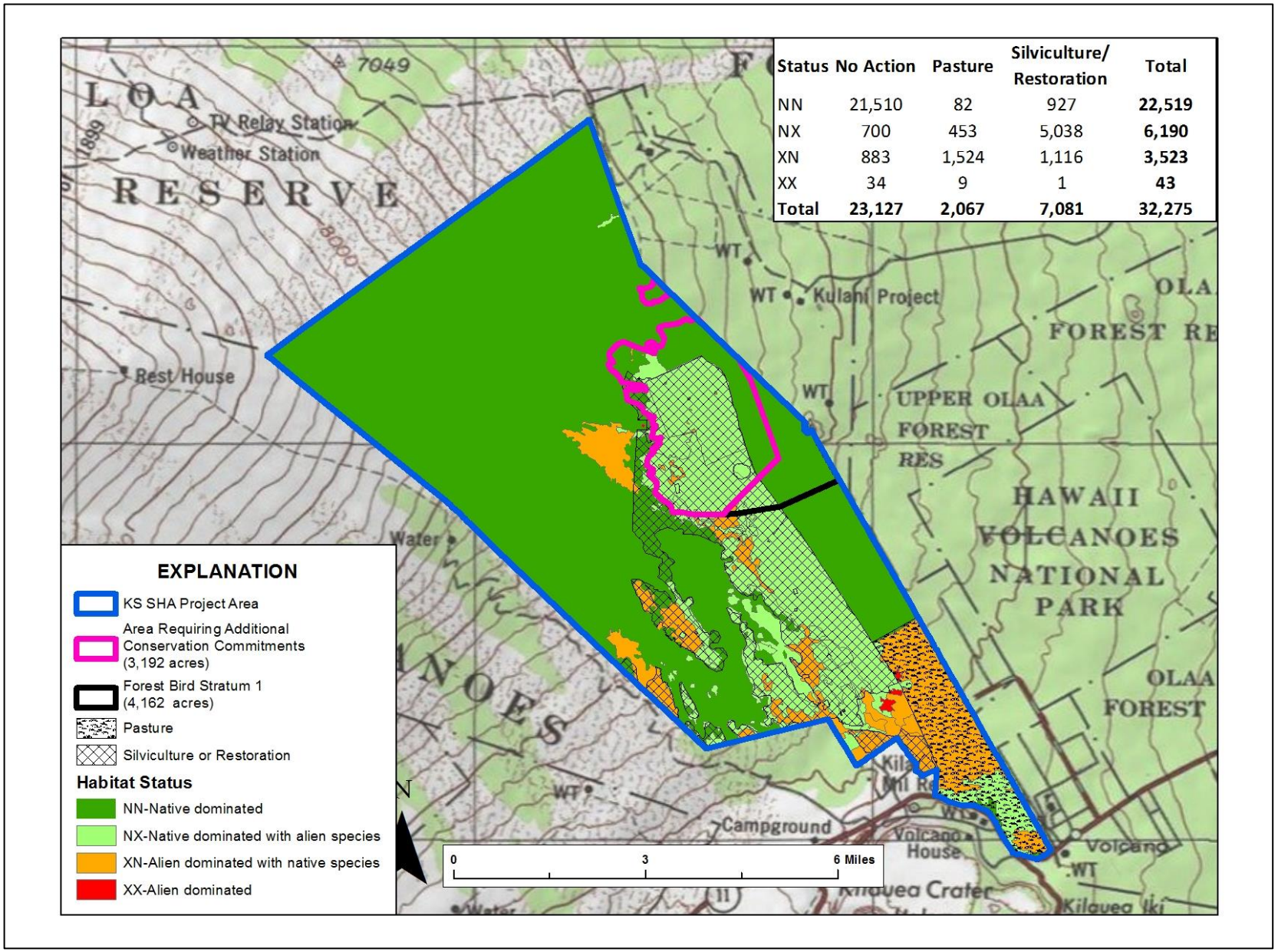
Appendix 1

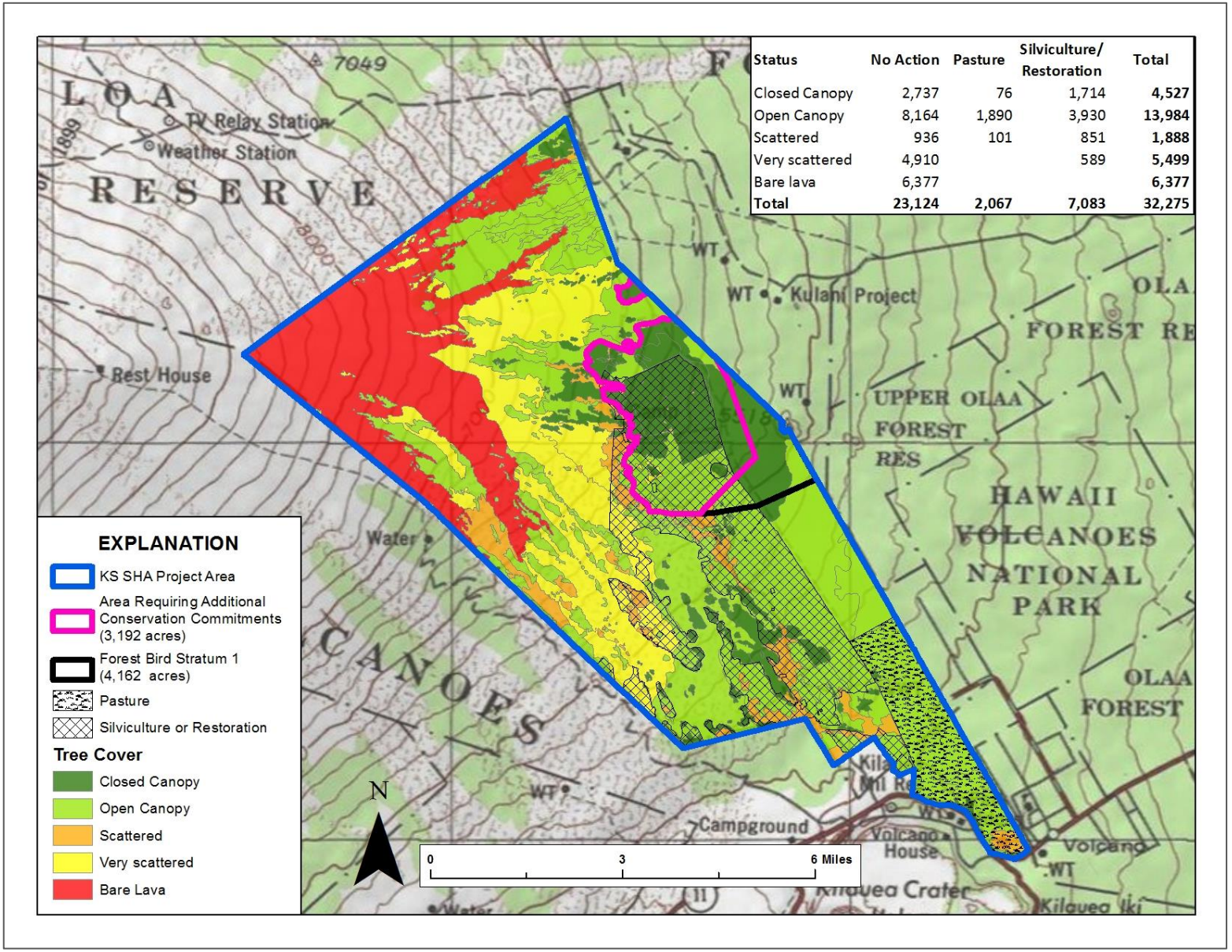
Maps of Enrolled Lands



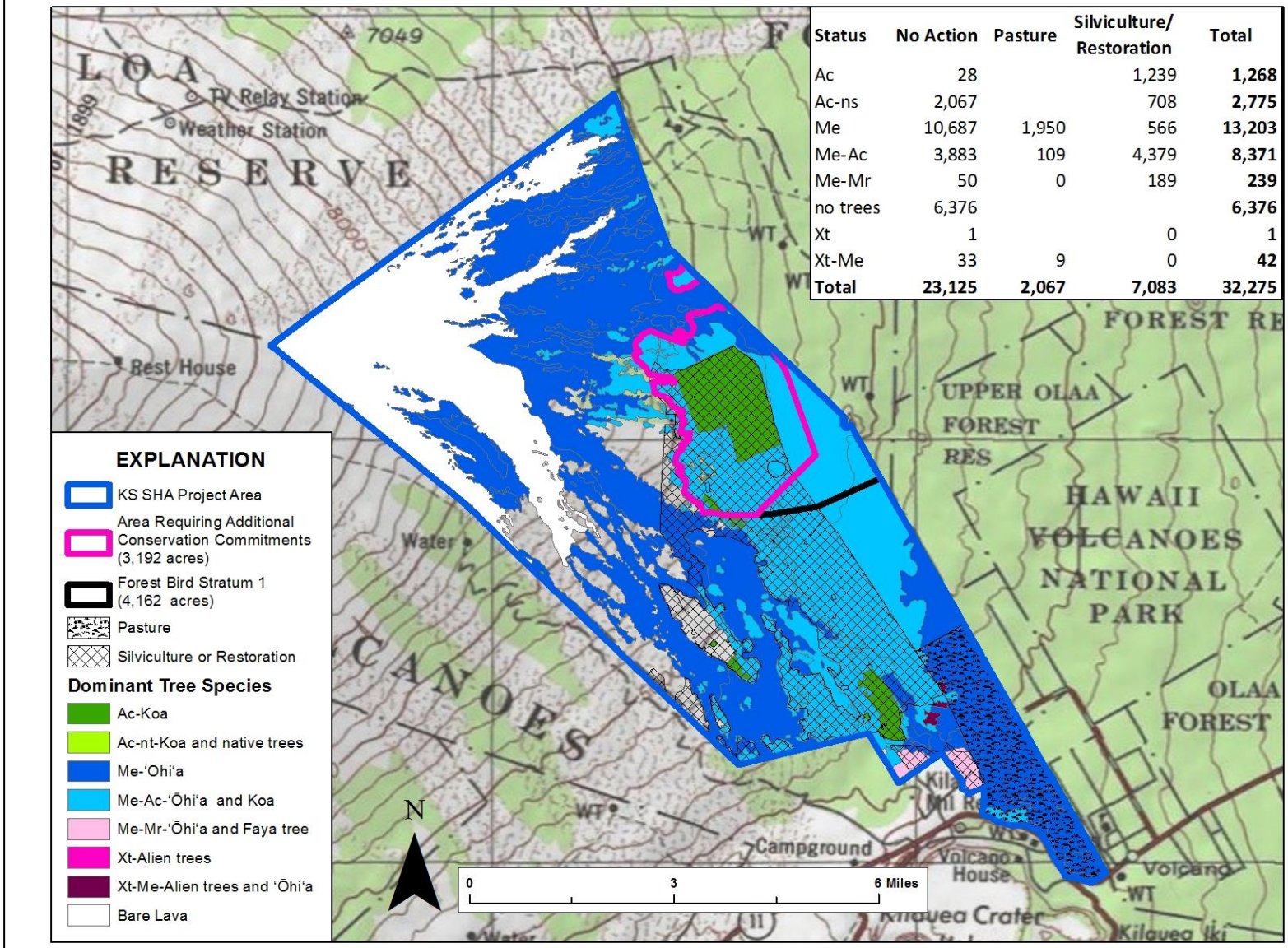
Map 1. Kamehameha Schools, Keauhou (TMK: 399001004) and Kīlauea Forest (TMK: 399001007), the largest portions of the enrolled property and surrounding properties. Enrolled property provides a contiguous protected area with the multiple protected areas.



Map 2. Baseline Conditions described by acres of native dominated habitats (as mapped by J. Jacobi, USGS, May 2015).



Map 3. Baseline conditions described by tree canopy cover (as mapped by J. Jacobi, USGS, May 2015).



Status	No Action	Pasture	Silviculture/ Restoration	Total
Ac	28		1,239	**1,268**
Ac-ns	2,067		708	**2,775**
Me	10,687	1,950	566	**13,203**
Me-Ac	3,883	109	4,379	**8,371**
Me-Mr	50	0	189	**239**
no trees	6,376			**6,376**
Xt	1		0	**1**
Xt-Me	33	9	0	**42**
Total	**23,125**	**2,067**	**7,083**	**32,275**

Map 4. Baseline conditions based on tree species descriptions (as mapped by J. Jacobi, USGS, May 2015)

Appendix 2

Technical Report of Native Bird Populations on Kamehameha Schools Lands.

Technical Report HCSU-016

STATUS AND TRENDS OF NATIVE BIRDS IN THE KEAUHOU AND KĪLAUEA FOREST, HAWAIʹI ISLAND

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Table of Contents

Abstract v
Introduction 1
Methods 4
  Bird species 4
  Bird surveys 5
  Study area 5
  Density estimates 6
  Data analysis 6
Results 8
Discussion 10
Acknowledgements 14
References 15

List of Figures

Figure 1. Location of bird survey transects and intact/altered forest strata in the Keauhou-Kīlauea Forest study area. 18
Figure 2. Examples of altered and intact forest strata. 19
Figure 3. Annual density estimates for native birds within the Keauhou-Kīlauea Forest study area. 21
Figure 4. Location of the three endangered species detected during the 2008 forest bird survey in the Keauhou-Kīlauea Forest study area. 22

List of Tables

Table 1. Transects sampled during annual surveys conducted within the Keauhou-Kīlauea Forest study area. 23
Table 2. Number of stations sampled within the Keauhou-Kīlauea Forest study area. 24
Table 3. List of species detected during forest bird surveys in the Keauhou-Kīlauea Forest study area. 25
Table 4. Results from the 2008 Keauhou-Kīlauea survey: relative abundance and densities of native birds in the intact and altered forest strata. 26
Table 5. Comparison of bird densities between intact and altered forest strata over 14 years in the Keauhou-Kīlauea Forest study area. 27
Table 6. Trends in forest bird density within the Keauhou-Kīlauea Forest study area. 28
Table 7. Power to detect a 25 or 50 % decline in density and trend. 29
Table 8. Attributes of surrogate species assigned to common native Hawaiian passerine birds 30

List of Appendices

Appendix 1. Detection function models and distance histograms. 31
Appendix 2. Species list and relative abundance of native and alien birds detected during the 2006 survey in the lower elevations of Keauhou 33
Appendix 3. Native bird density by forest stratum 34

Abstract

A Safe Harbor Agreement (SHA) is a voluntary arrangement between the U.S. Fish and Wildlife Service and non-Federal landowners to promote the protection, conservation, and recovery of listed species without imposing further land use restrictions on the landowners. Kamehameha Schools is considering entering into a SHA for their Keauhou and Kīlauea Forest lands on the island of Hawai′i. Bird surveys were conducted in 2008 to determine the current occurrence and density of listed species for the Keauhou and Kīlauea Forest, a prerequisite for establishing an agreement. Because of different management practices in the proposed SHA area we stratified the survey data into intact and altered forest strata. The listed passerines—′Akiapōlā′au (*Hemignathus munroi*), Hawai′i Creeper (*Oreomystis mana*), and Hawai′i ′Ākepa (*Loxops coccineus*)—occur in both strata but at low densities. The endangered ′Io (Hawaiian Hawk; *Buteo solitarius*) also occurs within both strata at low densities. This report was prepared for the U.S. Fish and Wildlife Service and Kamehameha Schools to provide information they can use to establish baseline levels for the SHA. In addition, we describe the status and trends of the non-listed native birds.

Introduction

Many threatened and endangered listed species occur on privately owned property. Thus, the U.S. Fish and Wildlife Service (FWS) has developed a policy, the Safe Harbor Agreement (SHA), with cooperating non-Federal landowners to benefit listed species. A similar process is available through the State of Hawai′i Department of Land and Natural Resources (DLNR). The main purpose of a SHA is to promote voluntary management plans with landowners for the protection, conservation, and recovery of listed species. In return, participating landowners are provided assurances that no further land use or management restrictions will be imposed on the landowners for their covered lands and species if listed species colonize or increase in numbers as a result of restoring or enhancing habitat. It is important to note that the establishment of a SHA does not affect preexisting regulatory restrictions on property already supporting listed species. Details defining roles and responsibilities, and guidelines for establishing SHA are provided by the FWS (*available online*)[1] and Hawai′i DLNR (*available online*)[2].

Agreements must identify covered lands and actions to be taken; they must specify the baseline for listed species found or expected to be found there; and they must be expected to produce a net conservation benefit for the listed species. At some time in the future the landowner can take back created habitats or populations (return to baseline), and there will be a net conservation benefit for the recovery of the covered species.

Kamehameha Schools is considering entering into a SHA with the FWS and DOFAW for their Keauhou and Kīlauea Forest lands on the island of Hawai′i. These parcels are situated where several endangered forest bird populations—′Akiapōlā′au, Hawai′i Creeper, and Hawai′i ′Ākepa—are located within the central windward portion of the island at 1,500 to 2,000 m elevation (19° 29′10″N 155° 17′45″E; Figure 1). The vegetation in the area is comprised of native montane wet and mesic forest, portions which have a history of ranching and logging. ′Ōhi′a (*Metrosideros polymorpha*) and koa (*Acacia koa*) dominate the forest canopy, and the understory is comprised of native trees, shrubs, tree ferns, and many species of ground ferns, although some open meadows of grass remain (Sakai 1988). Average annual rainfall exceeds 3,500 mm, and daily air temperature averages 16°C with an annual variation of <5°C (Juvik and Juvik 1998). Kamehameha Schools manages Keauhou and portions of Kīlauea Forest. Logging and ranching commenced in the Keauhou area more than a century ago, but clearing of forest and grazing largely ceased in this area in the 1990s. The region is now managed mainly as native forest with activities including the removal of feral ungulates, pasture reforestation, and educational projects. Kīlauea Forest has never been logged and is primarily managed for its natural resource conservation (although hapu′u tree ferns [*Cibotium* spp.] were extracted from the lower section of Kilauea Forest prior to 2003).

Historically this area has been a focus of bird surveys and research on the island of Hawai′i. In the 1960s and 1970s, the area was surveyed as part of the U.S. International

[1] http://www.fws.gov/Endangered/factsheets/harborqa.pdf; accessed 6 November 2008.
[2] http://www.capitol.hawaii.gov/hrscurrent/Vol03_Ch0121-0200D/HRS0195D/HRS_0195D-0022.htm; accessed 6 November 2008.

Biological Program (Mueller-Dombois et al. 1981), and the first bird searches were conducted between January and July 1972 by Berger (1972). By this time, large tracts of forest on what was then the Keauhou Ranch had already been converted to pasture for cattle ranching, and ungulates (cattle, horses, sheep, goats, and pigs) had degraded the surrounding, largely-intact forests. ʻIo, ʻAkiapōlāʻau, Hawaiʻi Creeper, and Hawaiʻi ʻĀkepa sightings were recorded in the Kīlauea Forest, and a few incidental sightings were made in the adjacent Keauhou Ranch while accessing the study area. In addition to the endangered birds, Berger documented relatively large numbers of Hawaiʻi ʻElepaio (*Chasiempis sandwichensis*), ʻŌmaʻo (*Myadestes obscurus*), Hawaiʻi ʻAmakihi (*Hemignathus virens*), ʻIʻiwi (*Vestiaria coccinea*), and ʻApapane (*Himatione sanguinea*). Interestingly, Berger considered the ʻAkiapōlāʻau population in the Kīlauea Forest to be the largest remaining population on Hawaiʻi Island.

Between 1972 and 1975, Conant (1975) conducted the first quantitative bird surveys in both Keauhou and Kīlauea Forest. Conant's survey provided density estimates based on strip transect sampling and calculating a coefficient of detectability following Emlen (1971). Comparison of Conant's results with those of other surveys is limited because of differences in sampling and analyses, and because Conant's study area did not correspond directly with the SHA study area; however, limited inference can be garnered from the patterns she documented. Conant found that in general densities of the common birds were greater in the Kīlauea Forest than in the pasture and logged areas in Keauhou, and densities of the endangered birds were about equal between the two study areas, although their densities were substantially less than those of the common birds (<0.5 birds/ha versus >2 birds/ha, respectively).

Scott et al. (1986) established the standard bird sampling method used in the Hawaiian Islands during the landmark Hawaiʻi Forest Bird Survey (HFBS; Camp, Reynolds, et al. 2009). Portions of two HFBS transects ran through the proposed SHA area and were sampled in 1977. Similar to Conant's study, the results from Scott et al. are not directly comparable to subsequent surveys in the SHA area because Scott et al. surveyed at a much larger scale and too few of the HFBS sampling stations fall within the limited SHA area. Like the previous surveys, Scott et al. found the general pattern was that native bird densities were greater in forests than in logged or pasture habitats, and the endangered birds were rare. Scott et al. also identified that the endangered birds existed in disjunct populations on the island, with one occurring in the Keauhou-Kīlauea region.

The U.S. Forest Service conducted bird surveys in both the Keauhou and Kīlauea Forest between 1977 and 1982. Similar to the results from previous surveys, densities were greater in forest than logged or pasture habitats, except for ʻAkiapōlāʻau (Ralph and Fancy 1994a, 1994b, 1995, 1996), and densities of the endangered birds were lower than Conant's estimates (Conant 1975). By that time, large portions of the upper Keauhou were logged and much of the vegetation removed to encourage regrowth of koa as part of a silviculture program. Ralph and Fancy (1996) noted a shift in ʻAkiapōlāʻau densities between the two study areas with greater densities recorded in Keauhou than in Kīlauea Forest, but this shift was not seen for Hawaiʻi Creeper or Hawaiʻi ʻĀkepa. Sakai (1988) used Forest Service data from Keauhou to assess differences in bird abundance indices

(numbers of birds detected per station and percent occurrence) between study plots in mechanically cleared forest that was regenerating and adjacent intact forest. Sakai showed that results for both indices were greater in the intact forest than in the logged plots. Furthermore, Sakai found that ʻApapane numbers were initially high in the logged and cleared plots and fell to lower levels shortly after clearing, and eventually ʻApapane numbers remained stable but abundance was low.

Beginning in 1990, Kamehameha Schools and the U.S. Geological Survey, Biological Resources Discipline (USGS BRD) initiated bird surveys in the Keauhou-Kīlauea region, and these surveys were conducted annually to present. In 1993, these surveys were expanded to include additional portions of the proposed SHA area. Gorresen et al. (2005) reported the status and trends for native and alien forest birds in the Keauhou-Kīlauea region and Hawaiʻi Volcanoes National Park (surveys in the `Ōla`a, Mauna Loa Strip, and East Rift study areas). Five of eight native forest birds, including ʻAkiapōlāʻau and Hawaiʻi Creeper, had undergone declines in occurrence and density. In addition, Gorresen et al. identified that ʻŌmaʻo and ʻIʻiwi may have undergone range contractions and suggested expanding the regional surveys to include sampling the areas between Keauhou, `Ōla`a, and Mauna Loa Strip. The 2006 survey was expanded to include surveys adjacent to Mauna Loa Strip and the lower portion of Keauhou, and the results are presented here for the first time.

`Io are not reliably monitored using the standard point-transect sampling for surveying other forest birds, although `Io are detected and recorded during the counts. In 2007, Gorresen et al. (2008) reported the status of ʻIo on Hawaiʻi Island using play-back calls during 10-min point-transect sampling. ʻIo movements in response to the play-back calls were accounted for in the analyses. Gorresen et al. compared ʻIo densities between their survey and a 1998 survey by Klavitter et al. (2003) and found that the 2007 and 1998 estimates did not differ. ʻIo density was estimated to be about one bird every two km^2 in the Keauhou-Kīlauea region.

In this report, we describe the current conditions for listed endangered forest birds—ʻIo, ʻAkiapōlāʻau, Hawaiʻi Creeper, and Hawaiʻi ʻĀkepa—that occur in the Keauhou and Kīlauea Forest area. For reference, we also describe the status and trends of the other native birds. Because of different management practices across the landscape we assess the trends and differences in native forest bird densities between intact and altered forest strata.

Methods

Bird species

Only a small portion of the original Hawaiian avifauna have survived human settlement, and as many as 13 historically known species that could have occurred in the Keauhou-Kīlauea region are now either extinct or have been extirpated from the area (Banko and Banko 2009). The result is that only nine forest birds—ʻIo, Hawaiʻi ʻElepaio, ʻŌmaʻo, Hawaiʻi ʻAmakihi, ʻAkiapōlāʻau, Hawaiʻi Creeper, Hawaiʻi ʻĀkepa, ʻIʻiwi, and ʻApapane—persist in the Keauhou-Kīlauea region and four of those birds—ʻIo, ʻAkiapōlāʻau, Hawaiʻi Creeper, and Hawaiʻi ʻĀkepa—are listed as endangered under the Endangered Species Act by the U. S. Fish and Wildlife Service (1984, 2006). Here we provide general ecological background for the listed species. Descriptions of the nine non-listed Hawaiian forest birds that occur in the Keauhou-Kīlauea region can be found in Poole (2005) and Pratt (2005).

ʻIo is a small, broad-winged hawk of the genus *Buteo*. This woodland predator evolved to hunt birds, but has expanded its prey base to include small mammals and insects since Polynesian contact (Clarkson and Laniawe 2000). ʻIo occupy a wide variety of forested and open habitats from sea level to tree line, but breeding habitats appear to be restricted to mid- to tall-stature, open- to closed-canopy native and/or mixed exotic tree forests with some tall ʻōhiʻa.

The ʻAkiapōlāʻau is a medium-sized honeycreeper with a relatively short tail, endemic to Hawaiʻi Island (Pratt 2005). The most striking feature of the ʻAkiapōlāʻau is its hetero-bill where the upper mandible is long and decurved and lower mandible is short and straight. ʻAkiapōlāʻau diet consists almost entirely of arthropods including caterpillars, spiders, larvae and adult beetles, which they extract from trunks, branches and twigs with their upper mandible. They also take nectar opportunistically and consume tree sap by drilling sap wells with their lower mandible. Historically ʻAkiapōlāʻau were distributed island-wide but now occur only in high elevation mixed koa/ʻōhiʻa forests, and exhibit a clear preference for koa. ʻAkiapōlāʻau benefit from planting and natural recruitment of koa, and also make use of young koa stands (Pejchar et al. 2005).

The Hawaiʻi Creeper is a small honeycreeper endemic to Hawaiʻi Island with a relatively short tail and short, slightly decurved bill. It forages mainly on arthropods, especially insects and spiders, caterpillars and historically on snails (Pratt 2005). They glean prey from the bark of larger limbs and trunks of trees, favoring koa but also foraging on other trees. Hawaiʻi Creeper previously occupied a wide variety of forest habitats including lowland very wet rainforests, but currently they are found mostly in high-elevation koa/ʻōhiʻa forests.

Hawaiʻi ʻĀkepa are a very small honeycreeper with a notched tail and express striking sexual dichromatism (Pratt 2005). ʻĀkepa have a short bill where the mandible is curved to one side, which it uses to probe terminal leaf clusters and open leaf buds foraging for spiders and insects, especially psyllid and lepidopteran larvae, leafhoppers and bugs. They also take nectar opportunistically. ʻĀkepa are currently distributed only in high-

elevation old-growth ʻōhiʻa and koa forest, although they formerly occurred in lowland forests. ʻĀkepa require old-growth forest that provides cavities for nest sites.

Bird surveys

In 1977, Scott et al. (1986) conducted the first quantitative bird surveys in the Keauhou-Kīlauea region as part of the HFBS. The scale at which the HFBS was conducted did not allow for comparisons with current bird densities (too few stations). Surveys subsequent to the HFBS commenced in 1990 in the Keauhou-Kīlauea region, and in the SHA area in 1993 (Table 1, Figure 1). Our analyses excluded the 1993 survey because it was conducted outside of the breeding season, whereas the surveys beginning in 1994 sampled during the breeding season when birds are usually more vocal. The number of stations sampled in the SHA area varied by year, with a minimum of 85 stations in 1999 and a maximum of 160 stations 2008 (Table 2).

All subsequent surveys have followed the same point-transect sampling procedures implemented by Scott et al. (1986). Variability among observers was minimized through pre-survey training to calibrate for distance estimation and learn bird vocalizations for the local populations (Kepler and Scott 1981). During 8-min counts, observers recorded the horizontal distance from the station center point to individual birds detected and the detection type (heard, seen, or both). Birds only flying over or through the survey area were excluded. Observers also recorded the sampling conditions (i.e., cloud cover, rain, wind, gust, and time of day) at each station. Sampling was conducted between 06:00 and 12:00 hr and halted when rain, wind, or gust exceeded pre-specified levels.

Study area

The 1994-2008 survey data relate to the general location of the proposed SHA, although the final SHA boundary has not been established. We stratified the survey data into altered forest and intact forest strata based on different management practices. Management practices in the altered forest stratum included cattle grazing on native forests that were converted to pastureland, and clearing to facilitate koa regeneration for lumber production. Cattle have been grazed on Keauhou for > 100 years, and the pastureland consists of scattered old-growth ʻōhiʻa trees with introduced pasture grasses. Clearing of the forest on Keauhou and subsequent regeneration of the koa silviculture stands are described in Sakai (1988). A total of 80 ha of pastureland were cleared of all vegetation using bulldozers from 1977 to 1980. Mechanical clearing stimulated regeneration of pure stands of koa. The koa stands remain relatively monospecific with an understory of alien grass and mixed native shrub/fern. Bird survey stations within the pasture and koa silviculture stand were assigned to the altered forest stratum (Figures 1 and 2). Bird survey stations in the adjacent forest to the north (upper Keauhou) and east (Kīlauea Forest) of the koa silviculture stand were assigned to the intact forest stratum (Figures 1 and 2). For clarification, population status and trend estimates reported here are for the SHA area only, and exclude estimates for surveys from the Kūlani Boys School, Puu Kipu, and other portions of the central windward Hawaiʻi region (see Gorresen et al. 2005).

Density estimates

Density estimates (birds/ha) for forest bird species were estimated by fitting species-specific detection functions to histograms of distance measurements (Buckland et al. 2001) using program DISTANCE, version 5.0, release 2 (Thomas et al. 2005). Distance data were pooled across forest strata and year to produce a single species-specific detection function (i.e., a global detection function), and post-stratification procedures were used to calculate strata and year specific density estimates. Detections from surveys in the Kūlani Boys School, Puu Kipu, and other portions of Kīlauea Forest were used to increase the number of samples to fit detection functions; however, we do not present status estimates for those areas in this report. Data were right-tail truncated to remove approximately 10% of the distance measurements and thereby facilitate modeling. We used Akiake's Information Criterion (AIC) to select the best approximating model (Buckland et al. 2001, Burnham and Anderson 2002). Candidate models were limited to half normal and hazard-rate detection functions with expansion series of order two (Buckland et al. 2001:361, 365). Candidate models were further restricted to those where the proportion of variance in the model due to variability in the detection function was less than 70% (K. Burnham, pers. comm.). Covariates were incorporated in the multiple covariate distance sampling (MCDS) engine of DISTANCE to improve model precision (Marques and Buckland 2004, Thomas et al. 2005). Covariates included cloud cover, rain, wind, gust, observer, time of detection, and month of survey (Appendix 1). Buckland et al. (2001, 2004) describe distance sampling procedures and analyses in detail.

Data analysis

Change in bird densities between the two forest strata were assessed with repeated measures analysis of variance (ANOVA: PROC MIXED; SAS Institute Inc., Cary, NC). The error variances were stabilized by log transforming densities by station values, after a constant of 1 was added (to avoid ln(0)). Because of low bird densities for the listed species we assumed a compound symmetry variance-covariance structure, and stations were treated as the random factor (Littell et al. 1996).

Changes in population densities by stratum were assessed by estimating the posterior probability of a trend within a Bayesian framework (Wade 2000, Camp et al. 2008). We defined the ecological relevance of a trend as a 25% change in a population in 25 years. Ecologically meaningful trends were defined as: decreasing when the rate of change (i.e., slope) $\hat{\beta} < -0.0119$ and increasing when $\hat{\beta} > 0.0093$. Populations were considered ecologically negligible when $-0.0119 < \hat{\beta} < 0.0093$. We also assessed the probability of the population changing more than 50% in 25 years, or $\hat{\beta} < -0.0285$ and $\hat{\beta} > 0.0170$, respectively. The posterior probabilities of the $\hat{\beta}$s were calculated using a log-link regression model in WinBUGS (Lunn et al. 2000) within program R (R version 2.7.0; 2008-04-22; The R Foundation for Statistical Computing). Camp et al. (2008) provide modeling details.

The likelihood of a trend was defined with four categories: very weak, weak, strong, or very strong evidence derived from the posterior odds (Wade 2000). Evidence for the categories was based on the posterior probability (P) limits of: very weak if $P < 0.1$; weak if $0.1 \leq P < 0.7$; strong if $0.7 \leq P < 0.9$; and very strong if $P \geq 0.9$. We concluded that a trend was inconclusive when the posterior odds provide weak and very weak evidence among all trend categories, and that a population was "stable" given strong or very strong evidence of a negligible trend.

Power to detect 25% and 50% population declines for a 10-year period were calculated using program TRENDS (Gerrodette 1993). Significance level for a Type I error was 0.10 based on a one-tailed exponential model. Coefficient of variation was calculated as the standard error divided by the density or slope, and set proportional to 1/sqrt(A) (the most conservative setting). See Gerrodette (1993) and Gorresen et al. (2005) for details.

Results

Between 1994 and 2008, 33 bird species were detected in the Keauhou-Kīlauea study area (Table 3), and 17 species were coincidently detected in the lower portion of the region during the 2006 survey (Appendix 2). One-third of the species were native or migratory species (10 and one, respectively), and the remaining species were aliens. We were able to calculate densities for eight of 10 native birds. ʻApapane had the greatest densities and the three endangered passerines—ʻAkiapōlāʻau, Hawaiʻi Creeper, and Hawaiʻi ʻĀkepa—had the lowest densities, both over the 14 year period and in the most recent 2008 survey (Figures 3 and 4, Table 4, Appendix 3).

Current Status and Trends of T&E Species

Significant differences in population densities between intact forest and altered forest strata were detected for two of the three endangered passerines. Average densities for Hawaiʻi Creeper were greater in the intact forest stratum, whereas densities for ʻAkiapōlāʻau were greater in the altered forest stratum, which included the koa silviculiture stand at Keauhou (Table 5). The model to assess the difference between Hawaiʻi ʻĀkepa densities in intact and altered forest strata failed to converge due to small sample size. A two-sample *z*-test comparison of the 2008 Hawaiʻi ʻĀkepa densities indicated that they were no more abundant in the intact forest than in the altered forest stratum ($z = -1.11$, $p = 0.268$). This comparison should be viewed with caution because it does not include the variability among the time series densities and 2008 was the only year where densities were greater in the altered forest stratum than in the intact forest stratum (Appendix 3). The average Hawaiʻi ʻĀkepa density between 1994 and 2008 in the intact forest stratum was 0.20 birds/ha (SD = 0.17), which was significantly greater than the average Hawaiʻi ʻĀkepa density in altered forest stratum (0.04 [0.04]; two-sample *t*-test assuming unequal variances: $t = 2.14$, df = 14, $p = 0.005$).

Hawaiʻi Creeper and Hawaiʻi ʻĀkepa showed declining trends in the intact forest stratum (Figure 3, Table 6). The model to assess ʻAkiapōlāʻau trends failed to converge because the densities varied widely and were generally poorly estimated (mean CV = 0.61 ± 0.27 [SD]), thus a general regression model was not discernable. The trends for ʻAkiapōlāʻau and Hawaiʻi Creeper in the altered forest stratum were not estimated well enough to make strong consensus, and the model to assess Hawaiʻi ʻĀkepa trends failed to converge (for reasons see ʻAkiapōlāʻau trends description above).

The current monitoring of endangered species' densities yields results with inadequate power to detect either 25 or 50 % declines in density and trend over a 10 year period (Table 7).

Current status and trends of common species

Average densities for ʻIʻiwi and ʻApapane were greater in the intact forest stratum, whereas densities for Hawaiʻi ʻElepaio and Hawaiʻi ʻAmakihi densities were greater in the altered forest stratum (Table 5). ʻŌmaʻo densities were not different between the two strata.

Most species showed declining trends in the intact forest stratum. Trends were declining for Hawai′i ′Elepaio, ′Ōma′o, and ′I′iwi (Figure 3, Table 6). Although Hawai′i ′Amakihi trend did not increase in intact forest, we were unable to determine whether its trend was stable or declining (weak evidence for both trends). There was, however, almost double the support for stable versus declining Hawai′i ′Amakihi trends. ′Apapane was the only native bird to portray a stable trend in the intact forest stratum.

Overall, trends were more positive in the altered forest stratum. Strong and very strong evidence of increasing trends was found for Hawai′i ′Elepaio, Hawai′i ′Amakihi, and ′Apapane (Figure 3, Table 6). The trend for all three of these species was an increase by at least 50% over 25 years. Another positive finding was strong evidence of a stable trend for the ′Ōma′o, with only weak evidence that the ′Ōma′o population had declined by 25% over 25 years. In contrast, the combined evidence that the ′I′iwi trend in densities declined was very strong, with the greatest proportion of evidence supporting a 25% decline over 25 years.

There was adequate power to detect both 25 and 50% declines in all of the common bird densities (power ≥ 80%; Table 7). Additionally, there was adequate power to detect a negative trend of 50% over 10 years for the Hawai′i ′Elepaio and ′Apapane, whereas, Hawai′i ′Amakihi had sufficient power to detect a negative trend of 25% over 10 years. There was inadequate power (< 80%) to detect either moderate (25%) or catastrophic (50%) trends in ′Ōma′o or ′I′iwi. This was likely due to fluctuations between annual density estimates, not to uncertainty in the density estimates.

Discussion

Current status and trends of T&E species

The current bird status in Keauhou-Kīlauea area can be used to help determine the baseline state of bird populations for the proposed SHA area. Furthermore, the analysis of historic population levels informs managers of the potential population levels and variability inherent in bird distribution and density. The lower portion of Keauhou-Kīlauea is below 1,500 m elevation and does not harbor the listed passerine birds (Appendix 2; Gorresen et al. 2005), as is the case throughout Hawai′i Island below that elevation (Gorresen et al. 2009). In the upper elevations (above 1,500 m), Hawai′i ′Ākepa and ′Akiapōlā′au occurrence were two to four times greater in the altered forest than in the adjacent intact forest stratum, but these species were detected only a few times (a total of seven and six birds, respectively). Hawai′i Creeper occurrence was different by only one percent, and the creeper was detected on only four stations in each stratum. Thus, it is difficult to assess the status of these three species with the data, except to say that they exist at low densities in both strata. Interestingly, most bird densities were greater in the altered forest than in the intact forest. This does not imply that logging and grazing are beneficial for Hawaiian forest birds (e.g., Van Horne 1983). Instead the intact forest sustains the core population for all of the native birds, including the listed species. Hawai′i ′Ākepa are a cavity nesting bird, and, are therefore, obligate on old-growth ′ōhi′a forests (Pratt 2005). A few suitable nest-cavity trees may exist in the pastureland; however, these trees are absent from the koa silviculture where all vegetation was mechanically removed.

Similarly, ′Akiapōlā′au are reliant on old-growth, intact forests for breeding. However, Goldsmith et al. (2005) noted that wood-boring beetles, an important prey, were abundant in young koa trees in the reforested pastures in Hakalau Forest National Wildlife Refuge. ′Akiapōlā′au have been observed in the young koa trees in the refuge (Camp, Pratt, et al. 2009), and it may be that they are using the koa silviculture stands in the altered stratum in the same way.

The intact forest also serves as a source for native vegetation for areas where there is not a seed bank (i.e., dozed area for koa silviculture) or where the seed bank has been depleted (i.e., in pasturelands that have been grazed for extended periods). Without the adjacent intact forest colonization of native plants in the altered stratum is limited (see Drake 1992, Drake and Mueller-Dombois 1993), which could hinder succession of trees and understory plants, and delay the recovery of bird populations.

Trends were not estimated well enough for the listed species to make strong conclusions; the models either provided weak evidence amongst the three trends or the models failed to converge. Densities of the endangered birds were very low in both the intact and altered forest strata (<< one bird per ha), and this may have precluded trends detection. Two additional explanations are that densities either varied substantially (e.g., ′Akiapōlā′au) or the uncertainty about the estimates is large (seen in all three listed birds). Distance sampling model assumptions were not violated, and with minimal pooling, adequate numbers of birds were detected to estimate densities.

Power to detect changes in listed bird distribution and densities is low. Therefore, it may be necessary to monitor changes in the common birds as a surrogate or proxy for the listed birds. Surrogate species serve as a measure of the environmental conditions that exist in a given locale and may indicate how the listed birds respond to conservation and management activities (Caro and O'Doherty 1999). Additionally, the effectiveness of management will equally benefit the surrogate and listed birds, although this relationship has not been rigorously tested. In this situation, the value of using common birds as surrogate is to provide inference for the listed species that cannot be feasibly monitored directly. Caro and O'Doherty (1999) provide a framework for identifying the various types and attributes of indicator species, and the most appropriate type is the one that assess the changes in population of other species, termed population indicators. There are considerable difficulties in identifying and extrapolating between the target and surrogate species, including assuming that the surrogate species provides a direct correlation with the listed birds for which they are serving as surrogate.

Caro and O'Doherty (1999) identify five key attributes of surrogate species: (1) measurement attributes, (2) life-history traits, (3) ecological characteristics, (4) abundance (attributes of commonness and rarity), and (5) sensitivity to environmental change. In general, the biology of the surrogate should be well known and the surrogate easily sampled. The generation time should be short; however, this may be relaxed as long as the growth rates of the surrogate mirror those of the listed birds. It is best if the surrogate is a resident and therefore is subject to the same environmental stressors as the listed birds. It is also advantageous if the surrogate population is large and widely distributed because large populations are usually easier to monitor. Finally, the surrogate must be sensitive to changes in the environment due to management and possess low levels of individual variability in response to management and environmental changes. Given those criteria, it is possible to categorize the non-listed native birds according to a selection profile to identify which bird(s) is the most appropriate surrogate for the listed passerines (Table 8). Because of the differences in niche requirements and life history traits we eliminated the two non-honeycreepers—Hawai′i ′Elepaio and ′Ōma′o. ′Apapane possess several similar attributes as the listed passerines but were eliminated as a surrogate because they are super abundant and make large-scale movements tracking flowering phenology (Ralph and Fancy 1995). Both the Hawai′i ′Amakihi and ′I′iwi are good candidate surrogate species for the listed passerines. Hawai′i ′Amakihi and ′I′iwi portray many of the same attributes and patterns as the listed passerines, and both species are abundant enough to reliably track changes in occupancy and density. The largest difference between Hawai′i ′Amakihi and ′I′iwi is that Hawai′i ′Amakihi are resident to the area and are therefore not exposed to threats outside the proposed SHA. Whereas, I′iwi, which are very susceptible to avian diseases (Atkinson and LaPointe 2009) and are considered as an indicator of forest health, make large-scale movements to track flowering phenology exposing them to external threats.

In 2007, Gorresen et al. (2008) surveyed 15 stations using ′Io playback calls in the Keauhou-Kīlauea region. Six birds were detected on four stations (% occurrence = 26.7, bird per station = 0.4), and ′Io density was estimated to be about one bird every two km^2

(0.51 ± 0.34 birds/km^2; mixed exotic forest, shrubland, and grassland including forestry plantations in the Puna region; Gorresen et al. 2008). Monitoring ʻIo is difficult because they defend large territories and are very mobile, and there were very few sampling stations in the altered stratum (four stations). Furthermore, ʻIo have low detection probabilities unless counts incorporate playback calls. Therefore, and like the listed passerines, it is difficult to assess the status of ʻIo, except to say that they exist at low densities in both strata.

Occurrence of common birds

In the altered forest stratum, the common native birds were detected on at least two-thirds of the stations, and three birds—ʻŌmaʻo, Hawaiʻi ʻAmakihi, and ʻApapane—were detected on all or almost all altered forest stations. Within the study area, ʻApapane were ubiquitous despite habitat and elevation differences. ʻApapane were detected on all of the intact and altered strata stations in 2008 and all but two stations during the 2006 survey in the lower portion of Keauhou. ʻŌmaʻo occurrence was almost nine percent lower in the intact forest stratum (88% occurrence) and 17% lower in the low elevation surveyed (80% occurrence) than in the altered forest stratum (97% occurrence). Likewise, Hawaiʻi ʻAmakihi occupancy was substantially lower in the adjacent closed and low elevation forests (23% and 58% lower, respectively) then in the altered forest stratum (99% occurrence).

Occupancy was slightly lower for the Hawaiʻi ʻElepaio and ʻIʻiwi. Hawaiʻi ʻElepaio were detected on almost twice as many stations in the altered stratum than in the intact forest. This pattern was less pronounced for the ʻIʻiwi but with slightly more stations being occupied in the intact forest than in the altered stratum. Occurrence was very low for both the Hawaiʻi ʻElepaio and ʻIʻiwi in the lower elevations of Keauhou.

Status and trends of common birds

Densities of Hawaiʻi ʻElepaio and Hawaiʻi ʻAmakihi were greater in the altered stratum than in the intact stratum. In contrast, ʻIʻiwi and ʻApapane densities were greater in intact than altered stratum. Differences between the strata were not significant for ʻŌmaʻo. Trends for most of the common birds were definitive with strong or very strong evidence of decreasing, stable or increasing trends. The only exception was the trend of Hawaiʻi ʻAmakihi in the intact forest, which portrayed weak evidence for both stable and declining trends, and very weak evidence for increasing trends. This indicates that there is insufficient evidence to decide if ʻamakihi is declining slowly or remaining the same. There is adequate power to detect differences in densities and declining trends for most of the common birds, at least given substantial declines of 50% over 10 years.

Monitoring Future Changes in Forest Bird Populations

Reliable density estimates allow for comparing the state of the bird population to the established baseline. Given the historical fluctuations in bird occurrences and densities, and the relatively small area of the proposed SHA the current annual sampling frequency and numbers of stations sampled (about 150 stations) will be needed to maintain marginal levels of power to detect declines in densities or trends of the listed birds, and to assess net conservation benefits.

Assessing changes in bird status can be accomplished by comparing current bird distributions and densities to the baseline. It may be difficult to detect changes initially because there is a relatively large amount of variability in bird status. For example, bird occurrence changes seasonally and annually, and densities are relatively imprecise (i.e., average annual coefficient of variation exceed 55% for listed birds; see Appendix 3). Additionally, statistical tests that compare end-point estimates (e.g., two-sample z-test of bird densities) have lower power to detect change than tests based on a time-series (e.g., repeated measures regression). However, the sampling methodology is based on probability sampling and when applied correctly the estimates are unbiased and allow for calculating estimates of error which facilitates assessing changes in bird distributions and densities.

Plotting bird occurrence across the study area is the first measure for tracking the population's spatial distribution. Although plotting occurrence is not a quantitative approach, this method can reveal gross patterns and shifts in bird distributions. Indices (e.g., percent occurrence) can be compared to the baseline and threshold levels set to determine net benefits. Empirical models (e.g., negative binomial distribution) can be used to measure and quantify differences in species aggregated spatial distributions; however, these approaches may require data beyond the scope of a SHA and at scales different from our study.

Comparing density estimates is more straightforward than tracking spatial distribution. For example, until a sufficiently long time-series can be acquired, future population densities can be compared to the baseline using a two-sample z-test end-point comparison (Buckland et al. 2001). We recommend that end-point comparisons be applied to determine if the population has significantly fallen below the baseline. Once sufficient monitoring has occurred to generate a long time-series (e.g., seven to 10 surveys) regression or repeated-measures regression methods can be applied to assess trends, in addition to end-point comparisons. Camp et al. (2008) and Camp, Pratt, et al. (2009) provide detailed methods for assessing trends in bird densities using log-link regression in a Bayesian framework. These methods can be used to assess short-term trajectories (e.g., < 10 consecutive surveys) and long-term trends (e.g., > 10 consecutive surveys) in bird densities.

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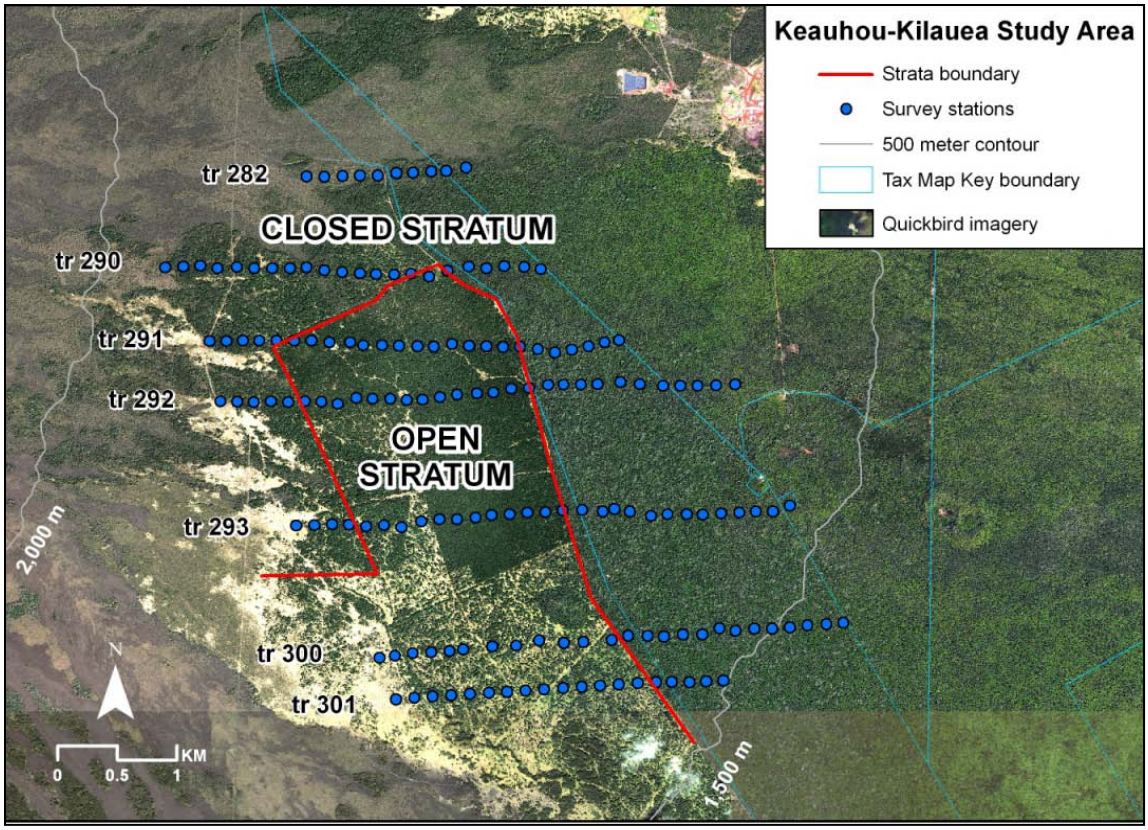


Figure 1. Location of bird survey transects and intact/altered forest strata in the Keauhou-Kīlauea Forest study area.

Figure 2. Examples of altered and intact forest strata. (a) Altered forest stratum consisting of formerly grazed and koa silviculture.

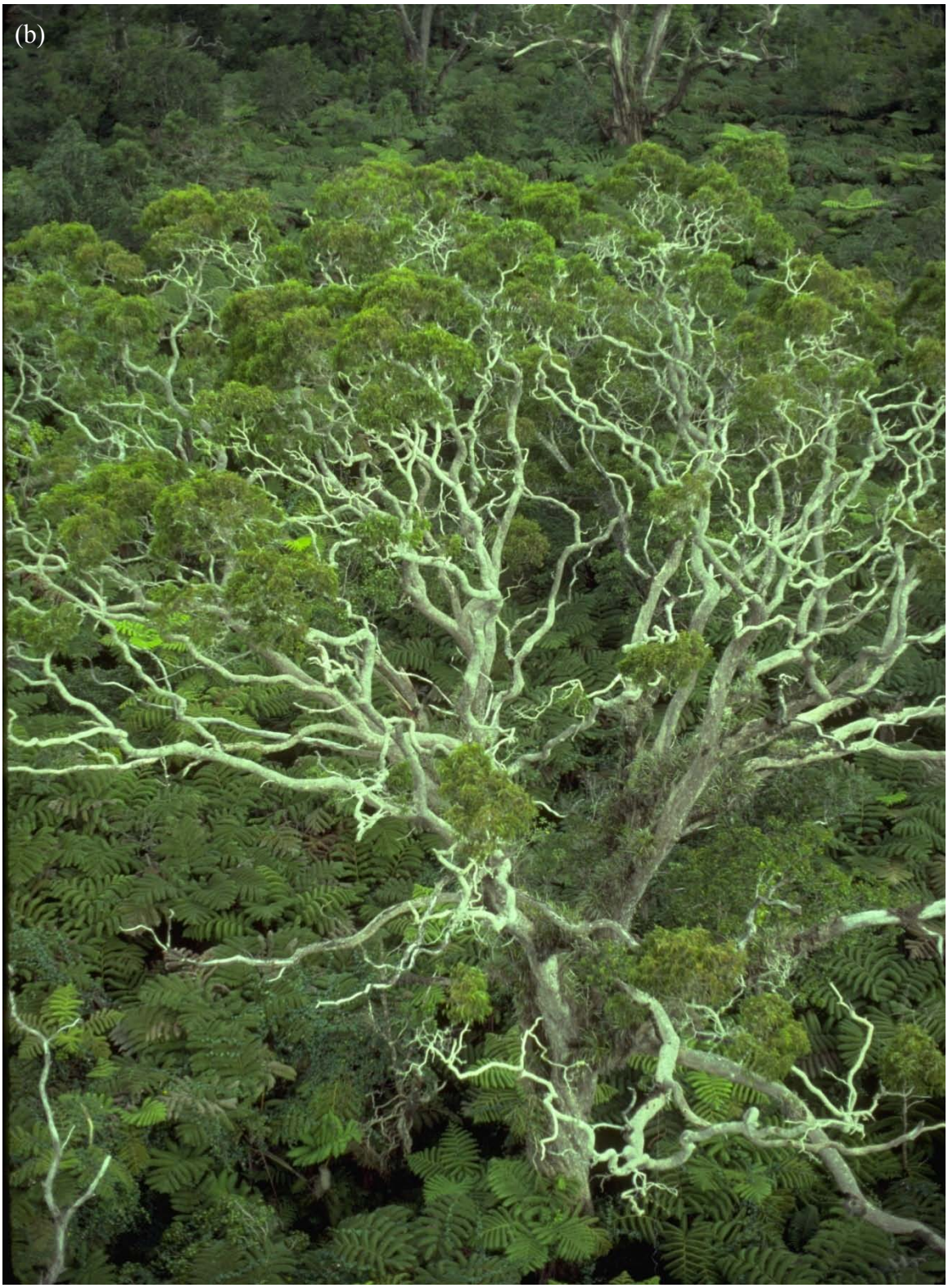


Figure 3. Examples of altered and intact forest strata. (b) Native rainforest representative of the intact forest stratum.

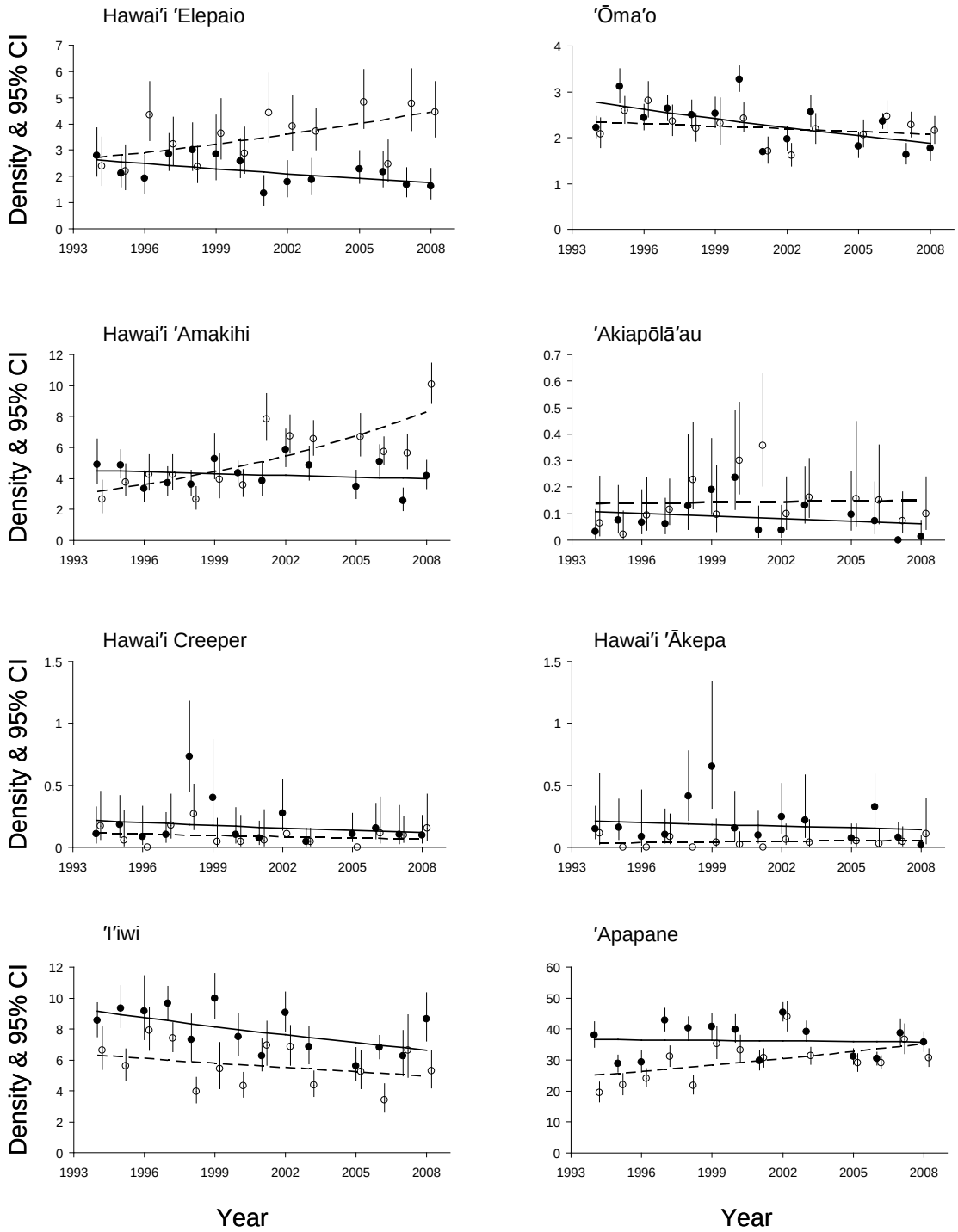


Figure 3. Annual density estimates (birds/ha) and 95% confidence intervals for native birds in intact forest (solid circle; solid line) and altered forest (open circles; dashed line) strata within the Keauhou-Kīlauea Forest study area in the Keauhou-Kīlauea region. Trend lines for ′Akiapōlā′au in the intact forest stratum and Hawai′i ′Ākepa in the altered forest stratum were calculated from least squares regression using an exponential model because the Bayesian based model failed to converge.

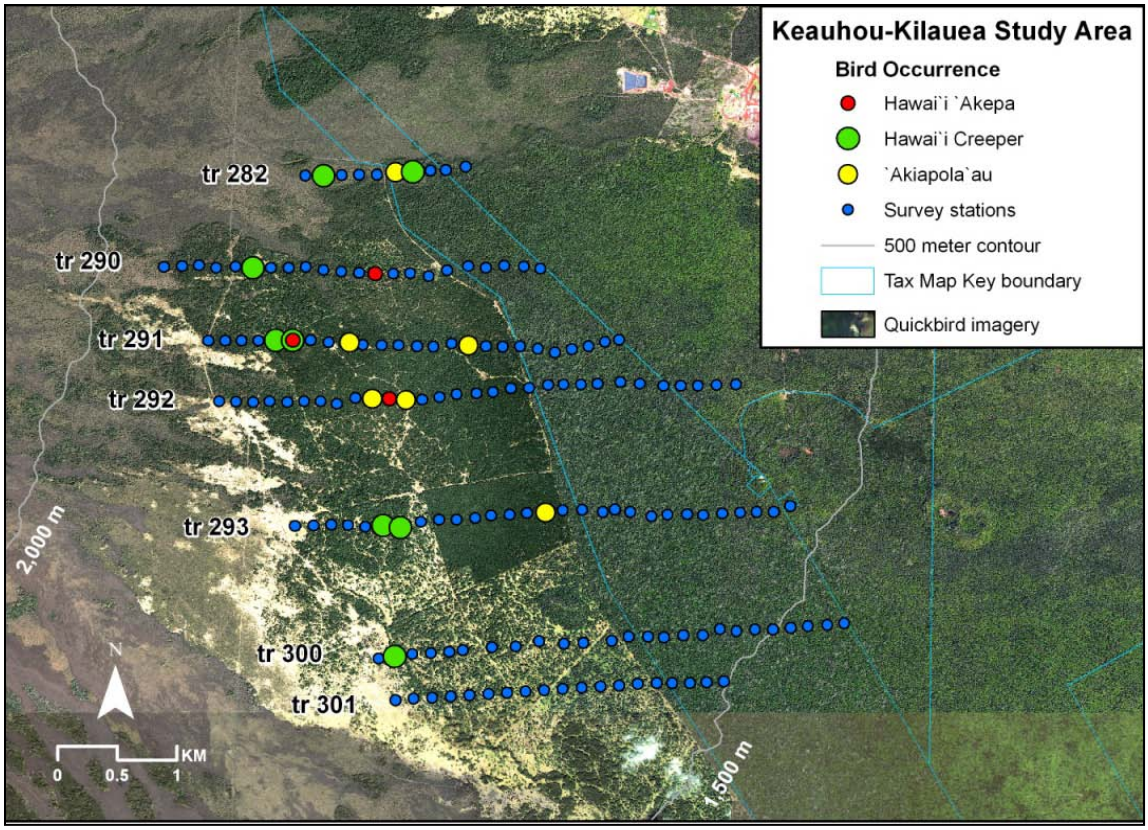


Figure 4. Location of the three endangered species—ʻAkiapōlāʻau, Hawaiʻi Creeper, and Hawaiʻi ʻĀkepa—detected during the 2008 forest bird survey in the Keauhou-Kīlauea Forest study area. Size of dots was used to plot occurrence where more than one species was detected at a station and does not indicate a difference in bird abundance.

Table 1. Transects sampled during annual surveys conducted within the Keauhou and Kīlauea Forest study area in the Keauhou-Kīlauea sampling region. Survey transects are identified by number.

Year	Transects																		
1993	282	290	291	292	293	300	301	302	303		310	311							
1994	282	290	291	292	293	300													
1995	282	290	291	292	293	300													
1996	282	290	291	292	293	300	301												
1997	282	290	291	292	293	300	301												
1998	282	290	291	292	293	300	301												
1999	282	290	291	292	293	300													
2000	282	290	291	292	293	300	301												
2001	282	290	291	292	293	300	301												
2002	282	290	291	292	293	300	301												
2003	282	290	291	292	293	300	301												
2004																			
2005	282	290	291	292	293	300													
2006	282	290	291	292	293	300		302	303	309	310	311	312	313	314	315	316	317	318
2007	282	290	291	292	293	300	301												
2008	282	290	291	292	293	300	301												

Table 2. Number of stations sampled, by forest stratum and totals, during annual surveys conducted within the Keauhou-Kīlauea Forest study area. A limited number of stations were sampled during all 14 annual surveys; 31 in the intact forest stratum, and 20 stations in the altered forest stratum.

Year	No. Stations in Intact Forest	No. Stations in Altered Forest	Sum of Stations Sampled	Survey Dates
1994	78	59	137	19 Jan. – 9 Mar.
1995	77	60	137	12 – 30 Jan.
1996	57	54	111	16 – 19 Jan.
1997	80	73	153	21 – 25 Jan.
1998	69	76	145	20 Jan. – 1 Feb.
1999	46	39	85	20 – 22 Jan.
2000	64	68	132	12 – 14 Jan.
2001	69	57	126	12 – 14 Mar.
2002	68	76	144	4 – 5 Feb.
2003	76	78	154	21 – 22 Jan.
2005	82	59	141	28 Jan. – 5 May
2006	86	59	145	21 Feb. – 4 Apr.*
2007	81	70	151	20 Feb. – 7 Mar.
2008	86	74	160	13 – 15 Feb.

* Keauhou Lower survey dates 21 April – 28 May 2006.

Table 3. List of species detected during forest bird surveys in the Keauhou-Kīlauea Forest study area, Hawai′i Island. Origin (E – endemic, V – visitor, and A – alien) of birds are presented.

Common Name	Scientific Name	Origin
Hawaiian Goose	*Branta sandvicensis*	E
′Io	*Buteo solitarius*	E
Erckel's Francolin	*Francolinus erckelii*	A
Kalij Pheasant	*Lophura leucomelanos*	A
Ring-necked Pheasant	*Phasianus colchicus*	A
Wild Turkey	*Meleagris gallopavo*	A
California Quail	*Callipepla californica*	A
Gambel's Quail	*Callipepla gambelii*	A
Pacific Golden-Plover	*Pluvialis fulva*	V
Rock Dove	*Columba livia*	A
Spotted Dove	*Streptopelia chinensis*	A
Zebra Dove	*Geopelia striata*	A
Barn Owl	*Tyto alba*	A
Hawai′i ′Elepaio	*Chasiempis sandwichensis*	E
Sky Lark	*Alauda arvensis*	A
′Ōma′o	*Myadestes obscurus*	E
Hwamei	*Garrulax canorus*	A
Red-billed Leiothrix	*Leiothrix lutea*	A
Japanese White-eye	*Zosterops japonicus*	A
Common Myna	*Acridotheres tristis*	A
Yellow-billed Cardinal	*Paroaria capitata*	A
Northern Cardinal	*Cardinalis cardinalis*	A
House Finch	*Carpodacus mexicanus*	A
Yellow-fronted Canary	*Serinus mozambicus*	A
Hawai′i ′Amakihi	*Hemignathus virens*	E
′Akiapōlā′au	*Hemignathus munroi*	E
Hawai′i Creeper	*Oreomystis mana*	E
Hawai′i ′Ākepa	*Loxops coccineus*	E
′I′iwi	*Vestiaria coccinea*	E
′Apapane	*Himatione sanguinea*	E
House Sparrow	*Passer domesticus*	A
African Silverbill	*Lonchura malabarica*	A
Nutmeg Mannikin	*Lonchura punctulata*	A

Table 4. Results from the 2008 Keauhou-Kīlauea survey: relative abundance and densities (birds/ha) of native birds in the intact and altered forest strata. Scientific names are provided in Table 3. Relative abundance included number of stations occupied (#Occ), number of individuals detected (# Birds), proportion of stations occupied (i.e., percent occurrence [% Occur]), and birds per station (BPS). Densities are birds/ha and 95% confidence intervals. The 2008 survey included 86 stations on seven transects in the intact forest stratum and 74 stations on six transects in the altered forest stratum. Gorresen et al. (2008) estimated ʻIo densities to be 0.0051 birds/ha in the mixed exotic forest, shrubland, and grassland including forestry plantations in the Puna region.

Species	# Occ	# Birds	% Occur	BPS	Density and 95% CI
Intact Forest					
Hawaiʻi ʻElepaio	32	46	37.21	0.53	1.63 (1.15—2.32)
ʻŌmaʻo	76	222	88.37	2.58	1.77 (1.50—2.09)
Hawaiʻi ʻAmakihi	65	166	75.58	1.93	4.15 (3.32—5.19)
ʻAkiapōlāʻau	1	1	1.16	0.01	0.01 (0.00—0.08)
Hawaiʻi Creeper	4	5	4.65	0.06	0.09 (0.04—0.25)
Hawaiʻi ʻĀkepa	1	1	1.16	0.01	0.02 (0.00—0.10)
ʻIʻiwi	75	308	87.21	3.58	8.65 (7.22—10.36)
ʻApapane	86	916	100.00	10.65	35.74 (32.70—39.06)
Altered Forest					
Hawaiʻi ʻElepaio	49	109	66.22	1.47	4.44 (3.51—5.61)
ʻŌmaʻo	72	221	97.30	2.99	2.15 (1.88—2.46)
Hawaiʻi ʻAmakihi	73	323	98.65	4.36	10.06 (8.85—11.44)
ʻAkiapōlāʻau	5	6	6.76	0.08	0.10 (0.04—0.24)
Hawaiʻi Creeper	4	7	5.41	0.09	0.15 (0.05—0.43)
Hawaiʻi ʻĀkepa	2	5	2.70	0.07	0.11 (0.03—0.40)
ʻIʻiwi	55	172	74.32	2.32	5.27 (4.20—6.61)
ʻApapane	74	780	100.00	10.54	30.66 (27.92—33.66)

Table 5. Comparison of bird densities between intact and altered forest strata over 14 years in the Keauhou-Kīlauea Forest study area using repeated measures analysis of variance. Stratum differences are averaged over years (Appendix 3) and used to assess fixed effects and differences of least squares means repeated measures (below). Degrees of freedom are provided in subscript to the *F* and *t* values. Significant differences between strata were detected for all birds except ʻŌmaʻo. Comparisons between strata for Hawaiʻi ʻĀkepa were not estimated because the sample size was too small.

	Fixed Effects						Differences of Least Squares Means		
	Stratum		Year		Interaction				
Species	*F* value	*P* value	*F* value	*P* value	*F* value	*P* value	Estimate ± SE	*t* value	*P* value
Hawaiʻi ʻElepaio	$11.85_{1,174}$	0.001	$2.46_{13,1803}$	0.003	$5.31_{13,1803}$	<0.001	-0.26 ± 0.076	-3.44_{174}	<0.001
ʻŌmaʻo	$0.06_{1,171}$	0.801	$12.77_{13,1804}$	<0.001	$4.57_{13,1804}$	<0.001	-0.01 ± 0.034	-0.25_{171}	0.801
Hawaiʻi ʻAmakihi	$7.16_{1,174}$	0.008	$10.81_{13,1798}$	<0.001	$8.94_{13,1798}$	<0.001	-0.22 ± 0.084	-2.68_{174}	0.008
ʻAkiapōlāʻau	$5.26_{1,181}$	0.023	$3.56_{13,1843}$	<0.001	$1.58_{13,1843}$	0.085	-0.03 ± 0.013	-2.29_{181}	0.023
Hawaiʻi Creeper	$8.81_{1,182}$	0.003	$5.68_{13,1901}$	<0.001	$2.08_{13,1901}$	0.013	0.04 ± 0.014	2.97_{182}	0.003
Hawaiʻi ʻĀkepa	$23.46_{1,214}$	<0.001	$2.41_{13,1731}$	0.003	$2.20_{12,1731}$	0.010	Non-est		
ʻIʻiwi	$9.83_{1,166}$	0.002	$9.98_{13,1787}$	<0.001	$4.18_{13,1787}$	<0.001	0.26 ± 0.084	3.13_{166}	0.002
ʻApapane	$37.12_{1,177}$	<0.001	$17.42_{13,1816}$	<0.001	$9.54_{13,1816}$	<0.001	0.22 ± 0.036	6.09_{177}	<0.001

Table 6. Trends in forest bird density within the Keauhou-Kīlauea Forest study area. Results of Bayesian trends (▲ – increasing; ▼ – decreasing; ▬ – stable; ▬▲ – stable to increasing; and ▬▼ – stable to increasing), magnitude change, slope ($\hat{\beta}$; 90% credible interval), and distribution of Bayesian posterior probabilities for each species are shown for the intact forest (first row; shaded) and altered forest (second row) strata. Threshold limits delineating the ecological relevance of a trend was based on a 25% change in density over 25 years. Proportion of the posterior probability for strong ($70\% < P < 90\%$) and very strong ($P > 90\%$) evidence of a trend are highlighted in bold. Models to estimate the ʻAkiapōlāʻau trend in the intact forest strata and Hawaiʻi ʻĀkepa trend in altered forest strata failed to converge; therefore, those trends were estimated using simple linear regression.

Species	Trend (magnitude change)	$\hat{\beta}$ (90% credible interval)	Decline	Negligible	Increase
Hawaiʻi ʻElepaio	▼ (49%)	-0.028 (-0.044 — -0.012)	**95.55%**	4.45%	<0.01%
	▲ (134%)	0.036 (0.022 — 0.050)	0%	0.09%	**99.91%**
ʻŌmaʻo	▼ (49%)	-0.028 (-0.034 — -0.022)	**100%**	<0.01%	0%
	▬ (20%)	-0.009 (-0.016 — -0.001)	23.18%	**76.82%**	<0.01%
Hawaiʻi ʻAmakihi	▬▼ (20%)	-0.009 (-0.021 — 0.003)	33.55%	65.98%	0.47%
	▲ (400%)	0.069 (0.058 — 0.081)	0%	0%	**100%**
ʻAkiapōlāʻau	Model failed	-0.003 (-0.011 — 0.004)	$F_{1,12} = 0.580$ $P = 0.46$		
	No consensus (13%)	0.005 (-0.034 — 0.043)	23.36%	34.54%	42.10%
Hawaiʻi Creeper	▼ (64%)	-0.042 (-0.086 — -0.001)	**88.41%**	9.54%	2.05%
	No consensus (60%)	-0.037 (-0.125 — 0.042)	69.09%	14.14%	16.78%
Hawaiʻi ʻĀkepa	▼ (47%)	-0.026 (-0.071 — 0.017)	**70.27%**	20.90%	8.82%
	Model failed	0.002 (-0.003 — 0.006)	$F_{1,12} = 0.533$ $P = 0.41$		
ʻIʻiwi	▼ (43%)	-0.023 (-0.031 — -0.015)	**98.49%**	1.51%	0%
	▼ (34%)	-0.017 (-0.028 — -0.005)	**75.65%**	24.34%	0.01%
ʻApapane	▬ (5%)	-0.002 (-0.006 — 0.003)	0.02%	**99.98%**	0.01%
	▲ (77%)	0.024 (0.018 — 0.030)	0%	<0.01%	**100%**

Table 7. Power to detect a 25 or 50 % decline in density and trend. Coefficients of variation were calculated as the standard error divided by the density or slope. Bold text indicates adequate power (≥ 80%) to detect a decline. Power was not calculated for Hawai′i ′Ākepa trends.

	Density		Trend	
Species	25%	50%	25%	50%
Hawai′i ′Elepaio	**80**	**100**	42	**85**
′Ōma′o	**100**	**100**	23	45
Hawai′i ′Amakihi	**100**	**100**	**90**	**100**
′Akiapōlā′au	24	50	13	18
Hawai′i Creeper	21	41	15	24
Hawai′i ′Ākepa	19	35	—	—
′I′iwi	**85**	**100**	26	55
′Apapane	**100**	**100**	67	**100**

Table 8. Attributes of surrogate species assigned to common native Hawaiian passerine birds. Attribute categories adapted from Caro and O'Doherty (1999).

Attributes	Species				
	Hawai′i ′Elepaio	′Ōma′o	Hawai′i ′Amakihi	′I′iwi	′Apapane
Well-known biology	Yes	Yes	Yes	Yes	Yes
Easily sampled or observed	Moderate	Moderate	Yes	Yes	Yes
Accessible breeding site	Yes	Moderate	Yes	Yes	Yes
Generation time[1]	Yes	Yes	Yes	Yes	Yes
Resident or migratory[2]	R	R	R	M	M
Particular trophic level[3]	Yes	Yes	No	Yes	Yes
Large population size	Yes	Yes	Yes	Yes	Yes
Wide geographic range	Yes	Yes	Yes	Yes	Yes
Habitat specialist	No	No	No	No	No
Sensitive to human disturbance	Yes	Yes	No	No	No
Low variability in response	Yes	Yes	Yes	Yes	Yes
Occupancy matches listed species	Yes	No	Yes	No	No
Trend matches listed species	No	Yes	Partially	Yes	No

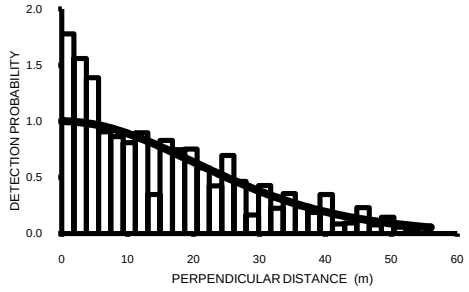
[1] Generation time approximately matches listed species.
[2] Migratory behaviors include daily large-scale movements tracking flowering phenology.
[3] Species that occupy particular trophic levels (e.g., feeding niches).

Appendix 1. Detection function models and distance histograms.

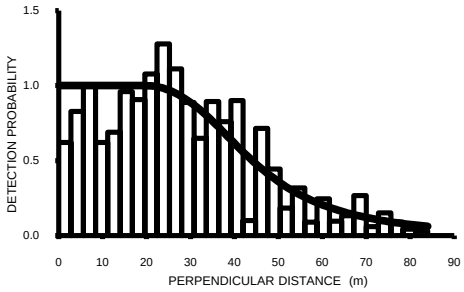
a)
A hazard-rate key function without covariates was fit to Hawai′i Creeper and Hawai′i ′Ākepa distance measures. The Hawai′i Creeper data were also left-tail truncated at 3.0 m. A hazard-rate key detection function with the covariate representing observer was fit to Hawai′i ′Elepaio and ′Ōma′o distance measures, and the covariate representing year was fit to ′Akiapōlā′au distance measures. ′I′iwi distance measures were fit with the hazard-rate key function and a simple polynomial expansion series of order two, and the covariate representing observer. The half-normal key function with the covariate representing observer was fit to the Hawai′i ′Amakihi distance measures. This same key detection function and covariate, and a hermite polynomial expansion series of order two was fit to ′Apapane distance measures.

b) Appendix 1 cont.

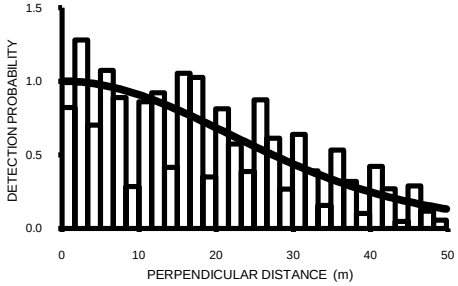
Hawai′i ′Elepaio



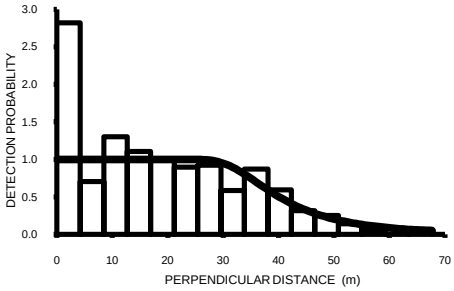
′Akiapōlā′ au



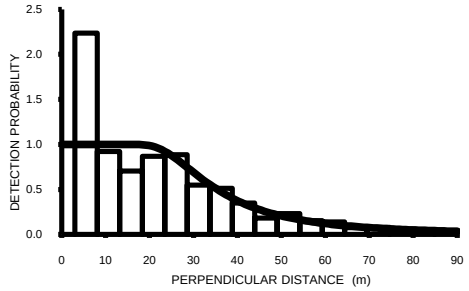
Hawai′i ′Amakihi



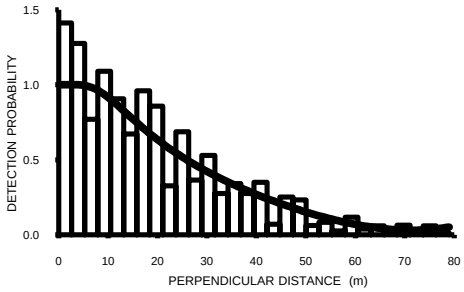
Hawai′i ′Ākepa



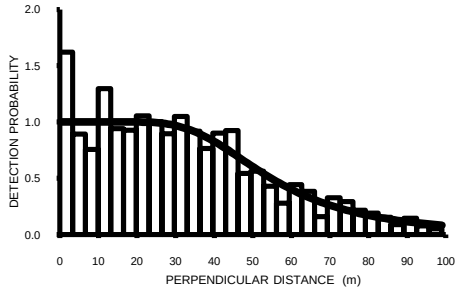
Hawai′i Creeper



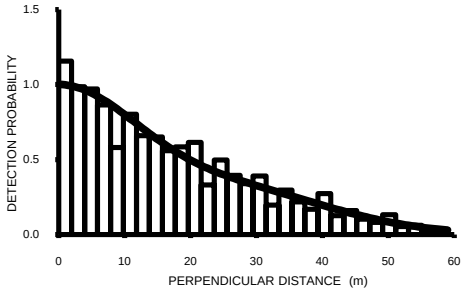
′I′iwi



′Ōma′o



′Apapane



Appendix 2. Species list and relative abundance of native and alien birds detected during the 2006 survey in the lower elevations of Keauhou (transects 312-318; 158 stations). Scientific names provided in Table 3. Relative abundance included number of stations occupied (#Occ), number of individuals detected (# Birds), proportion of stations occupied (i.e., percent occurrence [% Occur]), and birds per station (BPS).

Species	# Occ	# Birds	% Occur	BPS
ʻIo	2	2	1	0.01
Kalij Pheasant	1	2	1	0.01
Wild Turkey	13	17	8	0.11
Spotted Dove	1	1	1	0.01
Zebra Dove	1	1	1	0.01
Hawaiʻi ʻElepaio	14	17	9	0.11
Sky Lark	11	13	7	0.08
ʻŌmaʻo	126	289	80	1.83
Red-billed Leiothrix	34	114	22	0.72
Japanese White-eye	135	286	85	1.81
Common Myna	8	13	5	0.08
Yellow-billed Cardinal	2	3	1	0.02
Northern Cardinal	79	140	50	0.89
Hawaiʻi ʻAmakihi	64	111	41	0.7
ʻAkiapōlāʻau	1	1	1	0.01
ʻIʻiwi	7	10	4	0.06
ʻApapane	156	822	99	5.2

Appendix 3. Native bird density (birds/ha ± SE) and 95% confidence intervals by forest stratum (intact or altered) from annual surveys conducted between 1994 and 2008 within the Keauhou-Kīlauea Forest study area. The 2004 survey data were not available. A '—' denoted densities of zero birds. Summary statistics, average density (SD), and differences in least squares means (DLSM)(SE), used in the repeated measures analysis, are provided (statistical results are presented in Table 5).

Hawai′i ′Elepaio

Year	Intact Stratum	Altered Stratum
1994	2.79 ± 0.460 (2.01—3.87)	2.40 ± 0.453 (1.65—3.49)
1995	2.12 ± 0.293 (1.61—2.79)	2.19 ± 0.419 (1.50—3.20)
1996	1.94 ± 0.368 (1.33—2.83)	4.35 ± 0.552 (3.37—5.60)
1997	2.85 ± 0.354 (2.23—3.64)	3.23 ± 0.453 (2.44—4.26)
1998	3.00 ± 0.452 (2.23—4.05)	2.35 ± 0.346 (1.76—3.15)
1999	2.85 ± 0.602 (1.87—4.34)	3.63 ± 0.569 (2.65—4.97)
2000	2.59 ± 0.371 (1.95—3.44)	2.87 ± 0.439 (2.12—3.89)
2001	1.35 ± 0.279 (0.90—2.03)	4.43 ± 0.655 (3.30—5.95)
2002	1.78 ± 0.344 (1.21—2.61)	3.91 ± 0.526 (2.99—5.10)
2003	1.86 ± 0.346 (1.29—2.69)	3.72 ± 0.390 (3.02—4.58)
2005	2.28 ± 0.311 (1.74—2.98)	4.83 ± 0.560 (3.84—6.09)
2006	2.17 ± 0.339 (1.59—2.95)	2.46 ± 0.394 (1.79—3.38)
2007	1.69 ± 0.275 (1.22—2.33)	4.79 ± 0.584 (3.75—6.10)
2008	1.63 ± 0.291 (1.15—2.32)	4.44 ± 0.523 (3.51—5.61)
Average	2.21 (0.53)	3.54 (0.96)
DLSM	0.730 (0.0531)	0.992 (0.0542)

′Ōma′o

Year	Intact Stratum	Altered Stratum
1994	2.22 ± 0.114 (2.01—2.46)	2.08 ± 0.161 (1.79—2.43)
1995	3.11 ± 0.185 (2.76—3.50)	2.59 ± 0.147 (2.31—2.90)
1996	2.43 ± 0.139 (2.17—2.73)	2.81 ± 0.195 (2.45—3.23)
1997	2.63 ± 0.138 (2.37—2.92)	2.36 ± 0.165 (2.05—2.71)
1998	2.50 ± 0.153 (2.21—2.82)	2.20 ± 0.154 (1.92—2.53)
1999	2.53 ± 0.166 (2.22—2.89)	2.31 ± 0.247 (1.86—2.86)
2000	3.27 ± 0.143 (3.00—3.57)	2.42 ± 0.160 (2.12—2.76)
2001	1.69 ± 0.116 (1.47—1.93)	1.71 ± 0.142 (1.44—2.02)
2002	1.97 ± 0.131 (1.72—2.25)	1.61 ± 0.122 (1.38—1.87)
2003	2.55 ± 0.171 (2.23—2.92)	2.18 ± 0.161 (1.88—2.53)
2005	1.81 ± 0.138 (1.56—2.11)	2.07 ± 0.148 (1.79—2.39)
2006	2.36 ± 0.083 (2.20—2.53)	2.46 ± 0.159 (2.16—2.80)
2007	1.63 ± 0.113 (1.42—1.87)	2.28 ± 0.137 (2.02—2.56)
2008	1.77 ± 0.149 (1.50—2.09)	2.15 ± 0.146 (1.88—2.46)
Average	2.32 (0.51)	2.23 (0.32)
DSLM	1.110 (0.0236)	1.118 (0.0241)

Appendix 3 cont. Native bird density within the Keauhou-Kīlauea forest study areas.

Hawai′i ′Amakihi

Year	Intact Stratum	Altered Stratum
1994	4.90 ± 0.709 (3.68—6.53)	2.65 ± 0.519 (1.80—3.90)
1995	4.88 ± 0.460 (4.04—5.88)	3.77 ± 0.507 (2.89—4.93)
1996	3.36 ± 0.483 (2.52—4.47)	4.25 ± 0.567 (3.26—5.55)
1997	3.71 ± 0.474 (2.88—4.78)	4.28 ± 0.554 (3.31—5.53)
1998	3.60 ± 0.412 (2.87—4.52)	2.65 ± 0.373 (2.00—3.50)
1999	5.27 ± 0.718 (4.01—6.92)	3.92 ± 0.689 (2.76—5.58)
2000	4.33 ± 0.361 (3.67—5.11)	3.59 ± 0.430 (2.83—4.56)
2001	3.83 ± 0.538 (2.90—5.07)	7.81 ± 0.754 (6.44—9.47)
2002	5.86 ± 0.607 (4.77—7.20)	6.75 ± 0.627 (5.62—8.12)
2003	4.87 ± 0.558 (3.88—6.11)	6.54 ± 0.558 (5.52—7.75)
2005	3.50 ± 0.465 (2.69—4.56)	6.67 ± 0.685 (5.43—8.19)
2006	5.08 ± 0.507 (4.17—6.19)	5.73 ± 0.452 (4.89—6.70)
2007	2.54 ± 0.363 (1.92—3.37)	5.65 ± 0.562 (4.63—6.88)
2008	4.15 ± 0.468 (3.32—5.19)	10.06 ± 0.649 (8.85—11.44)
Average	4.28 (0.91)	5.31 (2.12)
DSLM	1.168 (0.0587)	1.391 (0.0597)

′Akiapōlā′au

Year	Intact Stratum	Altered Stratum
1994	0.03 ± 0.023 (0.01—0.11)	0.06 ± 0.047 (0.02—0.24)
1995	0.08 ± 0.041 (0.03—0.21)	0.02 ± 0.021 (0.00—0.11)
1996	0.07 ± 0.038 (0.02—0.19)	0.09 ± 0.045 (0.04—0.24)
1997	0.06 ± 0.031 (0.02—0.16)	0.12 ± 0.041 (0.06—0.23)
1998	0.13 ± 0.079 (0.04—0.40)	0.23 ± 0.079 (0.12—0.44)
1999	0.19 ± 0.068 (0.10—0.38)	0.10 ± 0.055 (0.03—0.28)
2000	0.24 ± 0.089 (0.11—0.49)	0.30 ± 0.084 (0.18—0.52)
2001	0.04 ± 0.026 (0.01—0.13)	0.36 ± 0.102 (0.20—0.63)
2002	0.04 ± 0.026 (0.01—0.13)	0.10 ± 0.046 (0.04—0.24)
2003	0.13 ± 0.051 (0.06—0.28)	0.16 ± 0.054 (0.08—0.31)
2005	0.10 ± 0.051 (0.04—0.26)	0.16 ± 0.088 (0.05—0.45)
2006	0.07 ± 0.044 (0.02—0.22)	0.15 ± 0.069 (0.06—0.36)
2007	—	0.07 ± 0.035 (0.03—0.18)
2008	0.01 ± 0.014 (0.00—0.08)	0.10 ± 0.046 (0.04—0.24)
Average	0.08 (0.07)	0.14 (0.09)
DSLM	0.049 (0.0091)	0.079 (0.0095)

Hawai′i Creeper

Year	Intact Stratum	Altered Stratum
1994	0.11 ± 0.064 (0.04—0.32)	0.17 ± 0.089 (0.06—0.46)
1995	0.18 ± 0.079 (0.08—0.42)	0.06 ± 0.056 (0.01—0.30)
1996	0.09 ± 0.066 (0.02—0.33)	—
1997	0.11 ± 0.055 (0.04—0.28)	0.18 ± 0.083 (0.07—0.43)
1998	0.73 ± 0.178 (0.45—1.18)	0.27 ± 0.089 (0.14—0.51)

Appendix 3 cont. Native bird density within the Keauhou-Kīlauea forest study areas.

Year	Intact Stratum	Altered Stratum
1999	0.40 ± 0.161 (0.19—0.87)	0.04 ± 0.043 (0.01—0.23)
2000	0.11 ± 0.064 (0.03—0.32)	0.05 ± 0.048 (0.01—0.25)
2001	0.07 ± 0.042 (0.03—0.21)	0.06 ± 0.057 (0.01—0.30)
2002	0.27 ± 0.099 (0.14—0.55)	0.11 ± 0.080 (0.03—0.40)
2003	0.04 ± 0.031 (0.01—0.16)	0.04 ± 0.030 (0.01—0.15)
2005	0.11 ± 0.054 (0.04—0.28)	—
2006	0.16 ± 0.067 (0.07—0.35)	0.11 ± 0.080 (0.03—0.41)
2007	0.10 ± 0.067 (0.03—0.34)	0.10 ± 0.047 (0.04—0.24)
2008	0.09 ± 0.050 (0.04—0.25)	0.15 ± 0.085 (0.05—0.43)
Average	0.18 (0.18)	0.01 (0.08)
DSLM	0.087 (0.0100)	0.044 (0.0105)

Hawai′i ′Ākepa

Year	Intact Stratum	Altered Stratum
1994	0.15 ± 0.062 (0.07—0.33)	0.11 ± 0.113 (0.02—0.60)
1995	0.16 ± 0.075 (0.07—0.39)	—
1996	0.09 ± 0.088 (0.02—0.46)	—
1997	0.10 ± 0.062 (0.03—0.31)	0.09 ± 0.054 (0.03—0.27)
1998	0.41 ± 0.136 (0.22—0.78)	—
1999	0.65 ± 0.241 (0.32—1.34)	0.04 ± 0.043 (0.01—0.23)
2000	0.16 ± 0.089 (0.05—0.45)	0.02 ± 0.024 (0.00—0.13)
2001	0.10 ± 0.058 (0.03—0.29)	—
2002	0.24 ± 0.094 (0.12—0.51)	0.07 ± 0.037 (0.02—0.19)
2003	0.22 ± 0.114 (0.08—0.58)	0.04 ± 0.043 (0.01—0.22)
2005	0.07 ± 0.037 (0.03—0.19)	0.05 ± 0.037 (0.01—0.19)
2006	0.33 ± 0.099 (0.18—0.59)	0.03 ± 0.028 (0.01—0.15)
2007	0.08 ± 0.039 (0.03—0.20)	0.05 ± 0.033 (0.01—0.17)
2008	0.02 ± 0.019 (0.00—0.10)	0.11 ± 0.079 (0.03—0.40)
Average	0.20 (0.17)	0.04 (0.04)
DSLM	0.089 (0.0108)	Not estimated

′I′iwi

Year	Intact Stratum	Altered Stratum
1994	8.54 ± 0.557 (7.50—9.72)	6.61 ± 0.689 (5.37—8.14)
1995	9.33 ± 0.678 (8.08—10.78)	5.60 ± 0.505 (4.67—6.70)
1996	9.15 ± 1.025 (7.32—11.45)	7.89 ± 0.690 (6.62—9.40)
1997	9.65 ± 0.536 (8.65—10.78)	7.41 ± 0.483 (6.51—8.43)
1998	7.30 ± 0.755 (5.94—8.97)	3.96 ± 0.418 (3.21—4.88)
1999	9.99 ± 0.730 (8.63—11.57)	5.43 ± 0.729 (4.14—7.12)
2000	7.51 ± 0.695 (6.24—9.03)	4.33 ± 0.397 (3.61—5.20)
2001	6.25 ± 0.513 (5.31—7.36)	6.93 ± 0.705 (5.66—8.49)
2002	9.04 ± 0.635 (7.86—10.4)	6.83 ± 0.640 (5.67—8.23)
2003	6.86 ± 0.606 (5.76—8.18)	4.37 ± 0.410 (3.63—5.27)
2005	5.62 ± 0.546 (4.63—6.81)	5.24 ± 0.620 (4.14—6.64)

Appendix 3 cont. Native bird density within the Keauhou-Kīlauea forest study areas.

Year	Intact Stratum	Altered Stratum
2006	6.79 ± 0.389 (6.06—7.60)	3.41 ± 0.462 (2.61—4.47)
2007	6.27 ± 0.736 (4.97—7.92)	6.60 ± 1.004 (4.89—8.93)
2008	8.65 ± 0.787 (7.22—10.36)	5.27 ± 0.601 (4.20—6.61)
Average	7.93 (1.43)	5.71 (1.37)
DSLM	1.783 (0.0587)	1.521 (0.0597)

ʻApapane

Year	Intact Stratum	Altered Stratum
1994	38.08 ± 2.037 (34.23—42.35)	19.49 ± 1.608 (16.52—22.98)
1995	28.81 ± 1.366 (26.22—31.66)	22.03 ± 1.699 (18.89—25.70)
1996	29.31 ± 1.759 (25.99—33.05)	24.13 ± 1.515 (21.28—27.36)
1997	42.87 ± 1.852 (39.34—46.72)	31.11 ± 1.692 (27.92—34.67)
1998	40.26 ± 1.731 (36.96—43.87)	21.69 ± 1.492 (18.92—24.87)
1999	40.74 ± 2.021 (36.87—45.01)	35.37 ± 2.603 (30.49—41.04)
2000	39.94 ± 2.209 (35.77—44.60)	33.25 ± 2.211 (29.12—37.96)
2001	29.77 ± 1.622 (26.70—33.19)	30.59 ± 1.484 (27.76—33.71)
2002	45.42 ± 1.499 (42.53—48.51)	43.97 ± 2.379 (39.48—48.97)
2003	39.23 ± 1.577 (36.21—42.50)	31.30 ± 1.377 (28.67—34.16)
2005	31.12 ± 1.282 (28.67—33.78)	29.01 ± 1.444 (26.26—32.04)
2006	30.34 ± 1.047 (28.33—32.50)	29.16 ± 1.044 (27.15—31.33)
2007	38.78 ± 2.156 (34.72—43.31)	36.57 ± 2.370 (32.14—41.61)
2008	35.74 ± 1.597 (32.70—39.06)	30.66 ± 1.441 (27.92—33.66)
Average	36.46 (5.57)	29.88 (6.57)
DSLM	3.515 (0.0249)	3.297 (0.0256)

Appendix 3

Excerpts from Technical Report of the Hawaiian Hoary Bat Population on Kamehameha Schools Lands.

Keahou Ranch Summary from 2008 to 2012

- High Elevation Site – 598 nights sampled, 217 nights with bat activity = 36% of nights sampled detected bats
  - 404 Bat Pass Events, 1,814 Bat echolocation calls recorded
  - Bat presence was highest during January and October
  - Seasonal highs in activity present in late fall and over winter periods.
- Low Elevation Site – 587 nights sampled, 180 nights with bat activity = 30.6% of nights sampled detected bats
  - 591 Bat Pass Events, 3,041 Bat echolocation calls recorded
  - Bat presence was highest during April, June, August, and September
  - Seasonal highs in activity present in the summer period.
- There is consistent use of the two areas surveyed within Keahou Ranch by bats; seasonal trends of bat presence are similar year to year.

Bat detections were greatest in the higher elevation survey area, but more passes and pulses collected in the lower area suggest that bats move down during the summer to reproduce.

Keahou Ranch High Elevation Site Bat Surveys 2008 - 2009 - 2010 - 2011 - 2012

Survey Date	Survey Nights	Stations	Nights Sampled	Active Nights	Passes	Pulses	Pulses*	Detectability	SE
3/14/2008-3/31/2008	17	9	78	32	65	312	4.00	0.59	0.07
8/08/2008-8/22/2008	7	11	77	27	55	239	3.10	0.48	0.07
12/09/2008-12/23/2008	7	11.1	78	38	77	286	3.67	0.47	0.06
4/13/2009 - 4/28/2009	15	1.93	29	4	5	18	0.62	0.25	0.14
6/19/2009 - 6/26/2009	7	2	14	3	3	14	1.00	0.25	0.12
8/19/2009 - 8/25/2009	7	2	14	7	13	92	6.57	0.50	0.13
10/19/2009 - 10/25/2009	7	3	21	18	61	262	12.48	0.86	0.07
12/17/2009 - 12/24/2009	7	3	21	11	18	73	3.48	0.52	0.11
2/17/2010 - 2/24/2010	7	3	19	4	4	12	0.63	0.22	0.13
4/21/2010 - 4/28/2010	7	3	21	0	0	0	0.00	0.00	0.00
6/27/2010 - 6/28/2010	7	2.85	20	5	5	16	0.80	0.25	0.09
8/18/2010 - 8/25/2010	7	3	21	6	6	18	0.86	0.29	0.09
11/8/2010 - 11/15/2010	7	3	21	4	9	35	1.67	0.25	0.13
1/18/2011 - 1/25/2011	7	3	21	9	14	77	3.67	0.43	0.11
3/15/2011 - 3/22/2011	7	3	21	10	11	65	3.10	0.48	0.11
5/12/2011 - 5/19/2011	7	3	21	2	2	6	0.29	0.24	0.19
7/29/2001 - 8/4/2011	7	2	14	4	8	51	3.64	0.28	0.12
9/21/2011 - 9/27/2011	7	3	21	8	14	96	4.57	0.38	0.11
11/21/2011 - 11/27/2011	7	3	21	10	12	38	1.81	0.48	0.11
1/20/2012 - 1/26/2012	7	1.28	9	6	13	52	5.78	0.85	0.14
3/23/2012 - 3/29/2012	7	2.14	15	5	5	16	1.07	0.33	0.13
5/15/2012 - 5/22/2012	7	3	21	4	4	36	1.71	0.56	0.18
		Totals	**598**	**217**	**404**	**1814**			
			Nights Sampled	**Active Nights**	**Passes**	**Pulses**			

Table 1. Keahou Ranch summary of Hawaiian hoary bat acoustic surveys at 1,890 m elevation from 2008 to 2012. Survey nights are the duration of the sample (usually a week). Stations are the number of Anabat ultrasonic bat detection devices deployed during the survey. Nights sampled represent the number of detector nights (survey nights X stations running). Active nights are the number of nights sampled in which bat echolocation calls were positively identified as present. A pass represents a bat detection event. Passes are the total number of times a bat "passed" in front of a microphone at a station during a survey period. A pulse represents one echolocation call emitted by a bat. Pulses are the total number of echolocation calls recorded during a survey period. Pulses* are the number of pulses per night per bat detector during a survey period. Detectability (with reported standard errors) represents the basic presence of bats during a survey. A value of 0 is equal to no bats being present; while a value of 1.0 means that a bat was recorded at every station during every night of the survey period (maximum presence).

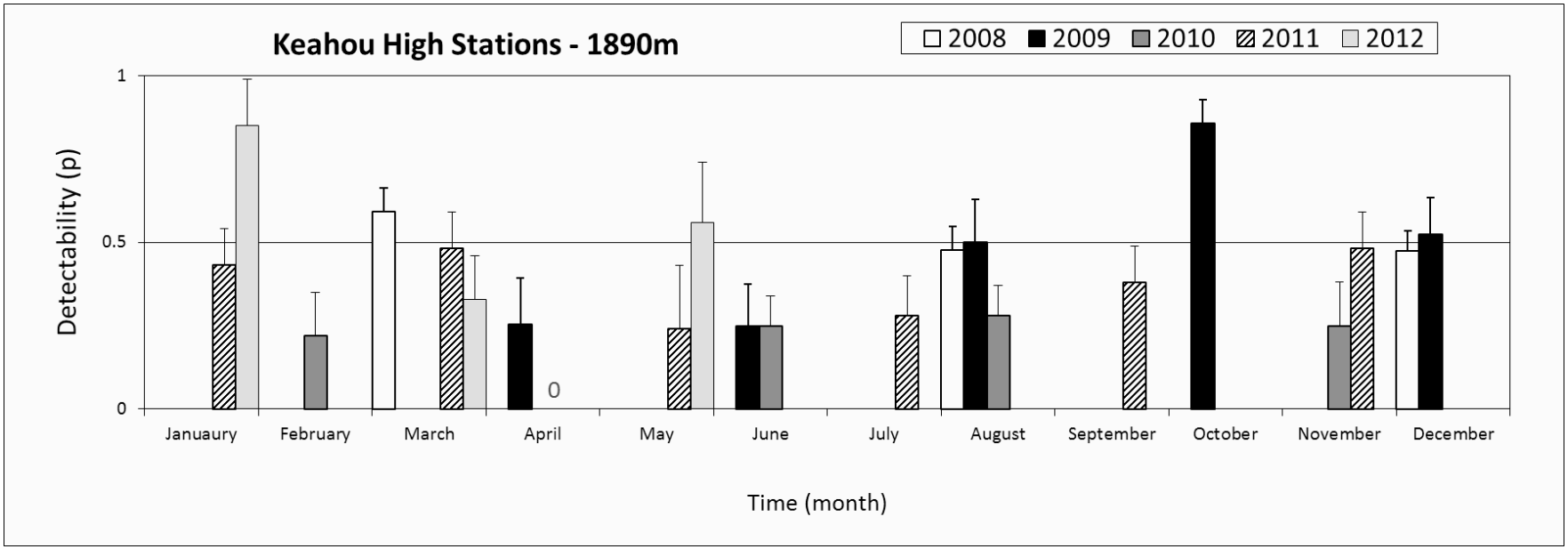


Figure 1. Graph of detectability values for bat detection surveys at Keahou Ranch, 1,890 meters elevation from 2008 to 2012. Detectability (with reported standard errors) represents the basic presence of bats during a survey. A value of 0 is equal to no bats being present; while a value of 1.0 means that a bat was recorded at every station during every night of the survey period (maximum presence). Bats were most present during January and October. Bat presence is consistent year to year, with seasonal highs in activity during fall and winter months.

Keahou Ranch Low Elevation Bat Surveys 2008 - 2009 - 2010 - 2011 - 2012

Survey Date	Survey Nights	Stations	Nights Sampled	Active Nights	Passes	Pulses	Pulses*	Detectability	SE
5/02/2008 - 5/16/2008	7	11	77	8	10	41	0.53	0.16	0.08
9/23/2008 - 10/07/2008	7	10.14	71	24	86	467	6.58	0.56	0.08
2/02/2009 - 2/17/2009	7,8	11	83	16	26	181	2.18	0.33	0.08
4/13/2009- 4/21/2009	8	3	24	10	51	219	9.13	0.62	0.12
6/19/2009 - 6/26/2009	7	2	14	6	9	84	6.00	0.42	0.14
8/19/2009 - 8/25/2009	7	2	14	9	13	97	6.93	0.64	0.13
10/19/2009 10/25/2009	7	2	14	7	13	43	3.07	0.50	0.13
12/17/2009 12/24/2009	7	2	14	8	112	499	35.64	0.57	0.13
2/17/2010 - 2/24/2010	7	2.28	16	3	6	37	2.31	0.39	0.21
4/21/2010 - 4/28/2010	7	3	21	11	14	80	3.81	0.52	0.10
6/21/2010 - 6/28/2010	7	3	21	15	93	613	29.19	0.71	0.09
8/18/2010 - 8/25/2010	7	3	21	4	6	83	3.95	0.25	0.13
11/8/2010 - 11/15/2010	7	3	21	3	3	25	1.19	0.14	0.07
1/18/2011 - 1/25/2011	7	2	14	3	6	20	1.43	0.21	0.11
3/15/2011 - 3/22/2011	7	3	21	3	5	15	0.71	0.42	0.19
5/12/2011 - 5/19/2011	7	3	21	2	2	6	0.29	0.24	0.19
7/26/2011-8/5/2011	7	3	21	12	28	134	6.38	0.52	0.11
9/21/2011-9/28/2011	7	2.14	15	9	36	156	10.40	0.60	0.13
11/21/2011-11/28/2011	7	3	21	5	9	18	0.86	0.24	0.09
1/20/2012-1/27/2012	7	3	21	9	42	147	7.00	0.33	0.10
3/23/2012-3/30/2012	7	3	21	5	10	31	1.48	0.34	0.14
5/15/2010 - 5/22/2012	7	3	21	8	11	45	2.14	0.38	0.10
		Totals	**587**	**180**	**591**	**3,041**			
			Nights Sampled	**Active Nights**	**Passes**	**Pulses**			

Table 2. Keahou Ranch summary of Hawaiian hoary bat acoustic surveys at 1,270 m elevation from 2008 to 2012. Survey nights are the duration of the sample (usually a week). Stations are the number of Anabat ultrasonic bat detection devices deployed during the survey. Nights sampled represent the number of detector nights (survey nights X stations running). Active nights are the number of nights sampled in which bat echolocation calls were positively identified as present. A pass represents a bat detection event. Passes are the total number of times a bat "passed" in front of a microphone at a station during a survey period. A pulse represents one echolocation call emitted by a bat. Pulses are the total number of echolocation calls recorded during a survey period. Pulses* are the number of pulses per night per bat detector during a survey period. Detectability (with reported standard errors) represents the basic presence of bats during a survey. A value of 0 is equal to no bats being present; while a value of 1.0 means that a bat was recorded at every station during every night of the survey period (maximum presence).

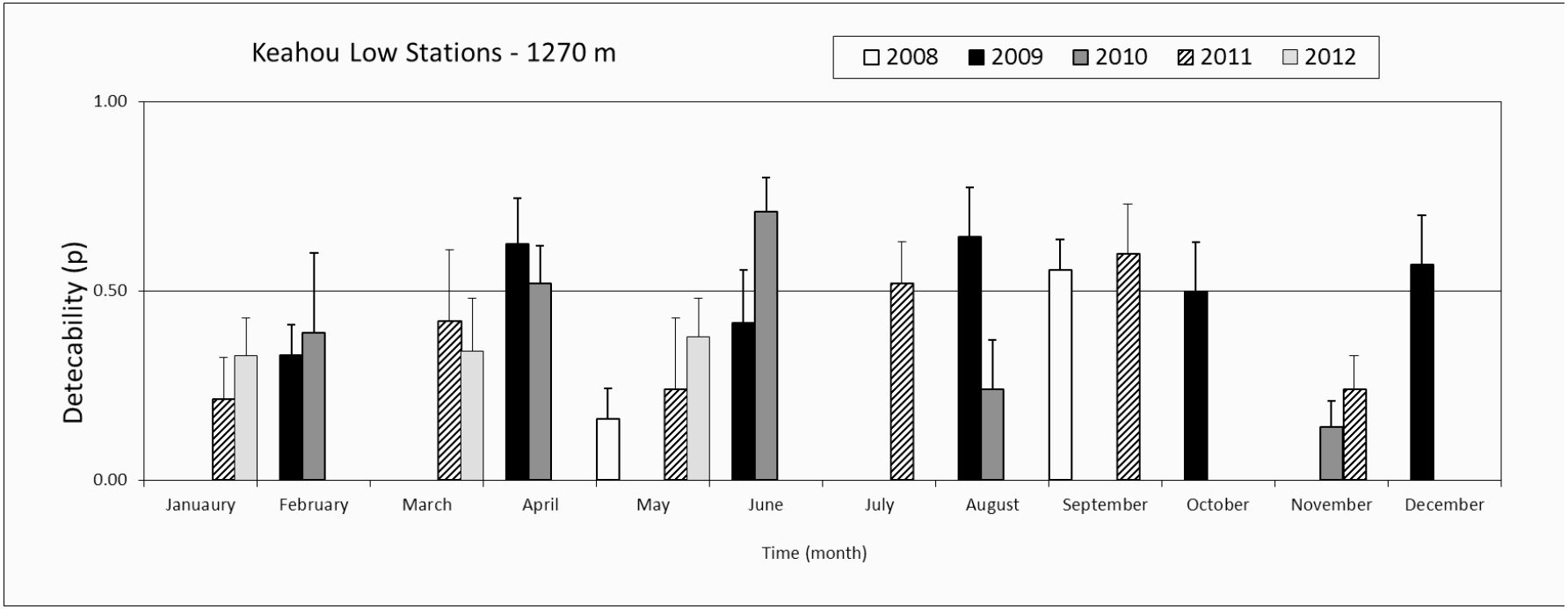


Figure 2. Graph of detectability values for Hawaiian hoary bat detection surveys at Keahou Ranch, 1,270 meters elevation from 2008 to 2012. Detectability (with reported standard errors) represents the basic presence of bats during a survey. A value of 0 is equal to no bats being present; while a value of 1.0 means that a bat was recorded at every station during every night of the survey period (maximum presence). Bats were most present during the months of April, June, August, and September. Bat presence is consistent year to year, with seasonal highs in activity during the summer.

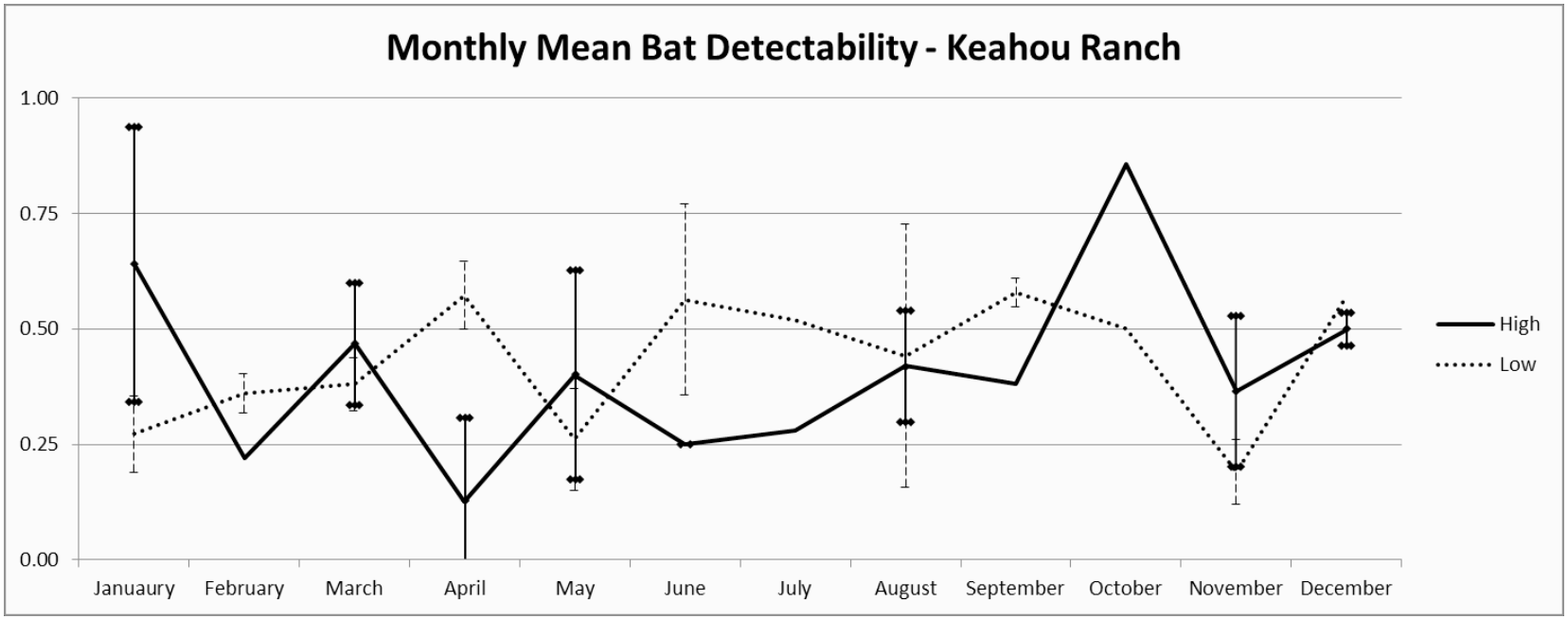


Figure 3. Mean monthly detectability of Hawaiian Hoary bats at High and Low elevation survey areas within Keahou Ranch. Bats are active at both elevations consistently throughout the year.

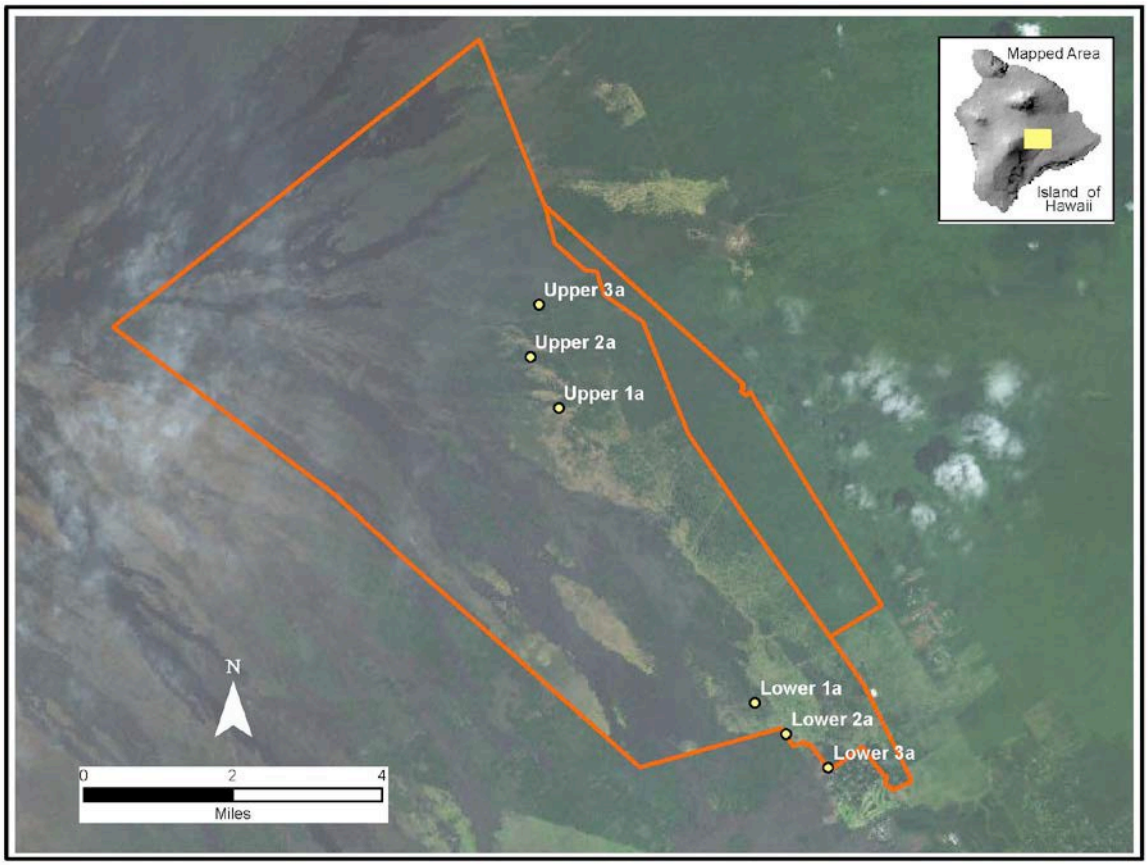


Figure 1. Accoustic bat detector locations on KS lands. Three located at 6000-6250 feet (Upper) and three located at 4000-4400 feet (Lower).

2009 Progress Report for Three Mountain Alliance:

Hawaiian Hoary Bat Ultrasound Surveys at Keahou Ranch

From: Frank Bonaccorso (U.S. Geological Survey) & Corinna Pinzari (Hawaii Cooperative Studies Unit) – Hawaiian Hoary Bat Project, PO Box 44, Hawaii National Park, HI 96718

Submitted: March 31st, 2010

To: Colleen Cole – Three Mountain Alliance Coordinator, Resources Management, PO Box 52, Hawaii National Park, HI 96718

Introduction & Method

In this report, we add to baseline information collected at Keahou Ranch on ultrasonic call detections of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), a subspecies of the bat listed as endangered by the U.S. Fish & Wildlife Service and the State of Hawaii.

U.S. Geological Survey's Hawaiian Hoary Bat project began conducting bat monitoring research at Keahou Ranch in March 2008, with the goal of providing a baseline dataset useful in tracking the seasonal movements and annual population trends of bats on the properties. This approach employs "occupancy analysis" described in Gorresen et al. 2008 (Journal of Mammology) as applied to the Hawaiian hoary bats to provide statistical inferences about whether the population of bats in the local confines of Keahou are stable, increasing, or decreasing over annual cycles. A measure of detectability (p) was calculated for each completed survey using the program Presence; this "*p* value" represents the occupancy of bats onsite during a survey relative to the amount of sampling effort. A *p* value of 1.00 indicates that all microphones deployed in a survey period recorded bats on every night. A *p* value of 0.5 implies that bat calls were recorded on half of the possible total microphone recording nights.

Study Areas

KeahouRanchLowElevationTransect: The transect ranges from 4,000 to 4,400 feet elevation and along a 2.3 kilometer interval of the road beginning just inside the property entrance gate, alongside the ranch quarters. Habitats along this transect include forest edge dominated by Ohia and Koa, scattered trees, and openings with shrub and grassland. Some emergent and canopy trees along the transect approach 20 meters in height. In 2008, we deployed 12 recording units or "stations" placed at approximately 200 meter intervals along the verges of the main roadway. Beginning April 2009, having determined that few bat detectors provide adequate sampling, we reduced the number of stations to three units and placed each 800 to 1000 meters apart using the same transect. We also adjusted our sampling regime from a trimester survey (once every three months) to a bi-monthly regime (every other month).

KeahouRanchHighElevationTransect: The transect ranges from 6,000 to 6, 250 feet elevation along a 2.3 kilometer interval of dirt road. It begins around the cabin, continues along the fence line under the power lines. Habitats sampled are similar to those described under the low elevation transect. In 2008, 12 stations were placed at approximately 200 meter intervals along the verges of the dirt or gravel roadway. Beginning April 2009, we also reduced the number of stations to three units and placed each 800 to 1000 meters apart using the same transect. We again, adjusted our sampling regime from trimester surveys to a bi-monthly survey regime.

Results

Results from the 2009 ultrasonic bat detection surveys conducted at both Keahou Ranch sampling transects are presented in Table 1.

The low elevation transect was sampled seven times during 2009, on a bi-monthly basis beginning in February. A total of 974 pulses of bat vocalizations have been identified out of 163 recording nights, with October having the lowest number of pulses (28) and December having the highest (421). Pulse counts from the low elevation

transect were much greater than those from the high elevation transect for the winter months of December, February, and April. Bat passes collected along this transect continue to include “feeding buzzes”, indicative of foraging events. Bats were detected during every survey, with detectability (*p)* ranging from 0.33 to 0.64. Figure 1 presents the seasonal detection pattern for bats at the low elevation transect in Keahou Ranch from surveys conducted in 2008 and 2009.

The high elevation transect was sampled five times during 2009, on a bi-monthly basis beginning in April. A total of 373 pulses of bat vocalizations have been identified out of 99 recording nights, with April and June having the lowest number of pulses (12) and October having the highest (206). Pulse counts from this transect are similar to the lower elevation transect during August, but much higher in October, and generally lower for the rest of the year. Bat passes collected along this transect also include “feeding buzzes”, indicative of foraging events. Bats were detected during every survey, with detectability or (*p*) ranging from 0.25 to 0.85. Figure 2 presents the seasonal detection pattern for bats at the high elevation transect in Keahou Ranch from surveys conducted in 2008 and 2009.

Survey Dates	Nights	Stations	Total Nights	Active Nights	**Active Nights***	Total Passes	**Passes***	Total Pulses	**Pulses***	**Detectability (p)**	SE	Reproductive Cycle
2/2/09 - 2/17/09	15	11	83	16	0.19	26	0.31	169	2.04	0.33	0.08	Post-Reproductive
4/13/09- 4/21/09	8	3	24	10	0.42	51	2.13	189	7.88	0.62	0.12	Pre-Pregnancy
4/13/09 - 4/21/09	15	3	29	4	0.14	5	0.17	12	0.41	0.25	0.14	Pre-Pregnancy
6/19/09 - 6/26/09	7	2	14	6	0.43	9	0.64	89	6.36	0.42	0.14	Pregnancy
6/19/09 - 6/26/09	7	2	14	3	0.21	2	0.14	12	0.86	0.25	0.12	Pregnancy
8/19/09 - 8/25/08	7	2	14	9	0.64	13	0.93	86	6.14	0.64	0.13	Lactation
8/19/09 - 8/25/09	7	2	14	7	0.50	13	0.93	84	6.00	0.50	0.13	Lactation
10/19/09 - 10/25/09	7	2	14	7	0.50	13	0.93	28	2.00	0.50	0.13	Fledging & Mating
10/19/09 - 10/25/09	7	3	21	18	0.86	61	2.90	206	9.81	0.86	0.07	Fledging & Mating
12/17/09 - 12/24/09	7	2	14	8	0.57	96	6.86	421	30.07	0.57	0.13	Post-Reproductive
12/17/09 - 12/24/09	7	3	21	11	0.52	19	0.90	59	2.81	0.52	0.11	Post-Reproductive

Table 1. 2009 Keahou Ranch Hawaiian Hoary Bat monitoring survey data. White rows are low elevation transect surveys, grey rows are high elevation transect surveys. Nights are number of nights survey ran; stations are number of detector units set out; total nights are number of nights multiplied by number of stations set out. Active nights are proportion of nights during survey that bats were detected at a station. A pass represents a bat flying by a station, and pulses are echolocation calls made by bats passing by a station. The bolded and starred columns of active nights, passes, and pulses, are proportions of these events over the total nights sampled during the survey. Detectability (*p*) represents the occupancy of bats during a survey. Standard errors are also provided for this metric.

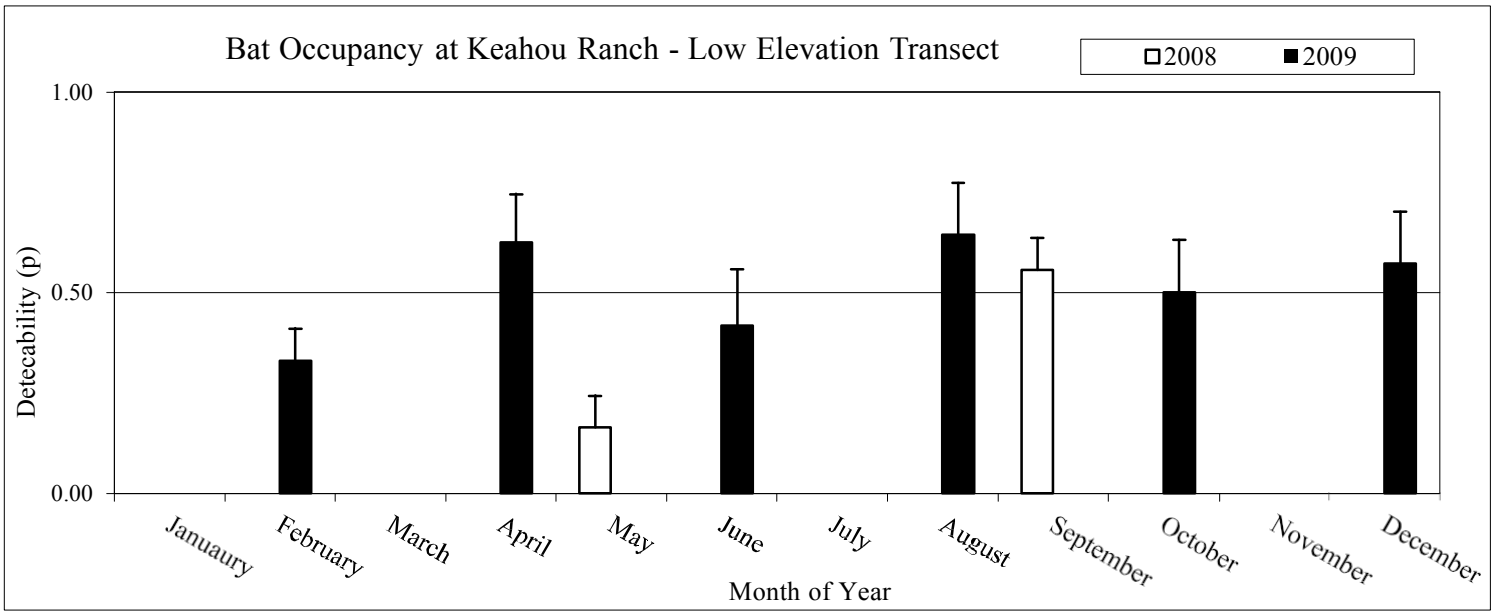


Figure 1. Seasonal patterns of bat detectability at Keahou Ranch's 4,000 ft transect for 2008 and 2009.

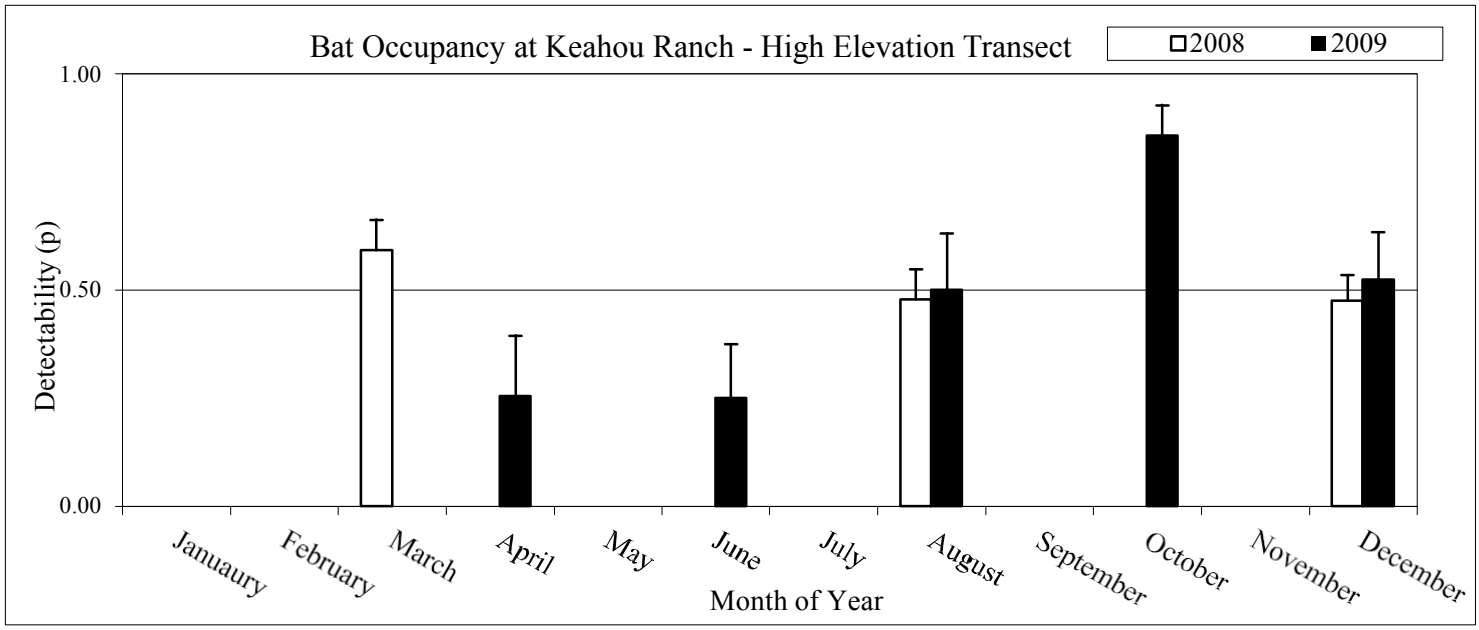


Figure 2. Seasonal patterns of bat detectability at Keahou Ranch's 6,000 ft transect for 2008 and 2009.

Assessment of 2009 Data

Bats were present in all months sampled at the Keahou Ranch on each of the two transects (4,000 and 6,000 feet). Bats are most likely resident at the habitat represented by the low elevation transect year-round, while commuting to the habitat represented by the high elevation transect during the winter months.

Recommendations

The USGS hoary bat project staff would be pleased to continue the cooperative study of bat occupancy with The Three Mountain Alliance in its Keahou Ranch. We are confident that additional surveys will refine understanding of bat occupancy with respect to both seasonal and annual cycles of variability and will permit evaluation of trends over time that can be useful for a Safe Harbor agreement. Keahou Ranch demonstrates moderate to high levels of bat occupancy for foraging activities through all periods thus far sampled, including the annual reproductive season for this endangered bat species. Keahou Ranch (the lower elevation transect) is a potentially very important site of residency, as well as a potential corridor for bats to move from lowland

areas to upper montane refugia, the latter being important during the cooler winter months (Keahou Ranch high elevation transect).

Appendix 4

Technical Report of Endangered Plant Populations on Kamehameha Schools Lands.

Endangered Plant Distribution
Kamehameha Schools Lands at Kīlauea and Keauhou

Report prepared by Hoala Fraiola and Tanya Rubenstein
for the ʻŌlaʻa-Kīlauea Partnership

June 5, 2007

Table of Contents

Project Summary 1
Methods 1
Survey 1
Baseline Conditions 2
Habitat Description 5
State and Federally Listed Plant Species 8
Species Accounts - Keauhou and Kīlauea 8
Asplenium peruvianum var. *insulare* 8
Clermontia lindseyana 9
Cyanea shipmanii 10
Cyanea stictophylla 12
Phyllostegia velutina 13
Phyllostegia racemosa 14
Plantago hawaiensis 15
Vicia menziesii 16
Management Recommendations 27
Threats 27
Recommendations 28
References 31

Project Summary

The primary objective of this report is to summarize the distributions of state and federally listed threatened and endangered plant species at Keauhou and Kīlauea as well as provide Kamehameha Schools (KS) with the information necessary to proceed with the planning and development of a Safe Harbor Agreement (SHA) or Habitat Conservation Plan (HCP). The Keauhou - Kīlauea area (TMK 3-99-001-004 and 9-9-01-7) within the ʻŌlaʻa Kīlauea Partnership (OKP) Area is approximately 33,000 acres of land owned by KS. The project area is located on the island of Hawaii on the southeastern slope of Mauna Loa, and lies in the district of Kaʼū (Fig. 1). It is surrounded by Federal lands (Hawaii Volcanoes National Park (HAVO)) to the west and south, and State lands to the east (Kūlani Correctional Facility and Puʻu Makaʼala Natural Area Reserve) and north (Mauna Loa Forest Reserve (FR)). Kīlauea Forest is separated from Keauhou by the Palakea fence.

This report summarizes endangered plant survey work performed by the OKP between 2001 and 2005 as well as information from previous surveys and incidental sightings of listed species. Surveys were conducted to determine distribution and population estimates of state and federally listed plant species present on these lands. The primary focus of surveys was to determine population levels for the listed plant species that may be affected by future management actions. This report also summarizes information about listed plant species known from adjacent areas with predicted ranges in the Keauhou - Kīlauea area. Although these species are not currently known from the project area, KS may be interested in including them in an SHA or HCP because they could potentially spread naturally and/or be reintroduced to KS lands in the future. In addition to providing information to prepare an SHA or HCP, this report will assist in management planning and recovery efforts for these listed species.

Methods

Survey

This report uses historical plant distribution data and current survey information as well as modeling of climate, habitat characteristics and endangered plant distribution to determine the baseline for state and federally listed threatened and endangered plants at Keauhou and Kīlauea. For the purposes of this report, “baseline” refers to population estimates and distribution and/or habitat characteristics of the species that are endangered, threatened, and candidate.

Historical surveys are those conducted prior to 1993, and current surveys are those that were conducted 1993 to present. The Keauhou - Kīlauea area has had extensive research and management activity underway since the 1980’s, and much of the information on rare plants was collected incidental to other research and management activities.

Information drawn from 1982 State of Hawaii Endangered Plant Species Program (EPSP) botanical surveys and other historical records was used to guide the scope of the more recent baseline surveys. EPSP conducted surveys in Keauhou and Kīlauea to collect information on the frequency and distribution of rare and listed plant species (Clarke et al. 1982). These surveys were conducted by qualified field botanists along transects in specific areas of Keauhou and Kīlauea. EPSP also collected plant data from incidental surveys in other areas likely to contain

endangered species. Other information on habitat and distribution of listed plant species in this report was provided by U.S. Fish and Wildlife Service (USFWS) Recovery Plans (USFWS 1984, 1994, 1995, 1996, 1998, 1998b and 1999), and other historical records and is not directly related to survey work.

Determining current population estimates and distribution for most species required organizing rare plant data from numerous sources collected between 1993 to present (U.S. Geological Survey Biological Resources Division (USGS-BRD), unpublished data). Current surveys include OKP SHA/HCP surveys (2001-2005) as well as plant data collected since 1993 incidental to other research and management work (e.g. forest bird surveys, weed surveys, and feral ungulate control). OKP survey work was focused on KS lands (Kīlauea and Keauhou) using qualified field botanists. Surveys were conducted to provide information on population and distribution of all threatened and endangered plant species. Botanists used several climatic and environmental variables and aerial imagery to help refine their search areas. Surveys were conducted in areas that were most likely to contain listed plant species based on intactness of habitat, past land-use practices, old survey data, and historically known locations. The area covered during these surveys included specific areas of Keauhou and Kīlauea Forest along forest bird, weed and ungulate survey transects, and localized searches (e.g., intact kīpuka in the lower Keauhou area) (Fig. 2).

Baseline Conditions

This report uses the term "population unit" rather than population. A population unit is defined as a group of individuals of a taxon that are in close spatial proximity to each other and are presumed to be capable of crossing for reproduction. For the remnant naturally occurring plants (e.g., for *Vicia menziesii*), we treat each location as a population unit, even if it contains only one individual. This approach is conservative, and reflects our lack of insight into whether the remaining, scattered individuals are able to exchange pollen effectively. For the reintroduced plants (e.g., for *Cyanea shipmanii* and *C. stictophylla*), we treat each planting location as a population unit. The planting locations contain some to many individuals, and are structured to promote crossing among the individuals. Planting locations for a given species that are separated by more than 1 km are considered to be different population units. Longer term genetic studies, especially with the remnant plants, may enable us to ascertain whether the different population units are linked by gene flow in such a way that they form larger, integrated biological populations.

Data collected during the OKP SHA/HCP surveys have detailed population estimates and counts of individuals. By contrast, plant data drawn from other sources vary in the level of detail regarding population estimates and other information. For example, some data contain information on the number of individuals within a population unit whereas other data lump numerous individuals into one population unit. It can be very difficult to distinguish numbers of individuals for vines such as *Vicia menziesii* and *Phyllostegia velutina*, and some data simply describe and map population units rather than individuals. This report represents data that describe a group of plants or population unit without actual counts of individuals as a single individual in our population estimate.

Figure 1 - Keauhou - Kīlauea Area

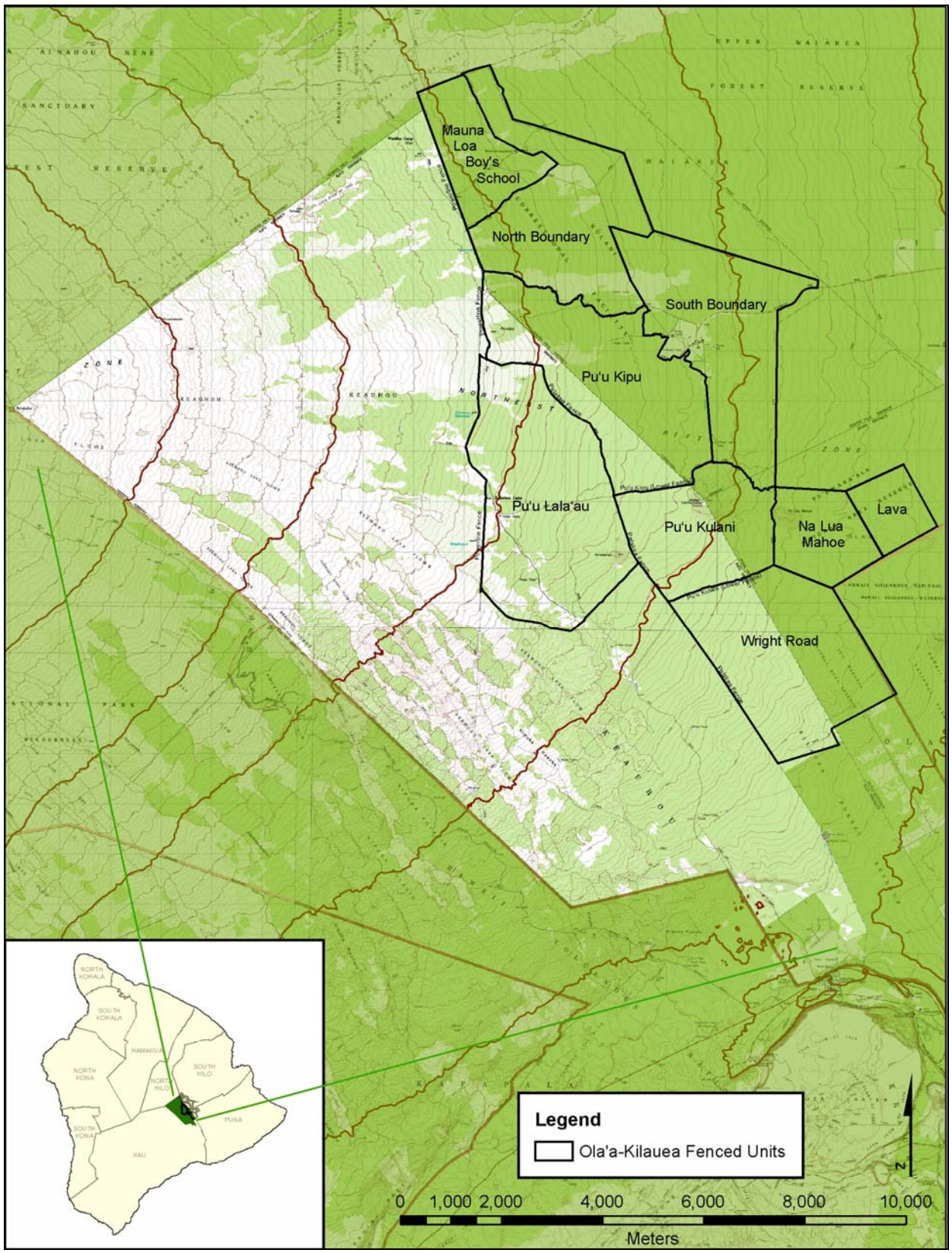
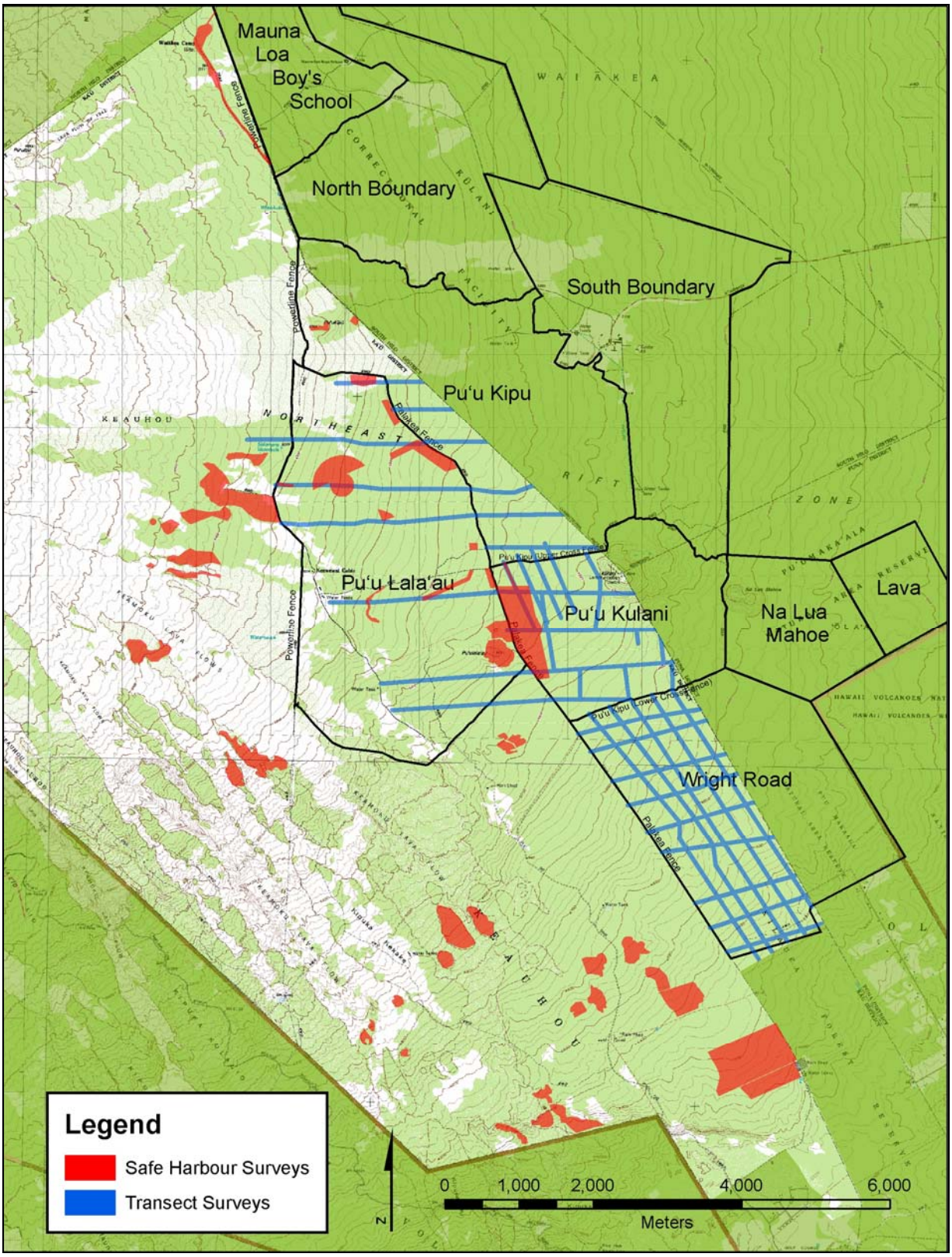


Figure 2 - Areas surveyed 1993 to present (Keauhou – Kīlauea)



Population estimates for all threatened and endangered plant species currently found within the Keauhou - Kīlauea area were based on the number of population units and individuals observed during botanical surveys and/or those planted at reintroduction sites. Listed species reintroduced to the Keauhou - Kīlauea area through planting are treated the same as wild individuals under the state and federal Endangered Species Act.

Modeling and plant distribution data (historic data and data from adjacent areas) were used to predict the potential ranges of rare and listed species that are not currently known from Keauhou - Kīlauea. These species are known from adjacent areas, and could potentially spread and/or be reintroduced to Keauhou- Kīlauea. To map plant species ranges a database of native Hawaiian plant species was built that includes data on the distribution of species by geographic region, major habitat type, and elevation range. These data come from published sources, herbarium specimens, unpublished reports and field notes, and targeted field work (Price et al., in press; Price, unpublished data).

Habitat Description

The vegetation communities in this area can be characterized by a combination of elevation range, moisture zone/regime, substrate type/age, and vegetation. Overall the climate varies from drier habitat at the southwestern and northwestern sections of the Keauhou - Kīlauea area to wet forest at the lower elevations to the southeast and northeast. The endangered plant species from the Keauhou - Kīlauea area are found in the three main plant communities described below.

These vegetation communities have been described from open to closed with various combinations of three dominant structural plants: ʻōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*) in the overstory, a subcanopy of hāpuʻu or tree fern (*Cibotium* spp.) as well as other native and non-native understory species. In general these plant communities range from Wet to Dry forests and Montane to Subalpine. The vegetation of the area has largely been determined by past land-use practices, a variety of different aged lava flows, feral animal introductions, and invasion by non-native plants. For the purposes of this report, the project area is generalized into the following three native plant communities (adapted from, Hawaiʻi Heritage Program 1989; Jacobi 1989; Gagne and Cuddihy 1990; Jacobi 1990, and the Nature Conservancy of Hawaiʻi's Ecoregional Plan):

1) Montane Wet - Natural communities between 1,000 and 2,000 m (3,000 - 6,000 ft) elevation, receiving greater than 75 inches annual precipitation.

- ʻŌhiʻa /Hāpuʻu Forest – Portions of Kīlauea forest, especially the lower elevation sections contain ʻōhiʻa with other native trees and a hāpuʻu tree fern and native fern and shrub understory. Portions of the ʻōhiʻa forest canopy have undergone defoliation and regeneration (a natural phenomenon known as "ʻōhiʻa dieback") at various times. The resulting openings are generally filled with younger ʻōhiʻa, native trees and shrubs and hāpuʻu.
- Koa/'Ōhiʻa Forest – Portions of Kīlauea and Keauhou contains tall stature koa and ʻōhiʻa with other native trees and an understory of hāpuʻu, native shrub and fern. The wet and mesic koa forest communities are generally found on older substrates.

2) Montane Mesic - Natural communities between 1,000 and 2,000 m (3,000 - 6,000 ft) elevation, receiving between 50 and 75 inches annual precipitation.

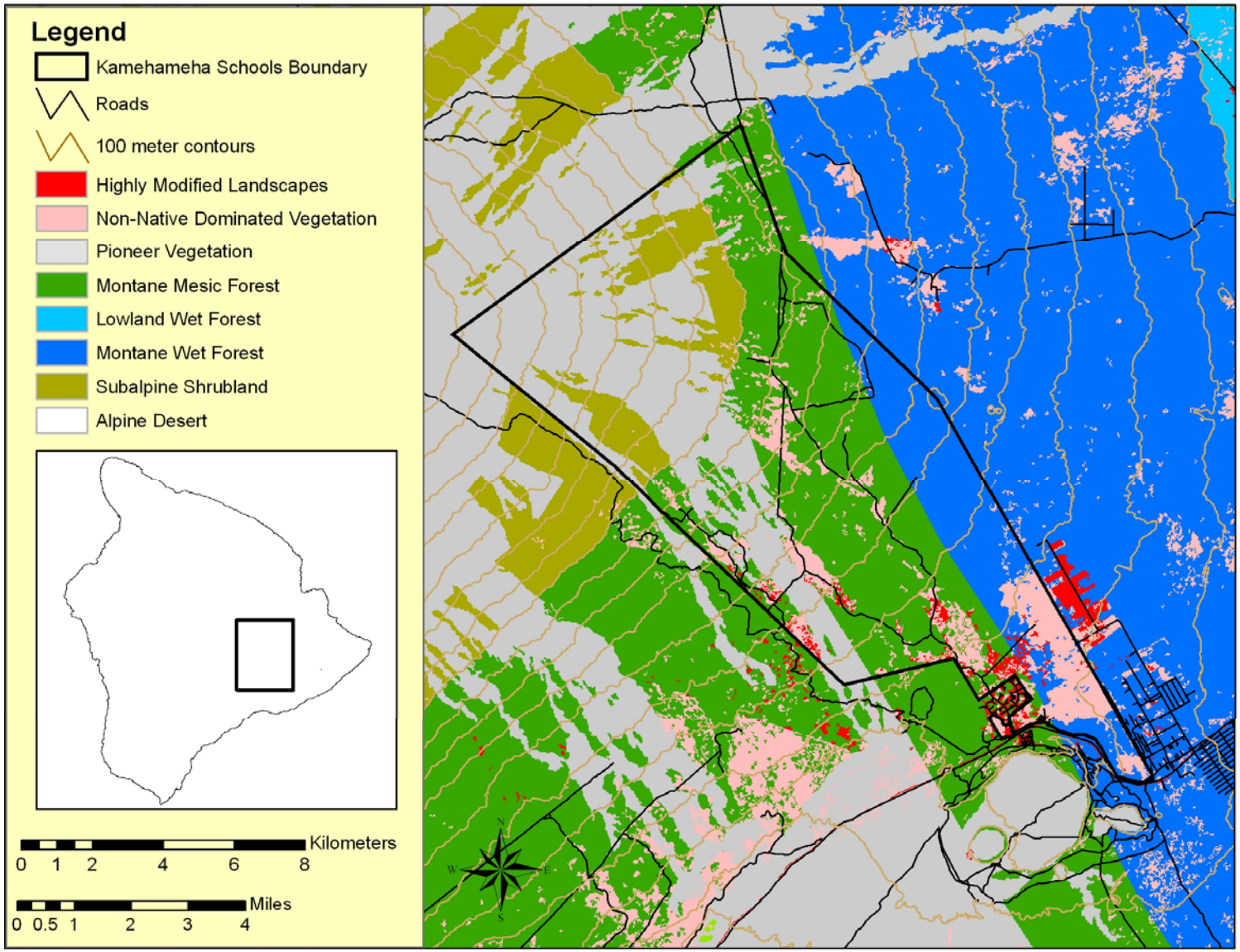
- Koa/'Ōhi'a Forest - Portions of Kīlauea Forest and Keauhou contain tall stature koa/'ōhi'a forest with other native trees and a hāpu'u tree fern, native shrubs and ground fern understory. This forest type differs from the wet koa/'ōhi'a in that wet forest tends to have higher densities of hāpu'u than mesic areas, which have more native trees and shrubs in the understory. Unless disturbed, both forest types have a diverse ground cover dominated by ferns.
- 'Ōhi'a Forest - Portions of Keauhou and upper Kīlauea contain plant communities composed primarily of open to closed canopy 'ōhi'a and an understory of native trees, shrubs, ferns and grasses without the prominent hāpu'u component. This community can be found on intermediate aged lava flows as well as on young lava flows in association with other pioneer vegetation.

3) Subalpine – Natural communities between 2,000 m (6,000 ft) and 3,000 m (9,000 ft) elevation.

- Pioneer vegetation on younger lava flows.
- Dry Native Shrub with scattered 'Ōhi'a - This plant community is found on younger lava flows and forested kīpuka, especially in the higher elevation, drier parts of Keauhou.
- Dry 'Ōhi'a Forest with mixed native trees and native shrub understory - This plant community is found on young to intermediate aged lava flows in the higher elevation, drier parts of Keauhou.

Within the Keauhou - Kīlauea area the substrate varies based on different aged lava flows from the Mauna Loa volcano. Keauhou and Kīlauea substrate is characterized by Ka'ū Basalt, Puna Basalt and Ash. These are composed of rock from lava flows as pahoehoe or 'a'a lava, spatter/tuff cones as cinder, and ash as tephra or coarse-fine grained fallout (Wolfe 1996). Most of the endangered plant species in the Keauhou - Kīlauea area are found on older flows.

Figure 3 - Keauhou - Kīlauea Ecosystems



State and Federally Listed Plant Species

The Keauhou - Kīlauea area currently provides habitat for eight state and federally listed plant taxa endemic to the Hawaiian Islands (Table 1). Information regarding their distribution, general appearance, habitat, phenology, and past and current threats is detailed for each species.

Table 1 - State and federally listed endangered plant species found in Keauhou - Kīlauea.

Family	Species	Listing Status	Habitat Type
Aspleniaceae	*Asplenium peruvianum* var. *insulare*	E	Dry ʻŌhiʻa Forest, Dry Native Shrub with ʻōhiʻa, Mesic Koa/ʼŌhiʻa Forest, lava tube skylights
Campanulaceae	*Clermontia lindseyana*	E	Wet Koa/ʼŌhiʻa Forest, Mesic Koa/ʼŌhiʻa Forest
Campanulaceae	*Cyanea shipmanii*	E	Mesic ʻŌhiʻa Forest
Campanulaceae	*Cyanea stictophylla*	E	Mesic ʻŌhiʻa Forest
Lamiaceae	*Phyllostegia racemosa*	E	Mesic Koa/ʼŌhiʻa Forest
Lamiaceae	*Phyllostegia velutina*	E	Wet Koa/ʼŌhiʻa Forest, Mesic Koa/ʼŌhiʻa Forest
Plantaginaceae	*Plantago hawaiensis*	E	Dry Native Shrub with ʻōhiʻa
Fabaceae	*Vicia menziesii*	E	Mesic Koa/ʼŌhiʻa Forest

Species Accounts - Keauhou and Kīlauea

Asplenium peruvianum var. *insulare*

Description

This fern is a member of the Spleenwort Family (Aspleniaceae). This small delicate fern is an endemic variety known only from the islands of Hawaiʻi (Fig. 3) and Maui. According to Palmer (2003), *A. peruvianum* var. *insulare* is usually found growing at 1,650 to 2,200 m elevation in: 1) dark moist areas, 2) rock crevices, and 3) near the mouth or in remote corners of lava tubes. The overall status and recovery needs for this species are outlined in USFWS (1998). In the Keauhou - Kīlauea area this plant has been observed growing close to the entrance of lava tubes on moist walls and rocks and growing in cave entrances and skylights.

Asplenium peruvianum* var. *insulare

Population Estimates and Distribution

Population estimates for this species were determined by botanical surveys conducted by OKP (2001 - 2005). Exact numbers of individuals were difficult to determine because of the clumping growth habit and spreading via rhizomes. Surveys found 7 population units, containing a total of 128 individual plants, between 1,798 and 2,011 m elevation (Table 2). In Keauhou, there are 46 individuals within the Pu‘u Lala’au Unit above the koa silviculture area, and 82 individuals above Powerline road.

Table 2 - Population estimates for *A. peruvianum var. insulare*.

Location		Population Units	Individuals
Above Power line Road	Keauhou	4	82
Pu‘u Lala’au Unit	Keauhou	3	46
TOTAL		7	128

Clermontia lindseyana

Description

This lobeliad member of the bellflower family (Campanulaceae), also known as ‘ōhā wai is endemic to the islands of Hawai‘i and Maui. It typically occurs in montane mesic forests between 1,200 and 1,858 m elevation (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1996). This branched shrub is usually found growing epiphytically on fallen decomposing logs of *M. polymorpha* or *A. koa* or in shaded ravines. In the past *C. lindseyana* has been observed growing in a variety of habitats[1] in the Keauhou - Kīlauea area: 1) disturbed koa-‘ōhi’a forest, pasture with scattered ‘ōhi’a-koa trees, and closed ‘ōhi’a forest with pūkiawe understory (Keauhou); 2) epiphytic on ‘ōhi’a, hāpu‘u, or mossy logs (Kīlauea Forest). During the OKP SHA/HCP surveys, plants were observed growing in the ground or rooted epiphytically in log jams.

Clermontia lindseyana

Population Estimates and Distribution

Population estimates for this plant were determined by OKP SHA/HCP surveys 2001-2005. Based on these surveys, there are 5 population units, containing a total of 24 individuals, between 1,500 and 1,860 m elevation (Table 3). Currently, 1 individual remains in the Pu‘u Kūlani Unit of Kīlauea Forest. This adult wild plant has been observed flowering (February) and fruiting (May-November). There are 4 individuals growing in the Pu‘u Kipu Unit with 2 near the upper Kīlauea cross fence, 1 within 150 m of the Palakea fence, and 1 in the upper section of the unit near Pu‘u Kipu. Of these plants there were 2 individuals observed fruiting and none flowering. There were 19 plants that were reintroduced to KS lands on 03/20/07 (see Figure 3 for planting locations) - 10 individuals were planted within the Pu‘u Kipu Unit in Site 2 and 7 individuals in Site 3. There were 2 individuals planted along the upper Kīlauea cross fence (site 4) in the Pu‘u Kipu and Pu‘u Kūlani Units.

Table 3 - Population estimates of *C. lindseyana*.

Location		Population Units	Individuals
Pu‘u Kipu Unit	Kīlauea Forest	1	4
Pu‘u Kūlani Unit	Kīlauea Forest	1	1
Puu Kipu Unit (Site 2 - reintrouduced)	Kīlauea Forest	1	10
Puu Kipu Unit (Site 3 - reintroduced)	Kīlauea Forest	1	7
Mauka Cross Fence (site 4 – reintroduced)	Kīlauea Forest	1	2
	TOTAL	5	24

Cyanea shipmanii

Description

A lobeliad member of the bellflower family (Campanulaceae), known as hāhā, this plant is endemic to the island of Hawaii. It typically occurs in montane mesic forests between 1,600 and 1,900 m elevation. This unbranched to sparsely branched (at base) shrub differs from others in its genus based on its pinnately lobed leaves and young stems with sharp thorny outgrowths (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). In the past *C. shipmanii* was observed growing epiphytically on fallen decomposing logs of *M. polymorpha* or *A. koa* or in shaded ravines.

Cyanea shipmanii

Population Estimates and Distribution

Population estimates and distribution for *C. shipmanii* were determined by the numbers of individuals planted in reintroduction sites, because there are no wild individuals currently known from Keauhou - Kīlauea. There are three reintroduction sites between 1,700 and 1,916 m elevation.

There are 474 individuals (as of 2006) located within 3 main reintroduction sites that are all located in the Pu‘u Kipu Unit within Kīlauea (see Fig. 3):

1) Site 1 – Located near the summit of Pu‘u Kipu.
2) Site 2 – Located along the Palakea fence approximately 20m inside Kīlauea Forest.between transects 290 and 282.
3) Site 3 – Located along the Palakea fence approximately 150m inside Kīlauea Forest between transects 290 and 291.

Reintroduction sites were chosen based on management status (e.g. free of feral ungulates) and habitat characteristics. All reintroduced plants were propagated by seed from five maternal lines.

As of our most recent census (summer 2006), survivorship for *C. shipmanii* is 97.3% (474 out of 487 planted). An almost equal number of seedlings from each of the maternal lines have been planted in the three sites since June 1991. Observations at these sites indicate flowering and fruiting, thus creating an ex-situ genetic repository of *C. shipmanii*. Further restoration and management of this area will increase this species' chances for natural recruitment. Two new maternal lines from wild plants found at Kūlani are under propagation, and we recommend planting seedlings from these new lines as they become available in order to balance founder representation.

Table 4 - Population estimates of *C. shipmanii*.

Location		Population Units	Individuals
Pu'u Kipu Unit (Site 1 - reintroduced)	Kīlauea Forest	1	356
Puu Kipu Unit (Site 2 - reintroduced)	Kīlauea Forest	1	64
Puu Kipu Unit (Site 3- reintroduced)	Kīlauea Forest	1	54
	TOTAL	3	474

Cyanea stictophylla

Description

Hāhā is also the Hawaiian name for this lobeliad member of the bellflower family (Campanulaceae). This plant is endemic to the island of Hawaii (Fig. 4). This unbranched to sparsely branched shrub typically occurs in montane mesic forests between 1,600 and 1,900 m elevation (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). It has been found growing on the walls of collapsed lava tubes in the closed koa-'ohi'a forest within Kīlauea forest and epiphytically.

Cyanea stictophylla

Population Estimates and Distribution

The population estimates for *C. stictophylla* were determined by monitoring the reintroduction site because there are no wild individuals currently known from Keauhou - Kīlauea. There is one population unit with a known location in this area at approximately 1,600 m elevation (Fig. 3). As of 2005 there are 104 individuals located within one main reintroduction site inside Kīlauea forest that is along the Palakea fence (below transect 292) and the upper Kīlauea cross fence in both the Pu‘u Kipu and Puu Kulani Units. This site is made up of 8 satellite areas (A-H):

1) Site 4 (A, B, C) – Pu‘u Kipu Unit. Sites A and B are near the Palakea fence below transect 292. Site C is above the upper Kīlauea cross fence.
2) Site 4 (D-H) – These sites are all along the upper Kīlauea cross fence from 0 m (Palakea fence) to 450m in both the Pu‘u Kipu and Puu Kūlani units.

Sites for *C. stictophylla* were chosen based on management status and habitat characteristics. All reintroduced plants have been propagated by seeds and cuttings from one maternal line. All seedlings have been planted in site 4 (A-H) since March 2003. Plants have been monitored annually and survivorship is 98.1% (104 out of 106 planted). Several individuals flowered and produced fruits in 2006. Further restoration and rehabilitation of this area will increase this species' chances for natural recruitment. One new maternal line from a wild plant found at Kūlani is under propagation, and we recommend planting seedlings from this new line as seedlings become available in order to increase founder representation.

Table 1 - Population estimates of *C. stictophylla*.

Location		Population Units	Individuals
Pu‘u Kipu Unit (Site 4, A-H)	Kīlauea Forest	1	104
	TOTAL	1	104

Phyllostegia velutina

Description

This endemic member of the mint Family (Lamiaceae) is known only from the island of Hawaii (Fig. 6). This climbing vine with dense straight, appressed hairs on the leaves and stems is uncommon in mesic to wet forest between 1,460 and 1,920 m elevation from Kīlauea to Pu‘u Kipu and above Nā‘ālehu (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b).

Phyllostegia velutina

Population Estimates and Distribution

The population estimates for this species were determined by botanical surveys conducted by OKP (2001 – 2005) in the Keauhou - Kīlauea area, and monitoring of the reintroduction site. It is difficult to count numbers of *P. velutina* individuals due to its' growth habit, and the fact that numerous stems may come from the same individual. There are 7 population units, containing a total of approximately 38 individuals, between 1,500 and 1,900 m elevation. In the Pu'u Kipu Unit there are 5 wild population units and 1 reintroduced population unit. Two are located along the Palakea fence and are visible from the road. Inside the unit, there is 1 population unit at 40m on transect 292A, and another off the old IBP trail (both of these population units are adjacent to *Cyanea stictophylla* planting sites – site 4A and 4C). Nine seedlings of *P. velutina* were outplanted next to the upper Kīlauea cross fence for educational purposes. There is one population unit known from the Pu'u Lala'au Unit.

Table 2 - Population estimates of *P. velutina*.

Location		Population Units	Individuals
Pu'u Kipu Unit	Kīlauea Forest	5	28
Pu'u Lala'au Unit	Keauhou	1	1
Pu'u Kipu Unit (Site 4 - reintroduced)	Kīlauea Forest	1	9
	TOTAL	7	38

Phyllostegia racemosa

Description

This endemic member of the mint Family (Lamiaceae), also known as kīponapona is endemic to the island of Hawai'i. This climbing vine with dense long, soft hairs on the leaves and stems is rare in mesic to wet forest between 700 and1,650 m elevation on the windward slopes of Mauna

Loa and Mauna Kea (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b).

Phyllostegia racemosa

Population Estimates and Distribution

Population estimates for *P. racemosa* were determined by botanical surveys conducted by OKP (2001 – 2005) in the Keauhou - Kīlauea area, and monitoring of the reintroduction sites. There is currently one reintroduced population. There were three population units of P. racemosa found in the the Pu‘u Lalaau Unit from 2000 - 2005, however, the last known wild individual of *P. racemosa* was extirpated from this area in November 2006 by unknown causes. We have reintroduced approximately equal numbers of cuttings from each of two maternal lines. No additional founders are currently available. All plantings were in the Pu’u Kipu Unit at sites 1 and 2. Plants were monitored in summer 2006, showing 6.6% survival (24 out of 359) with plants remaining only at site 1. Reintroduced plants have flowered, fruited and established seedlings. Some of the surviving plants have reached 2-3 m in canopy spread.

Table 3 - Population estimates of *P. racemosa*.

Location		Populations	Individuals
Pu‘u Kipu Unit (Site 1 – reintroduced)	Kīlauea Forest	1	24
	TOTAL	1	24

Plantago hawaiensis

Description

This endemic member of the plantain Family (Plantaginaceae) is known only from the island of Hawaii. It primarily occurs in mesic to dry shrubland on the leeward side, usually in lava cracks between 1,800 and 1,950 m elevation (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b).

Plantago hawaiensis

Population Estimates and Distribution

The population estimates for this species were determined by botanical surveys conducted by OKP (2001 – 2005) in the Keauhou - Kīlauea area. There is 1 individual inside Keauhou above Powerline road at 2,020 m elevation.

Table 4 - Population estimates of *P. hawaiensis*.

Location		Populations	Individuals
Above Power line Road	Keauhou	1	1
	TOTAL	1	1

Vicia menziesii

Description

A member of the pea family (Fabaceae), this vine is endemic to the island of Hawaii. It is usually found climbing on or supported by the canopy of trees or shrubs and reaches heights of up to 6 m. Typically it occurs in montane mesic to wet forests between 1,570 and 1,720 m elevation (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1984). *Vicia menziesii* was observed growing in two forest types: closed canopy koa-‘ōhi’a-hāpu’u forest (Kīlauea Forest) and open or disturbed remnant koa-‘ohi’a forest with altered understory (Keauhou). During the baseline surveys, some plants were found

growing in the following conditions: in partially protected fallen log piles, climbing on hāpu'u and small ohia, on nurse logs and sprawling on the ground.

Vicia menziesii

Population Estimates and Distribution

The population estimates for *V. menziesii* were determined by botanical surveys conducted by OKP (2001 – 2005) as well as incidental observations along transects and during other research and management activities. The baseline survey areas for *V. menziesii* were based on surveys conducted in Keauhou - Kīlauea by the EPSP in 1982 where core populations of approximately 706 *V. menziesii* were identified. There has been a major reduction in both the number of population units and individuals of this species since the surveys in the 1980's.

There are currently 27 known population units within this area between 1,500 and 1,920 m elevation (Table 5). It is difficult to count numbers of *Vicia* individuals due to its growth habit, and the fact that numerous stems may come from the same individual. Currently, there are 12 known locations within the Pu'u Kūlani Unit generally located within 30 m of the Palakea fence with the lowest individual located on the Lower Kīlauea cross fence. There are 12 known locations within the Pu'u Lala'au Unit. There are 2 locations near the summit of Pu'u Kipu. This species has also been outplanted in the Pu'u Kipu Unit at site 1 in 2003 and 2006. Survivorship of reintroduced individuals is 4.1% (4 out of 96 planted). Of the 33 individuals, 13 plants were identified as adults and 2 individuals were identified as seedlings. The age class of other individuals is unknown. Individuals have been observed flowering and producing seeds.

The areas in which *V. menziesii* presently occurs in Keauhou have been altered and are not ideal for supporting a viable population. Restoration and rehabilitation of this area will increase this species' chances for natural recruitment and reproduction. Moreover, the current distribution of *V. menziesii* should not discount the possibility for detecting the presence of more plants in this area. Additional surveys should be conducted in the Keauhou - Kīlauea area, particularly where populations were recorded with much higher densities in the Clarke et al. (1982) surveys.

Table 5 - Population estimates of *V. menziesii*.

Location		Population Units	Individuals
Kūlani Cone Unit	Kīlauea Forest	12	14
Pu‘u Kipu Unit	Kīlauea Forest	2	3
Pu‘u Lala’au Unit	Keauhou	12	12
Puu Kipu Unit - outplanting Site 1	Kīlauea Forest	1	4
	TOTAL	27	33

Figure 4 - *Vicia menziesii* locations and distribution within Keauhou - Kīlauea

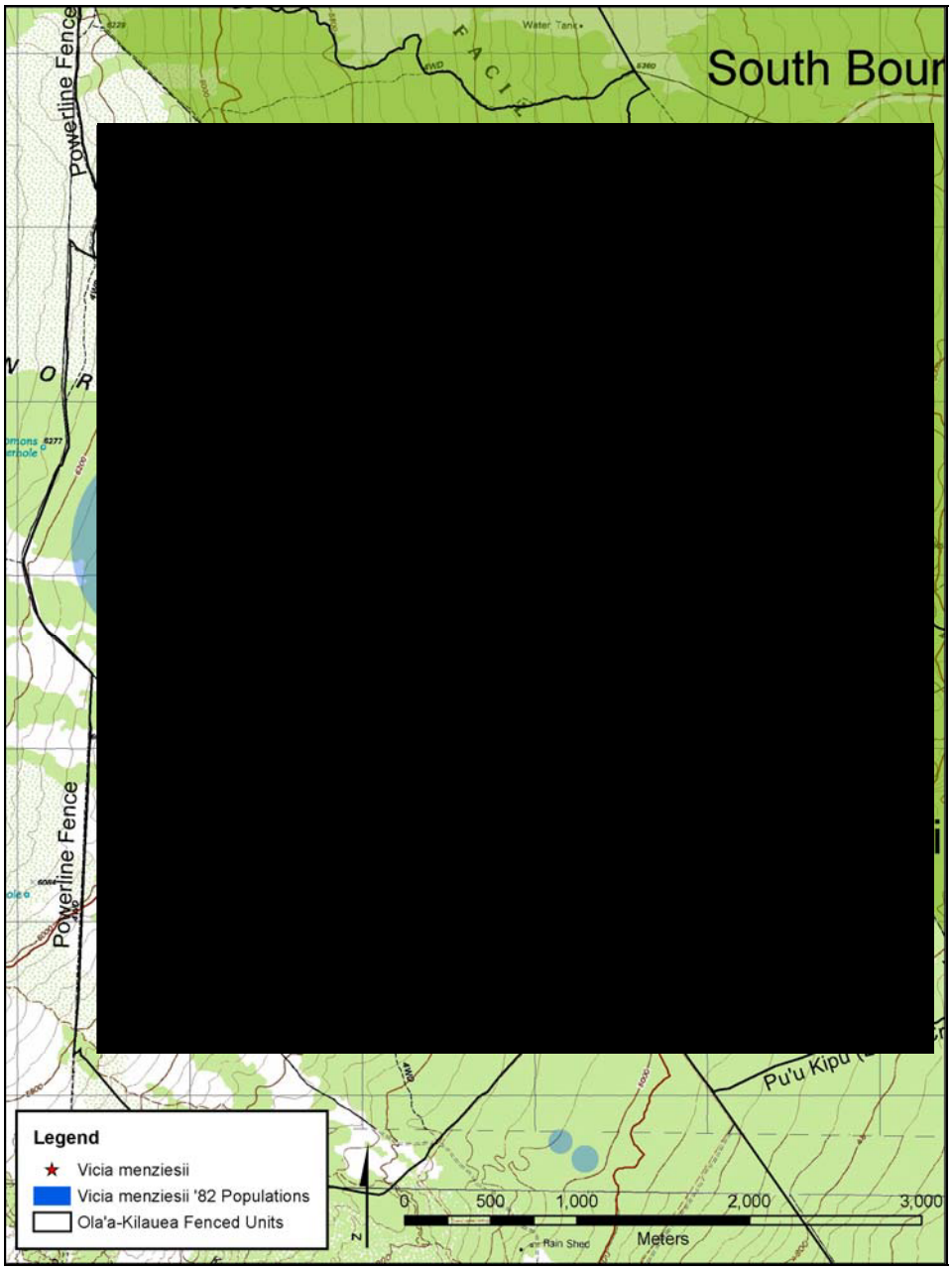


Table 6 - Summary of Population Estimates for State and Federally Listed Endangered Plant Species From Keauhou - Kīlauea.

Species	Population Units	Individuals	Locations	
Asplenium peruvianum var. *insulare*	7	128	Above Power line Road and Pu‘u Lala‘au Unit	Keauhou
Clermontia lindseyana	5	24	Pu‘u Kipu and Pu‘u Kūlani Units	Kīlauea Forest
Cyanea shipmanii	3	474	Puu Kipu Unit	Kilauea Forest
Cyanea stictophylla	1	104	Pu‘u Kipu Unit and Pu‘u Kūlani Units	Kīlauea Forest
Phyllostegia velutina	7	38	Pu‘u Kipu Unit and Pu‘u Lala‘au Unit	Kīlauea and Keauhou
Phyllostegia racemosa	1	24	Pu‘u Kipu Unit	Kīlauea
Plantago hawaiensis	1	1	Above Power line Road	Keauhou Ranch
Vicia menziesii	27	33	Pu‘u Kūlani, Pu‘u Kipu and Pu‘u Lala‘au Units	Keauhou and Kīlauea Forest

Reintroduced *Cyanea shipmanii*- All reintroduced individuals are tagged with a unique identification number.

Figure 5 - Locations of endangered plant species within Keauhou - Kīlauea.

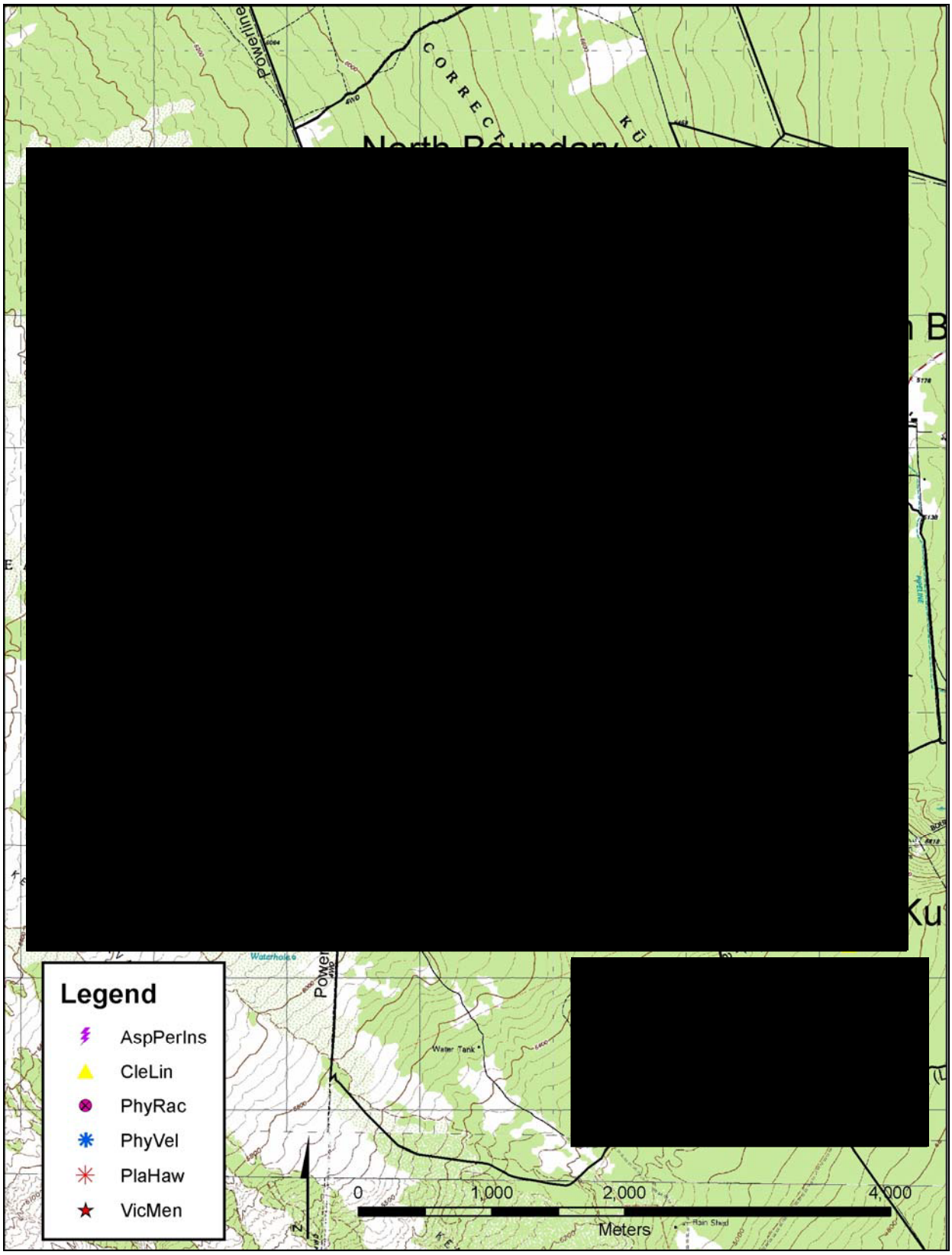
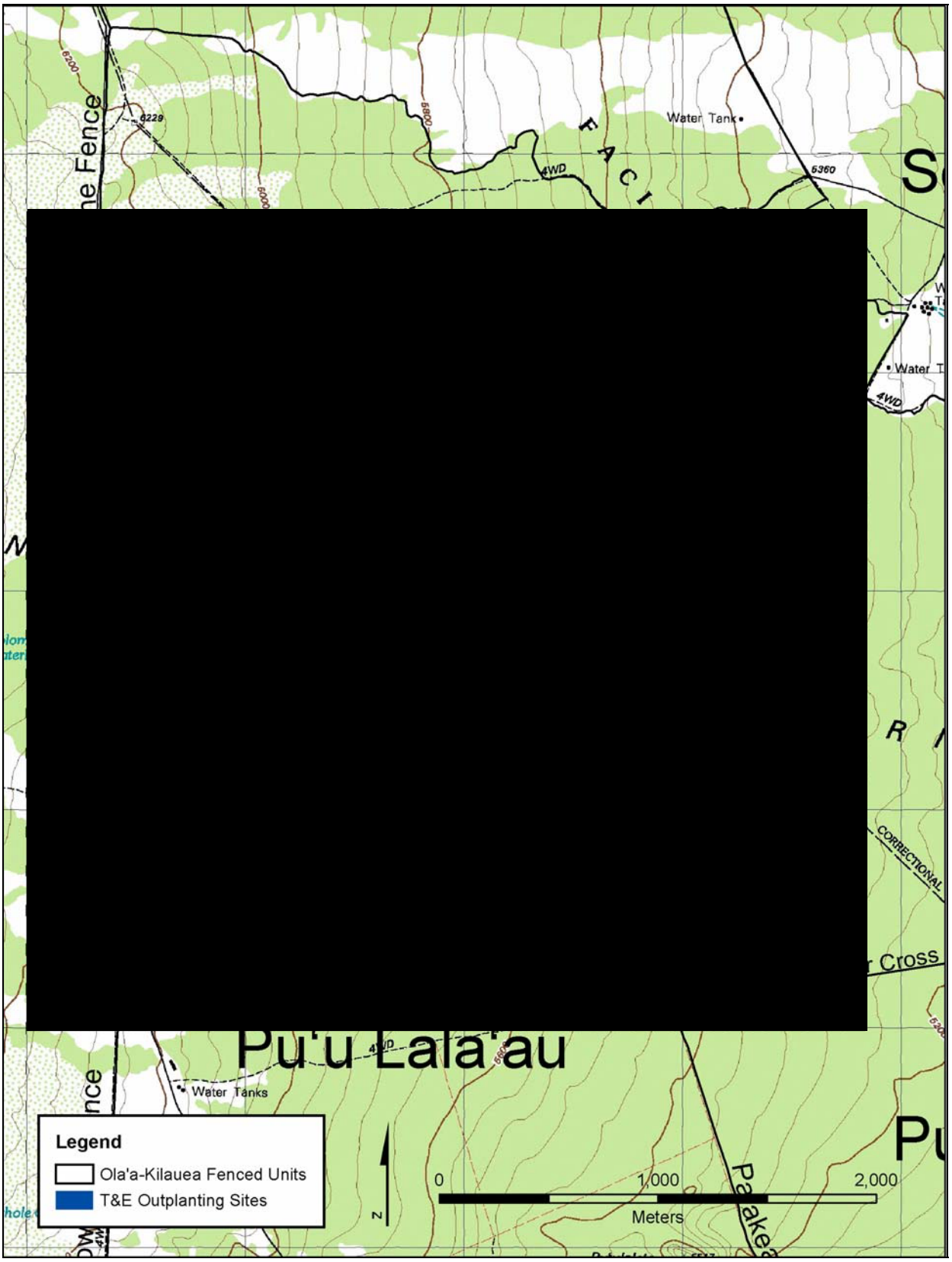


Figure 6 - Reintroduction sites in Keauhou - Kīlauea.



Potential Plant Species – Keauhou and Kīlauea

Table 7 summarizes state and federally listed species either historically known from Keauhou - Kīlauea and/or from adjacent areas (i.e., HAVO, State Forest Reserves, etc). These 17 species are also predicted as having potential for occurring in the Keauhou - Kīlauea area based on historical distribution, presence of suitable habitat and a predicted range (moisture regime, elevation and substrate age) (Price, unpublished data; Pratt, personal communication).

None of the species in Table 7 is presently known from KS lands at Keauhou and Kīlauea. These lands do contain suitable habitat for these species, and these species could be reintroduced to the area to enhance their recovery. It is also possible that some individuals of these species do occur on Keauhou and/or Kīlauea and have not yet been detected. Some of these species could also spread naturally into the area from adjacent lands as a result of the habitat restoration currently underway on KS lands. HAVO is currently working on reintroduction of many of these species to the park.

Population Estimates and Distribution

Population estimates of all potential plant species in Table 7 will remain at zero until they have been discovered through botanical surveys or reintroduced within Keauhou and Kīlauea.

***Kau silversword (Argyroxiphium kauense)* – This species is not currently found at Keauhou - Kīlauea**

Table 7 – Potential Plant Species
(State and federally listed species historically known and/or known from adjacent areas and predicted species)

Family	Species	Status	Location	Predicted Elevation Range (m)	Predicted Habitat
Asteraceae	*Argyroxiphium kauense*	E	Waiākea FR, Kapāpala	1598-2363	Mesic, Wet
Campanulaceae	*Clermontia peleana*	E	ʻŌlaʻa FR	530-1634	Wet
Campanulaceae	*Cyanea tritomantha*	E	ʻŌlaʻa Tract, Puʻu Makaʻala NAR	350 -1500	Wet to Very Wet
Gesneriaceae	*Cyrtandra giffardii*	E	ʻŌlaʻa Tract, Puʻu Makaʻala NAR	700-1540	Wet
Gesneriaceae	*Cyrtandra tintinnabula*	E	ʻŌlaʻa Tract, NE corner	450-1399	Wet
Malvaceae	*Hibiscadelphus giffardianus*	E	HAVO, Kīpuka Puaulu	1310	Mesic
Joinviileaceae	*Joinvillea ascendens*	C	ʻŌlaʻa Tract	300-1280	Mesic, Wet
Rutaceae	*Melicope zahlbruckneri*	E	HAVO, Kīpuka Puaulu	1220	Mesic, Wet
Uritcaceae	*Neraudia ovata*	E	HAVO, Keamoku flows 3,000 ft.	101 - 1470	Very Dry, Seasonal Mesic, Montane Dry
Solanaceae	*Nothocestrum breviflorum*	E	HAVO, Kīpuka Puaulu	79-1830	Mesic
Lamiaceae	*Phyllostegia floribunda*	C	ʻŌlaʻa Tract, ʻŌlaʻa FR, Puʻu Makaʻala NAR	430-1300	Moderately Wet to Very Wet
Lamiaceae	*Phyllostegia parviflora*	E	HAVO, Mauna Loa Strip	500-1799	Mesic, Wet
Ranunculaceae	*Ranunculus hawaiiensis*	C	All slopes of Mauna Loa (Kapāpala, Keauhou)	1768-2600	Mesic, Subalpine-Dry
Cucurbitaceae	*Sicyos alba*	E	ʻŌlaʻa Tract, Puʻu Makaʻala NAR	975-1600	Wet
Cucurbitaceae	*Sicyos macrophyllus*	C	HAVO, Kīpuka Ki	1097-2189	Seasonal Mesic to Very Wet, Montane Dry
Caryophyllaceae	*Silene hawaiiensis*	T	HAVO, Mauna Loa Strip	900-2561	Mesic, Wet, Young Lava
Lamiaceae	*Stenogyne angustifolia*	E	Kaʻū (between Kīlauea and Kapāpala)	1314-2150	Seasonal Mesic to Moist Mesic, Montane Dry

Argyroxiphium kauense

Description

This member of the sunflower family (Asteraceae), commonly known as ʻāhinahina or the Mauna Loa silversword, is endemic to Hawaiʻi island. This species is a rosette shrub with silver to gray leaves (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1995). Wild individuals of this species are found in upper Waiākea FR, Kāpapala FR and Kahuku Ranch (HAVO). This species is the focus of a large-scale reintroduction effort on state and federal lands. Reintroduction has taken place adjacent to Keauhou in Kūlani Correctional Facility and in HAVO Mauna Loa Strip Rd. area (above 2,130 m). Suitable reintroduction sites for this charismatic, high-profile endangered species may exist in upper elevation portions of Keauhou.

Clermontia peleana

Description

ʻŌhā wai is also the Hawaiian name for this lobeliad member of the bellflower family (Campanulaceae). This plant is endemic to the islands of Hawaiʻi and Maui. This epiphytic shrub typically is extremely rare in wet forests between 530 and 1,150 m elevation (Wagner et al. 1999). It has been observed growing on the ʻōhiʻa, koa, ōlapa, and tree ferns. The overall status and recovery needs for this species are outlined in USFWS (1996). Only 1 known plant remains from the original wild population, and this plant is under propagation at the Volcano Rare Plant Facility. HAVO has reintroduced this species to a protected site in ʻŌlaʻa tract. Lower elevation wet forests in Kīlauea and Keauhou may have suitable reintroduction sites for this species.

Cyanea tritomantha

Description

ʻAkū is also the Hawaiian name for this lobeliad member of the bellflower family (Campanulaceae). This palm-like tree is endemic to the island of Hawaiʻi. It typically occurs in wet forests between 350 and 1,080 m elevation in Waipio Valley, windward Mauna Kea, and windward Mauna Loa (Wagner et al. 1999). HAVO has reintroduced this species to a protected site in ʻŌlaʻa tract. Lower elevation wet forest portions of Kīlauea and Keauhou may have suitable reintroduction sites for this species.

Cyrtandra giffardii

Description

This endemic member of the African violet family (Gesneriaceae), or haʼiwale, is known only from the island of Hawaiʻi. This small shrubby tree has white tubular flowers that are sparsely hairy. It is rare in wet forest from 940 to 1,500 m elevation and is known from Kīlauea, Kūlani, Laupahoehoe and Hilo FR (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). Lower elevation wet forest portions of Kīlauea and Keauhou may have suitable reintroduction sites for this species.

Cyrtandra tintinnabula

Description

This endemic member of the African violet family (Gesneriaceae), or ha'iwale, is known only from the island of Hawai'i. This shrub with white tubular flowers that are densely hairy is rare in wet forest from 730 to 1,040 m elevation from the Laupahoehoe area (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). Lower elevation wet forest portions of Kīlauea and Keauhou may have suitable reintroduction sites for this species.

Hibiscadelphus giffardianus

Description

This endemic member of the mallow family (Malvaceae), or hau kuahiwi, is known only from the island of Hawai'i and may be extinct in the wild. This tree has circular to kidney shaped hairy leaves, solitary grayish green/magenta flowers and woody seed capsules. It is found only in mesic forest at 1,310 m elevation in Kīpuka Puaulu on the eastern slopes of Mauna Loa (Wagner et al. 1999). Portions of Keauhou adjacent to Kīpuka Puaulu may have suitable reintroduction sites for this species. The overall status and recovery needs for this species are outlined in USFWS (1998b).

Joinvillea ascendens subsp. *ascendens*

Description

This endemic subspecies of the Joinvillea family (Joinvilleaceae), or 'ohe, is known from the islands of Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i. This erect herb has long narrow leaf blades with longitudinal folds like a fan. It is rare in wet forest between 300 and 1,250 m elevation (Wagner et al. 1999). HAVO has outplanted this species in 'Ōla'a tract. Lower elevation wet forest portions of Kīlauea may have suitable reintroduction sites for this species.

Melicope zahlbruckneri

Description

This endemic member of the citrus family (Rutaceae), or alani, is known only from the island of Hawai'i This medium-sized tree has almost cube-shaped seed capsules and young vegetative growth with yellowish brown hairs. It is rare in mesic to wet forest at around 1,220 m elevation from Kīpuka Puaulu, Moa'ula and Glenwood on the windward slopes of Mauna Loa (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). Mesic portions of Keauhou may have suitable reintroduction sites for this species.

Neraudia ovata

Description

This endemic member of the nettle Family (Urticaceae) is known only from the island of Hawai'i. This sprawling shrub with dense fine, short hairs on the branches is rare in dry forest, subalpine forest and open lava flows between 300 and 1,470 m elevation on leeward slopes (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). HAVO has reintroduced this species to Kīpuka Ki (Mauna Loa Strip Rd. Area). Drier portions of Keauhou may have suitable reintroduction sites for this species.

Nothocestrum breviflorum (ʻAiea)

Description

This endemic member of the nightshade family (Solanaceae) is known only from the island of Hawaiʻi. This stout tree is rare in dry to occasionally mesic forest between 550 and 1,830 m elevation from Kaʻū District north to Waimea, Kohala and Puʻu Waʻawaʻa (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). Portions of Keauhou adjacent to Kīpuka Puaulu and Kīpuka Kī may have suitable reintroduction sites for this species.

Phyllostegia floribunda

Description

This endemic member of the mint Family (Lamiaceae) is known only from the island of Hawaiʻi. This erect small shrub has leaves with pale undersides, and is rare in mesic to wet forest from four distinct areas between 430 and 1,130 m elevation, Honokaia; Kaʻū District, Pahala; Kohala Mountains; and Kīlauea to Laupāhoehoe (Wagner et al. 1999). HAVO has reintroduced this species to ʻŌlaʻa Tract. Lower elevation wet forest portions of Kīlauea may have suitable reintroduction sites for this species.

Phyllostegia parviflora

Description

This endemic member of the mint Family (Lamiaceae) is known from the islands of Hawaiʻi, Oʻahu, and Maui. This erect perennial herb has dense straight hairs on the leaves, stems, and inflorescence, and it occurs in diverse mesic to wet forest between 500 and 730 m elevation in the Koolau and Waianae Mountains of Oʻahu, West Maui, and Hawaiʻi (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1999). Keauhou may have suitable reintroduction sites for this species (dry to mesic kīpuka).

Ranunculus hawaiiensis (makou)

Description

This endemic perenniel herb is in the buttercup family (Ranunculaceae). This species is known from East Maui and Hawaiʻi, and occurs in mesic habitats between 1,820 and 2,040 m elevation (Wagner et al. 1999). This species is historically known from Keauhou in the Powerline Rd. area (found in 1983 from 1,859 m). Keauhou may have suitable reintroduction sites for this species (dry to mesic kīpuka).

*Sicyos alba (*ʻānunu)

Description

This endemic member of the gourd Family (Cucurbitaceae) is known only from the island of Hawaiʻi. This annual vine is rare in wet forest between 1,000 and 1,600 m elevation on the windward slopes of Mauna Loa, Mauna Kea, and Kīlauea (Wagner et al. 1999). The overall status and recovery needs for this species are outlined in USFWS (1998b). Lower elevation wet forest portions of Kīlauea may have suitable reintroduction sites for this species.

Sicyos macrophyllus (ʻānunu)

Description

This endemic member of the gourd Family (Cucurbitaceae) is known only from the island of Hawai‘i. This perennial vine with leaves broadly ovate-cordate and annual stems hairy, smooth or black-spotted, is rare in wet forest and subalpine forest between 1,200 and 2,000 m elevation on the windward slopes of the Kohala Mountains, Mauna Kea and Mauna Loa,-Mauna Kea saddle (Wagner et al. 1999).

Silene hawaiiensis

Description

This endemic member of the pink Family (Caryophyllaceae) is known only from the island of Hawai‘i. This sprawling shrub with small purple flowers in narrow paniculate cymes and slender recurved leaves is scattered and restricted to primarily open, dry areas on decomposed lava and ash between 900 and 3,050 m elevation in Kīlauea, North Kona, Hāmākua Districts and along the Saddle Road (Wagner et al. 1999). Suitable habitat exists for this species at Keauhou (e.g. Keemoku flow along Powerline Rd. on older pahoehoe with some ash). The overall status and recovery needs for this species are outlined in USFWS (1998b).

Stenogyne angustifolia

Description

This endemic member of the mint Family (Lamiaceae) is known from the islands of Hawai‘i, Maui, and Moloka‘i. This climbing vine with occasionally hairs at the nodes and membranaceous leaves occurred in dry subalpine shrubland between 1,550 and 2,150 m elevation, but is now likely restricted to the Pohakuloa Training Area (Wagner et al. 1999). Portions of Keauhou may have suitable reintroduction sites for this species. The overall status and recovery needs for this species are outlined in USFWS (1994).

Management Recommendations

Current Habitat Protection and Management

The Partnership has fenced and completed feral ungulate control in three management units (6,900 acres, 2,792 ha) that include portions of Keauhou and Kīlauea. Ungulate control is almost completed in an additional 2,300 acres (930 ha) Wright Rd Unit, and is underway for most of the rest of Keauhou (approximately 20,000 acres or 8,000 ha). These are all high priority habitat for the endangered plants currently found at Keauhou - Kīlauea, and also contain habitat for other plants listed in Table 6. Keauhou - Kīlauea lands are included in the following units: Pu‘u Lala’au Unit (Keauhou), Pu‘u Kipu Unit (Kīlauea and also includes Kūlani lands), Pu‘u Kūlani and Wright Road Units (Kīlauea and also includes Division of Forestry and Wildlife lands).

Threats

Historical threats to these species in Keauhou - Kīlauea include both indirect and direct actions:

Indirect (habitat loss and/or alterations)

1) Alteration of habitat (logging and ranching)
2) Habitat degradation due to the presence of feral ungulates (cattle, pigs, sheep and goats)
3) Invasion by non-native plants (e.g alteration of nutrient of fire regime)
4) Global warming – changing habitat conditions

Direct (to the actual plant)

1) Volcanic eruption – Although these species may be adapted to volcanic eruptions, these now pose a threat because population sizes have been greatly reduced.
2) Fire
3) Physical damage and predation by herbivores (cattle, pigs, and rodents) and insects
4) Competition by non-native plants

All existing plants in the area are currently affected by several of these continued historic threats (i.e. invasion by non-native plants, predation by non-native and potentially native invertebrates (bugs and slugs), rodents, volcanic eruptions and fires). Other potential threats to these species, based on research and restoration efforts on the survivability of other critically endangered plants, include a continued decline in population numbers (affecting genetic diversity and seed viability), lower numbers of reproducing individuals, and declines in native pollinator populations.

Recommendations

The primary goal of recommended conservation actions is to protect and enhance existing populations in order to help stabilize and recover these species. USFWS considers a plant taxon stable when it has three populations with a minimum of either 25 mature and reproducing individuals of long-lived perennials (>10 year life span), 50 mature and reproducing individuals of short-lived perennials (<10 year life span) or 100 mature and reproducing individuals of annual taxa per season (<1 year life span). In addition to numerical criteria, genetic storage must be in effect for the taxon and all major threats must be controlled. Recovery is the process by which the decline of an endangered or threatened taxon is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The USFWS definition of recovery for plants varies according to the taxon's life history and other factors, but fundamentally requires the long-term maintenance of sufficient numbers of secure, self-sustaining wild populations of the taxon (typically 8-10 populations).

1) Protect intact and rehabilitate altered habitat through ungulate control, alien plant control, and reforestation.

2) Rare plant surveys - Activities that involve land clearing and disturbance (e.g. reforestation, fence construction, road clearing, construction) should require additional rare plant surveys prior to implementation. The rare plants discussed in this report are very difficult to detect, so intensive localized surveys are necessary if native forests and other ecosystems (e.g. lava tubes, shrublands etc) are going to be disturbed. Rare plants are unlikely to occur in open pasture areas, however, kīpuka within pasture areas should be surveyed if they are going to be disturbed by management actions. Additional surveys should also be done in more intact forested areas with high potential to contain additional rare plants (e.g. Pu‘u Lala‘au Unit and Kīlauea forest). These surveys will likely locate

additional individuals that were previously undetected. Additional plants will also be located as the habitat improves as a result of ungulate removal (both feral ungulates and domestic cattle).

3) Propagation

a. Collect propagation and storage materials (cuttings and seeds) from as many wild individuals as possible.
b. All propagated plants will be decontaminated for weeds, weed seeds, pathogens, slugs, mites, nematodes, scale, and other invertebrate pests routinely during propagation and prior to outplanting to prevent the introduction of new pests and pathogens into the target outplanting environments.

Appropriate federal and state permits will be obtained for all listed species prior to collecting and outplanting.

4) Reintroduction & Augmentation – Reintroduction generally refers to establishing a taxon into habitat within its known or suspected natural range that no longer includes extant individuals of that taxon. The purpose of reintroduction is to reestablish a sustained or growing population in the original or potential natural range of a plant or animal. Augmentation refers to addition of individuals of a taxon in habitat that is known to currently contain individuals of that taxon. The purpose of augmentation is to bolster the numbers and/or genetic variability of an existing population of plants or animals. Reintroduction is preferred to augmentation to avoid genetic and pest contamination. However, augmentation is unavoidable if suitable habitat is not available to establish new populations through reintroduction.

a. Select quality and/or prepare future outplanting sites to support outplanted individuals.
b. Adding plants to a population with fewer than 5 reproductive individuals is considered to be reintroduction because populations of this size will be genetically swamped by new outplantings and they are considered to be "functionally" extinct.
c. Reintroduction may be made in many phases over several years to the same site, as long as problems of pest contamination are addressed. Incremental reintroduction will not be considered augmentation.
d. Augment outplanting sites with as many genetic lineages as possible to minimize genetic bottlenecks. Decisions about numbers of founders will be made on a case-by-case basis and may vary among species. The Partnership and KS will attempt to learn as much as possible about breeding systems and genetic variability of potential non-Keauhou Kīlauea founders before using them.
e. Ideally, 50 or more founders will be used for a reintroduction or augmentation of each rare or federally listed plant species. It is recognized that there will be fewer founders available in most cases.
f. If 10 or fewer founders are available in Keauhou - Kīlauea, then outside sources will be used, if available, and if deemed suitable in terms of habitat similarities to the target habitat and phenotypic similarities of the source and target plant populations.

g. Small numbers of founders may be used in stabilization efforts, if only few founders are available. The intent of stabilization is to bolster numbers and minimize chance extinctions. As additional founders become available, outplantings from these new founders will be added to stabilize populations.
h. Establish outplanting sites in other areas and multiple sites to prevent extinction by unforeseen events (volcanic eruption, disease outbreak, fire, etc).
i. For threatened and endangered species, founder representation will be equalized by outplanting, to the extent possible.
j. Reintroduction of extirpated species to Keauhou - Kīlauea is appropriate for species whose presence is documented. However, it is recognized that the historical records may be incomplete.
k. Reintroduction of species whose prior occurrence is not documented may be undertaken if the following apply:
    i. Keauhou - Kīlauea is located within the broader historical range.
    ii. Source populations are close to Keauhou - Kīlauea.
    iii. Appropriate habitat is present.
    iv. It is reasonable that the species may have occurred in Keauhou - Kīlauea in the past even though direct documentation does not exist.
    v. There is a compelling need for recovery in Keauhou - Kīlauea.

5) Monitoring
    a. The location of founder populations and outplanted populations will be mapped and/or recorded in the outplanting records.
    b. Founders for all threatened and endangered species and very rare species will be tracked by individual. Founders will be identified with markers or GPS coordinates. Seeds from these must be kept separate by individual to keep track of founder representation.
    c. Paper files and computerized databases will be developed to track rare and listed plants. This includes seed collecting and tracking of founders and founder representation, monitoring of survival, growth, and phenology, and plant propagation methods and results.
    d. Outplantings of all threatened and endangered species will be tagged by individual with durable metal tags
    e. Monitor outplanted individuals for survivorship as well as viable population potential (based on mature/reproductive outplanted individuals and recruitment of their offspring).
    f. Monitor all reintroduced populations, i.e. *C. shipmanii* and *C. stictophylla* populations, regularly for insect damage and the presence of plant diseases.

6) If necessary establish a small mammalian predator/herbivore control program on site (i.e. rat bait grid and slug baiting)

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Appendix 5

Species Accounts

5.1ʻAkiapōlāʻau
5.2 Hawaiʻi Creeper
5.3 Hawaiʻi ʻĀkepa
5.4 ʻIʻiwi
5.5 ʻIo or Hawaiian Hawk
5.6 ʻAlalā or Hawaiian Crow
5.7 Nēnē or Hawaiian Goose
5.8 ʻŌpeʻapeʻa or Hawaiian Hoary Bat

Photo: UH EECB

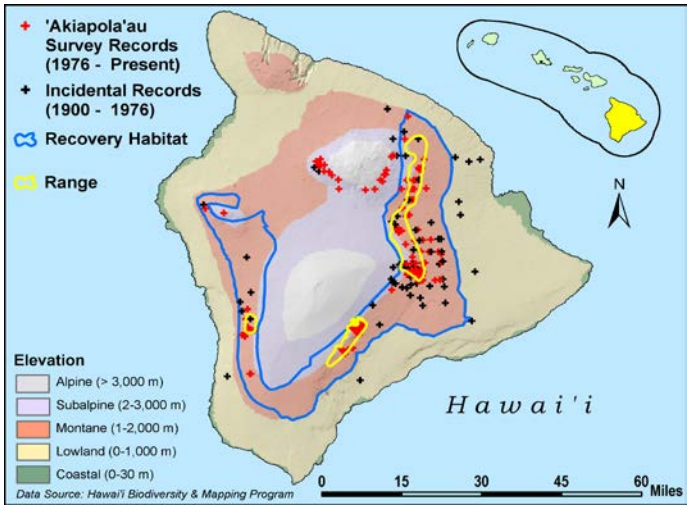
Forest Birds

ʻAkiapōlāʻau

Hemignathus munroi

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ʻakiapōlāʻau is a stocky Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Hawaiʻi and most famous for their specialized bills, which have a long, decurved upper mandible and a short woodpecker-like lower mandible. Adult males have a bright yellow head and underparts, yellow-green back and wings, and a small, black mask. Adult females are olive above with grayish-yellow to yellow underparts. Males are larger than females and have longer bills. They often join mixed species foraging flocks; the constituent species vary depending on habitat. ʻAkiapōlāʻau are mainly insectivorous, with Lepidoptera larva, spiders, and beetle larva being the most important prey items; rarely takes nectar but takes sap from holes it excavates in ʻōhiʻa (*Metrosideros polymorpha*) trees. Most frequently, creeps along lichen covered and dead branches of koa (*Acacia koa*), kōlea (*Myrsine lessertiana*), māmane (*Sophora chrysophylla*), and naio (*Myoporum sandwicense*) trees tapping branches with their lower mandible to locate prey. Once a food item is located, lower mandible is used similar to that of a woodpecker bill to chisel open a hole. The upper mandible is then used to fish out the prey item. Upper mandible also used to probe natural cracks and crevices. Breeding has been documented year-round, although most activity occurs from February to July. The species' open cup nest is most often placed in ʻōhiʻa trees. Clutch size is usually one, rarely two, and females perform all incubation and brooding. Males provide females and nestlings with the majority of food. Only one fledgling is produced per year, and a long period of parental dependency, usually four to five months, is typical. Family groups consisting of hatch-year and second-year young have been observed. This species is characterized by low annual productivity.



DISTRIBUTION: Occurs in three disjunct populations between 1,500 and 2,000 meters (4,875–6,500 feet) elevation on the Island of Hawaiʻi. Original range likely included all forested areas of the island.

ABUNDANCE: The Hawaiian Forest Bird Survey (1976-79, 1983), estimated the population at 1,500 ± 400 (95% confidence interval). Surveys conducted between 1990 and 1995 estimated the population at 1,109-1,217 birds and most recent analysis puts the population closer to 1,900. Significant declines occurred in two of the four populations known in the 1980s. The Kaʻū /Kapāpala population decreased from approximately 530 individuals to 44, and a Mauna Kea population dropped from approximately 50 birds to less than 10; in 2000 only three birds remained on Mauna Kea and this population is now extinct. The Kaʻū /Kapāpala population has since stabilized or increased at upper elevations, but the status of the small Kona population is unknown.

LOCATION AND CONDITION OF KEY HABITAT: Occurs in mesic and wet montane forests dominated by koa and ʻōhiʻa. The small and declining population on Mauna Kea occurred in subalpine dry forest dominated by māmane and naio. A recent study documented ʻakiapōlāʻau occurring entirely in areas reforested with koa (i.e., second-growth, young forests). Habitat quality varies across the species' occupied range. Most remaining populations occur on lands managed by the State of Hawaiʻi and the U.S. Fish and Wildlife Service.

THREATS: ʻAkiapōlāʻau are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For ʻakiapōlāʻau populations, the following are of particular concern:

- Low reproductive potential. Unlike many Hawaiian honeycreepers, ʻakiapōlāʻau have low annual fledgling production. This life history characteristic may be related to their very specialized foraging strategy. Regardless, the species is very susceptible to factors that reduce population size.
- Disease. Unlike several other honeycreepers found on the island of Hawaiʻi (e.g., Hawaiʻi amakihi [*H. virens*]), the ʻakiapōlāʻau is absent from most areas below 1,350 meters (4,500 feet). This suggests that the species is particularly susceptible to mosquito-borne avian disease.
- Predation. Although little evidence exists, predation by rats (*Rattus* spp.), cats (*Felis* silvestris), small Indian mongoose (*Herpestes auropunctatus*), and owls (*Asio flammeus sandwichensis, Tyto alba*) may limit ʻakiapōlāʻau populations. Recent surveys have determined that rat density in the Hakalau Forest National Wildlife Refuge, which supports a significant portion of the ʻakiapōlāʻau population, is high. In addition, the loud, persistent begging of juveniles may make them especially vulnerable to predators.
- Habitat degradation. Habitat loss and degradation from development, logging, and grazing has greatly fragmented the species' habitat.
- Population size. Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.

CONSERVATION ACTIONS: To date, conservation actions specific to ʻakiapōlāʻau have been restricted to annual population surveys of the Hakalau, ʻŌlaʻa/Kīlauea, Kona, and Mauna Kea populations. However, ʻakiapōlāʻau likely have benefited from actions to conserve other endangered forest birds in the Kapāpala Forest Reserve, Hakalau Forest National Wildlife Refuge, Puʻu Lāʻau, Hawaiʻi Volcanoes National Park, and the ʻŌlaʻa/Kīlauea Watershed

Partnership. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the ʻakiapōlāʻau may include the following:

- Add Hāmākua, the upper Waiākea kīpuka, Kaʻū /Kapāpala and south Kona to annual surveys.
- Continue koa forest restoration and fencing in the Hakalau Forest National Wildlife Refuge.
- Continue restoration of māmane forests on Mauna Kea.
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING:

- Continue forest bird surveys and habitat monitoring.
- Test survey methods for ʻakiapōlāʻau, and continue regular population surveys with improved methods.
- Monitor small mammal populations to assess effectiveness of control efforts, especially in dry forest sites.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to ʻakiapōlāʻau include the following:

- Conduct life history studies to quantify population structure, dispersal patterns, survivorship, nesting phenology, and success.
- Document habitat selection, preference, and foraging ecology, particularly in young forests.
- Document the response of ʻakiapōlāʻau to control of mammalian predators.
- Develop captive propagation techniques.
- Determine the feasibility of ʻakiapōlāʻau re-introductions to suitable locations (e.g., Puʻu Waʻawaʻa, Hawaiʻi Volcanoes National Park).

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Forest Birds


Photo: Jack Jeffrey

Hawai‘i creeper

Oreomystis (Loxops) mana

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Ranking G2—Imperiled
IUCN Red List Ranking—Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Hawai‘i creeper is a small, inconspicuous Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Hawai‘i. Adults are predominately olive-green above, dull buff below, and have a dark gray mask extending around the eyes; males are brighter. Their similarity to Hawai‘i ‘amakihi (*Hemignathes virens*), Hawai‘i ‘ākepa (*Loxops coccineus coccineus*), and introduced Japanese white-eyes (*Zosterops japonicus*) complicates field identification. Unlike many Hawaiian forest birds, their life history is well known. Outside the breeding season, they frequently join mixed-species foraging flocks and forages over home ranges that average 11 hectares (17.3 acres). They glean insects, spiders, and other invertebrates from the branches, trunks, and foliage of live ‘ōhi‘a (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees. During the breeding season, the species’ home range averages 4 to 7 hectares (10 – 17 acres) and a 10 – 20 meter (33 – 66 feet) territory around the nest is defended. Most nests are open cup structures, but about 15 percent are placed in cavities or in bark crevices. Females build nests, incubate eggs, and brood nestlings. Males deliver food to the female on and off the nest. Both parents feed the young for approximately one month. Hawai‘i creepers re-nest after nest failures and pairs may raise two broods in a season. Nest success is very low, but adults have high annual survival.

DISTRIBUTION: Occurs in four disjunct populations above 1,500 meters (5,000 feet) on the island of Hawai‘i. Historically occurred across the island above 1,070 meters (3,500 feet) elevation.

ABUNDANCE: The Hawaiian Forest Bird Survey (1976-79, 1983), estimated the population at 12,500 ± 2,000 (95% confidence interval) birds. The largest population consisted of 10,000 ± 1,200 birds.

LOCATION AND CONDITION OF KEY HABITAT: Most commonly in mesic and wet forests dominated by ‘ōhi‘a and koa, with a subcanopy of ‘ōlapa (*Cheirodendron trigynum*), pūkiawe (*Styphelia tameiameiae*), ‘ōhelo (*Vaccinium* spp.), ‘akala (*Rubus hawaiiensis*), kōlea (*Myrsine* spp.), kāwa‘u (*Ilex anomala*), and hapu‘u tree ferns (*Cibotium* spp.). Habitat conditions vary across the species’ range, with much of it degraded by grazing ungulates, especially feral pigs. Most of the current range of the Hawai‘i creeper is within the boundaries of State and Federally owned lands.

THREATS:

- Predation. Nest success is very low (11 to 50 percent) and rat (*Rattus* spp.) predation may be partially responsible. Hawai'i creepers place their nests near the main trunks of trees which may facilitate predation by rats.
- Disease. The Hawai'i creeper's absence below 1,350 meters (4,500 feet) elevation suggests that it may be particularly susceptible to mosquito-borne avian disease.
- Habitat loss and degradation. Logging and grazing ungulates have reduced, degraded, and fragmented suitable forest habitats. Habitat fragmentation may be a dispersal barrier preventing or restricting recolonization of the species' former range.
- Competition. Competition with Japanese white-eyes(*Zosterops japonicus*) may negatively affect Hawai'i creepers.

CONSERVATION ACTIONS: Past or ongoing actions specific to the Hawai'i creeper include studies on productivity, recruitment, and survival, and development of captive propagation techniques. They likely have benefited from actions to conserve other endangered forest birds in the Hakalau Forest National Wildlife Refuge, the Kona unit of the Hakalau Forest National Wildlife Refuge, 'Ōla'a/Kīlauea Watershed Partnership, Kapāpala Forest Reserve, and Pu'u Wa'awa'a Wildlife Sanctuary. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. Future management specific to Hawai'i creepers may include the following:

- Reintroduce the Hawai'i creeper to managed areas in their former range (e.g., Mauna Loa strip in Hawai'i Volcanoes National Park).
- Control rodents to enhance nestling and female survival. Aerial broadcast of rodenticides would be the most effective method to treat broad areas.
- Increase public education to engender support for conservation of forest birds.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the Hawai'i creeper include determining the efficacy and health implications of broadcast rodenticide.

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Forest Birds

Photo: DOFAW

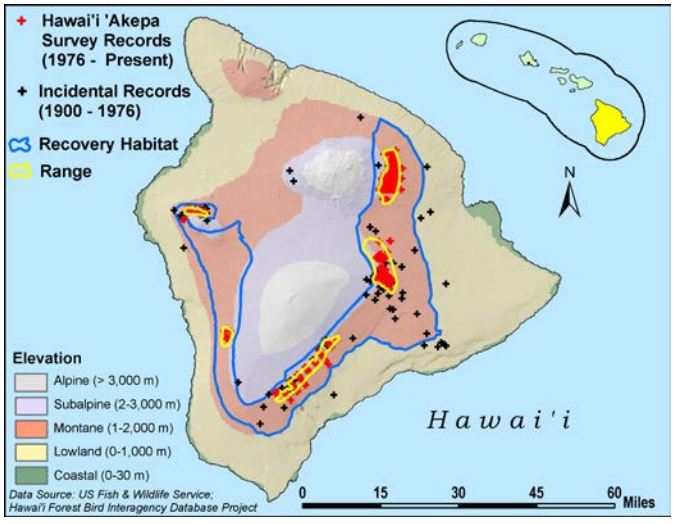
Hawai‘i ‘ākepa

Loxops coccineus coccineus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Hawai‘i ‘ākepa is a small, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Hawai‘i. ‘Ākepa also are known from Maui (*L. c. ochraceus*) and O‘ahu (*L. c. rufus*); both of which are likely extinct. Currently, all ‘ākepa are considered one species, although they are recognized as critically imperiled at the subspecies level. After three years, males obtain their bright orange adult plumage; subadult plumage is dull brownish orange, although individual variation is high. Females are grayish-green with a yellow breast band. The lower mandible of the ‘ākepa is slightly bent to one side which results in the mandible tips being offset; a characteristic shared with the ‘akeke‘e (*L. caeruleirostris*). The bend can be to the left or right, and depending on the direction of the bend, individuals also possess an accompanying leg asymmetry; the leg opposite the curve in the mandible is slightly longer than the other leg. Together, these adaptations likely improve the species foraging efficiency. They often join mixed-species foraging flocks, particularly those with Hawai‘i creepers (*Oreomystis mana*). They feed mainly on ‘ōhi‘a (*Metrosideros polymorpha*) leaf clusters, but also on koa (*Acacia koa*) leaves and seed pods, where it uses its bill to pry open leaf and flower buds in search of small arthropods. ‘Ākepa are obligate cavity nesters, with most nests placed in natural cavities found in old-growth ‘ōhi‘a and koa trees. Females build nests, incubate eggs, and brood nestlings, and males deliver food to the female on and off the nest. Both parents feed the young, which remain with their parents for two to three months after fledging.

DISTRIBUTION: Occurs in five disjunct populations above 1,300 meters (4,300 feet) elevation on the windward side of the island of Hawai‘i. Original range likely included all forested regions of the island.



ABUNDANCE: The Hawaiian Forest Bird Survey (1976-79, 1983), estimated the population at 14,000 ± 2500 (95% confidence interval) birds. The south Kona and Hualālai populations were estimated at 660 ± 250 birds and are apparently declining.

LOCATION AND CONDITION OF KEY HABITAT: Occurs in ʻōhiʻa and ʻōhiʻa/koa forests above 1,300 meters (4,300 feet). Density appears to be related to the number of available cavities, and because cavities primarily occur in older, large trees, old-growth forests may be preferred. The highest density of ʻākepa occurs in the Pua ʻĀkala tract of Hakalau Forest National Wildlife Refuge, which has numerous large trees but a degraded understory. Many areas occupied by the species have been degraded by feral ungulates. Most of the current range of the Hawaiʻi ʻākepa is managed by State and Federal agencies or private conservation partnerships.

THREATS:

- Habitat degradation and loss. Logging and ranching has fragmented and reduced the amount of suitable habitat. Breeding density may be limited by nest-site availability and current levels of food availability may limit populations. In forest fragments, the large trees required for nesting may be more susceptible to windfall and desiccation. The slow growth rate of ʻōhiʻa complicates management for ʻākepa. In addition, habitat fragmentation may prevent or restrict natural re-colonization of former range.
- Disease. The Hawaiʻi ʻākepa is not found below 1,300 meters (4,300 feet), which suggests that it is particularly susceptible to mosquito-borne diseases.
- Predation. Cavity nests may be vulnerable to rat predation, although nest success is high at Pua ʻĀkala in the Hakalau Forest NWR, where rat densities are high.

CONSERVATION ACTIONS: Completed or ongoing actions specific to the Hawaiʻi ʻākepa include: demographic and reproductive studies have determined the importance of old-growth trees for nesting and that the species will use artificial cavities for nesting, and captive propagation techniques have been developed. In addition, Hawaiʻi ʻākepa likely benefit from management activities to conserve other endangered forest birds in Hakalau Forest National Wildlife Refuge, the Kona unit of the Hakalau Forest National Wildlife Refuge, ʻŌlaʻa/Kīlauea Watershed Partnership, Kapāpala Forest Reserve, and Puʻu Waʻawaʻa Wilderness Sanctuary. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the Hawaiʻi ʻākepa may include the following:

- Aerially broadcast rodenticides to increase nestling and adult female survival.
- Conduct public education and outreach.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the Hawaiʻi ʻākepa include:

- Continue studies designed to refine the suitability of artificial cavities and evaluate their potential to facilitate the establishment of new populations.
- Determine the factors affecting the growth form of regenerating ʻōhiʻa and potential methods for protecting old-growth trees from wind and desiccation.

- Identify disease-resistant individuals. Determining if genetic markers or genotypes are associated with resistance would allow targeted translocations of individuals possessing this genotype into populations lacking disease resistance.

References:

Lepson JK, Freed LA. 1997. ʻAkepa (*Loxops coccineus*). *In* The Birds of North America, No. 294 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

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Photo: Eric VanderWerf

Forest Birds

ʻIʻiwi

Vestiaria coccinea

SPECIES STATUS:
State Listed as Endangered on Oʻahu, Molokaʻi, Lānaʻi
State Recognized as Endemic
NatureServe Heritage Rank G4/T1/TH—Apparently Secure/
Critically Imperiled Globally on Oʻahu and Molokaʻi/Possibly Extinct on Lānaʻi
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The ʻiʻiwi is one of the most beautiful of the extant Hawaiian honeycreepers (Family: Fringillidae). Both males and females are vermillion red, with a black tail and wings, and a long, decurved pink bill. Native Hawaiians created feather capes using hundreds of thousands of ʻiʻiwi feathers; such capes signified power and prestige. Like ʻapapane (*Himatione sanguinea*), ʻiʻiwi often fly long distances in search of flowering ʻōhiʻa (*Metrosideros polymorpha*) trees and are important ʻōhiʻa pollinators. Their diet consists primarily of nectar from a variety of native and non-native flowers and the presence of non-native flowers may have contributed to increases in some populations. In addition to nectar, ʻiʻiwi also eat small arthropods. Both sexes defend small nesting territories and may defend important nectar resources. Courtship chases and feeding may precede breeding. Nest sites are in terminal branches of ʻōhiʻa trees and both sexes build the open-cup nest. Only females incubate eggs (typically two) and brood young. Young are mostly provisioned by female; males feed females off the nest. Despite their widespread distribution, little is known about their life history.

DISTRIBUTION: Occurs above 1,250 meters (4,100 feet) elevation on the islands of Hawaiʻi, Maui, and Kauaʻi; and may occur at reduced densities below. Relict populations occur on Oʻahu and Molokaʻi. Historically, ʻiʻiwi were common down to low elevations on all the Main Hawaiian Islands.

ABUNDANCE: The following island population estimates are based on Paxton et al. (2013): 543,009 ± 26,697 (95% confidence interval) birds on island of Hawaiʻi, 59,859 ± 5,290 on east Maui, 176 on west Maui, 80 on Molokaʻi, and 2,551 ± 617 on Kauaʻi. Oʻahu supports a population of less than 50 birds. The population is probably declining, but the species' wide-ranging foraging complicates population estimates and the determination of long-term trends.

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet forest dominated by ʻōhiʻa and koa (*Acacia koa*). Loss and degradation of habitat and high densities of cold-intolerant *Culex* mosquitoes, an important disease vector, in lowland areas restrict most birds to elevations above 1,250 meters (4,100 feet). Habitats with the highest ʻiʻiwi densities also support kōlea (*Myrsine lessertiana*), naio (*Myoporum sandwicense*), and hapuʻu tree ferns (*Cibotium* spp.). Māmane (*Sophora chrysophylla*) is common in high-elevation foraging habitat. Although much of the species' current range is under State or Federal jurisdiction, habitat quality and habitat protection and restoration varies considerably.

THREATS: Although populations appear stable on the islands of Hawai'i and Maui, they are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For 'i'iwi, the following is of particular concern:

- Disease. 'I'iwi are very susceptible to avian malaria and avian pox. Nine of ten individuals died within 37 days after receiving a single bite from mosquitoes infected with *Plasmodium*. Individuals infected with pox also are more likely to be infected with malaria. Because the highest points on Moloka'i and O'ahu are below 1,250 meters (4,100 feet), this susceptibility likely explains the severe population declines noted on these islands. Foraging movements may increase their exposure to disease.

CONSERVATION ACTIONS: 'I'iwi likely have benefited from actions to conserve other endangered forest birds on northeastern Haleakalā, Hakalau Forest National Wildlife Refuge, Alaka'i Wilderness Preserve and surrounding areas, Hawai'i Volcanoes National Park, and the 'Ōla'a/Kīlauea Watershed Partnership. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. Future actions specific to the protection of 'i'iwi may include the following:

- Control mosquitos in degraded habitats.
- Conduct public education and outreach.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring on all islands.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats (*Rattus* spp.) and feral cats (*Felis silvestris*) in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to 'i'iwi include the following:

- Determine if disease-resistant birds exist, and if so, determine if resistance is passed to offspring. Disease-resistant birds could be used to establish new populations.
- Determine the role of 'i'iwi in transmitting disease between low and high elevations.
- Conduct life history studies to quantify the population structure, dispersal patterns, survivorship, nesting phenology and success of this poorly known species.

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Photo: Jack Jeffery

Raptors

ʻIo

Buteo solitarius

SPECIES STATUS:
Federally Listed as Endangered,
Proposed for Delisting
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G2—Imperiled
IUCN Red List Ranking—Near Threatened
Hawaiian Hawk Recovery Plan—USFWS 1984

SPECIES INFORMATION: The ʻio, or Hawaiian hawk, is the only broad-winged hawk (Family: Accipitridae) in Hawaiʻi. ʻIo are considered ʻaumākua, or family gods, by Native Hawaiians. Similar to many birds of prey, females are larger than males, and often weigh approximately 25 percent more than males. Also similar to many *Buteos*, two color morphs, light and dark, occur in ʻio populations. Prior to the arrival of Polynesians, ʻio may have exclusively preyed on birds, including now extinct flightless ibis, and rails. Its diet now includes non-native insects, birds and rodents, as well as native insects and birds. ʻIo form monogamous long-term pair-bonds and defend territories year-round. Nest construction is protracted, beginning up to two months before the first egg is laid, and continuing into the nestling period. Egg-laying generally occurs from March to June, and fledging from July to September. Both sexes contribute to nest-building. Clutch size is nearly always one, although historically clutches of two and three were reported. Both sexes incubate, although females perform most of the brooding of nestlings; males provide most of the food to chicks and female. Both adults feed fledglings, which are dependent on adults for up nine months.

DISTRIBUTION: Occurs throughout the island of Hawaiʻi from 300 to 2,600 meters (1,000 to 8,530 feet). Based on fossil evidence, they once occurred on Kauaʻi, Molokaʻi, and Oʻahu.

ABUNDANCE: Based on an island-wide survey in 2007**,** the population is estimated at 3,000 birds with a stable population trend over the past 20 years.
LOCATION AND CONDITION OF KEY HABITAT: Lowland non-native forests, urban areas, agricultural lands, pasturelands, and high-elevation native forests. Most nesting occurs in native ʻōhiʻa trees, although also occurs in non-native trees, including eucalyptus, ironwood, mango, coconut palm, and macadamia. In winter, they have been reported in subalpine māmane-naio forest, suggesting some seasonal movements.

THREATS:

- Habitat loss and degradation. Habitat is negatively affected by urbanization, land conversion to unsuitable foraging habitat (e.g., pasture and cane fields to eucalyptus forest), increase in fire frequency that may eliminate nesting and perching habitat, and invasion of understory plants which can conceal prey and reduce foraging success.

However, the species was proposed to be federally delisted in 2008, and again in 2014, because it was determined that the species is resilient enough to maintain itself in a variety of non-native and native habitat types.

- Disease. ʻIo does not appear to be susceptible to the avian malaria and avian pox that have devastated other Hawaiian endemic forest birds. However, West Nile virus could affect the species if the disease reaches Hawaiʻi.

CONSERVATION ACTIONS: ʻIo likely benefit from actions for other endangered birds, such as fencing, ungulate and small mammal control, and forest restoration. Actions specific to conservation of the ʻio should include the following: protect and manage the species' foraging and nesting habitat.

MONITORING: Conduct regular island-wide surveys to monitor abundance, distribution, and disease.

RESEARCH PRIORITIES: Evaluate potential effects of land management and changes in fire frequency and intensity on the species.

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Photo: DOFAW

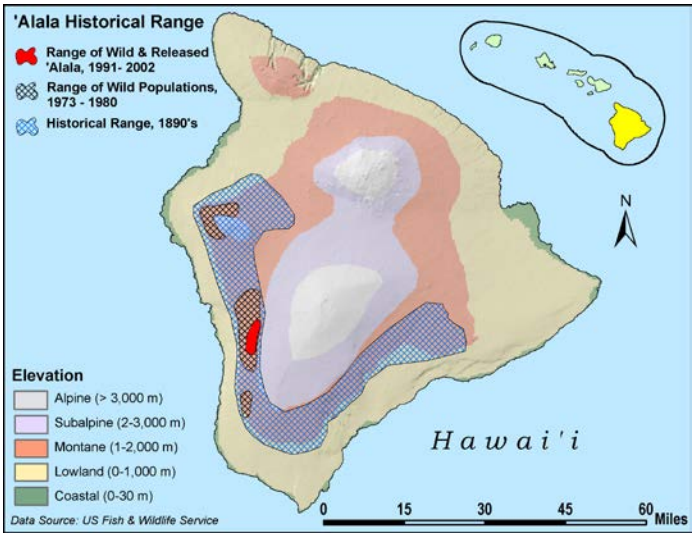
Forest Birds

ʻAlalā or Hawaiian crow

Corvus hawaiiensis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank: GXC-Presumed Extinct/ Captive Population
IUCN Red List Ranking—Extinct in the Wild
Revised Recovery Plan for the ʻAlalā —USFWS 2009

SPECIES INFORMATION: Historically at least five crow species (Family: Corvidae) occurred in Hawaiʻi, only the ʻalalā, or Hawaiian crow survives. Like other crows, ʻalalā are raucous, gregarious and vocal; young, captive-raised birds often engage in tug-of-war with sticks. Like many corvids, ʻalalā are long-lived with a life span of 20 or more years. The diet primarily consists of native and introduced fruits, invertebrates, and eggs and nestlings of other forest birds, as well as nectar, flowers and carrion. Seasonal movements in response to weather and availability of food plants (e.g., ʻieʻie [*Freycinetia arborea*]) have been noted. Although individuals form long-term pair bonds, extra-pair copulations have been observed. Nests are predominantly constructed in ʻōhiʻa (*Metrosideros polymorpha*) trees. Both sexes participate in nest construction, although only females incubate eggs and brood young. Clutch size ranges from two to five, although usually only one or two nestlings fledge. Fledglings typically cannot fly and often remain near the ground for long periods, likely increasing their susceptibility to disease (i.e., toxoplasmosis) and predation. Juveniles depend on their parents for at least eight months and remain with their family group until the following breeding season. Large flocks characteristic of American crows (*C. brachyrhynchos*) have not been reported, but there are historical reports of small local flocks after the breeding season.



DISTRIBUTION: No individuals are known to exist in the wild. Historically occurred in high- and low-elevation forests of the western and southeastern regions of the island of Hawaiʻi.

ABUNDANCE: World population of 114 individuals in 2014, housed entirely in the Keauhou and Maui Bird Conservation Centers.

LOCATION AND CONDITION OF KEY HABITAT: Historically, ʻalalā occupied dry and seasonally wet ʻōhiʻa and ʻōhiʻa/koa (*Acacia koa*) forests between 300 and 2,500 meters (1,000 – 8,200 feet) elevation. Because the last wild individuals were confined to a small subset of the species' former range, specific knowledge of key habitat requirements are unknown. Currently, all potential habitat is degraded. The presence of non-native mammalian predators and birds, which can act as disease reservoirs, further reduces habitat quality. Core areas of the species' former range are now managed by the State of Hawai'i and the U.S. Fish and Wildlife Service.

THREATS: ʻAlalā are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including: loss and degradation of habitat, predation by introduced mammals, and disease. For ʻalalā populations, the following are of particular concern:

- Predation. The small Indian mongoose, rats, and feral cats prey on ʻalalā. The ʻio (*Buteo solitarius*) and presumably pueo (*Asio flammeus sandwichensis*) also prey on juvenile and adults. ʻIo have been documented killing captive-raised birds released into the wild. Fledglings are unable to fly and this likely contributes to high rates of predation.
- Shooting. Many ʻalalā were killed around farms between 1890 and 1930. Despite legal protection in 1931, shooting of individuals occurred into the 1980s.
- Disease. Population declines were noted between 1890 and 1910, a period when other native bird populations declined, presumably because of mosquito-borne diseases. Seasonal movement may have increased exposure to diseases. In addition, ʻalalā are susceptible to toxoplasmosis carried by feral cats.
- Habitat degradation. Habitat conversion by human activity as well as by grazing ungulates has severely degraded former ʻalalā habitat. These changes may have limited food or nesting resources and may have increased the vulnerability of ʻalalā to predation by ʻio. Currently, little suitable habitat exists for the species.
- Population size. Small populations are plagued by a variety of potentially irreparable problems which fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios.
- Captive-breeding. There is some evidence that captive-reared birds lack important foraging and predator-avoidance behaviors.

CONSERVATION ACTIONS: The ʻalalā has been legally protected by the State of Hawai'i since 1931 and was listed as federally endangered in 1967. A captive propagation program was established in 1973; crows are now housed at the Keauhou Bird Conservation Center and the Maui Bird Conservation Center. The ʻAlalā Recovery Team was formed to facilitate the species recovery, and a related second group, the ʻAlalā Partnership, was formed to facilitate program implementation on private lands. Between 1993 and 1998, 27 captive-raised juvenile ʻalalā were released at McCandless Ranch. Of these, 21 died in the wild and six were recaptured and returned to the captive flock. Predator control was ongoing during the release program. Intensive field studies of the wild population and released juveniles were conducted between 1992 and 2002. In 1999, the Kona Forest Unit of Hakalau Forest National Wildlife Refuge was acquired, with the goal of restoring habitat in the core of the species' historic range. To date, legal and operational constraints have impeded this effort. Restoration of future re-introduction sites is ongoing and re-introductions are expected to occur in the near future. In addition to the above efforts, ʻalalā likely will benefit from management activities to conserve other

endangered forest birds on the island of Hawai'i including fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the 'alalā should include the following:

- Continue restoration of future reintroduction areas.
- Maintain and increase the captive flock without further loss of genetic diversity.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: The captive flock is monitored. If and when re-introduction occurs, wild populations will be intensively monitored.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the 'alalā include the following:

- Review all data from studies on captive and wild populations.
- Determine methods to increase the reproductive output of captive individuals.
- Conduct field studies to determine if understory restoration will reduce the ability of 'io to prey on 'alalā.
- Establish a set of habitat criteria that must be met prior to release of birds at a particular site.
- Develop methods to habituate captive-raised individuals to respond appropriately to mammalian and avian predators, and sources of toxoplasmosis.
- Determine potential reintroduction sites on other islands.

References:

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Waterbirds

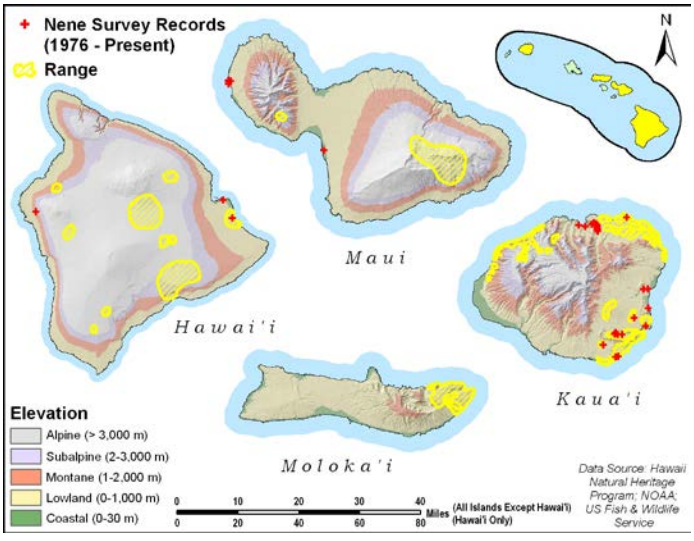
Photo: Jack Jeffery

Nēnē
or Hawaiian goose

Branta sandvicensis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1 - Critically Imperiled
IUCN Red List Ranking - Vulnerable
Revised Recovery Plan for the Nēnē or Hawaiian Goose (*Branta sandvicensis*) – USFWS 2004

SPECIES INFORMATION: Historically, at least five species of geese (family: Anatidae) occurred in Hawai'i; today, only the nēnē, or Hawaiian goose, survives. Adults are mostly dark brown or sepia with a black face and crown, cream-colored cheeks, and a buff neck with black streaks. Females are smaller than males. Compared to other geese, nēnē are more terrestrial and have longer legs and less webbing between their toes, which likely facilitates walking on lava flows. Nēnē graze and browse on the leaves, seeds, flowers, and fruits of at least 50 native and nonnative grasses, sedges, composites, and shrubs. Diet varies by location and habitat, and they may require a diverse suite of food plants. Currently, several species of nonnative grass are important in mid- and high-elevation habitats. Nēnē facilitate seed dispersal and play an important role in influencing the species composition of early successional plant communities. Historically, flocks moved between high-elevation feeding habitats and lowland nesting areas. Pairs mate for life and engage in relatively simple courtship displays in which the male attacks or threatens potential competitors, runs back to his mate, and calls loudly. Nēnē have an extended breeding season, and nesting may occur in all months except May, June, and July, although the majority of birds nest between October and March, and most clutches are laid between October and December. Nests consist of a shallow scrape lined with plant material and down. Breeding pairs usually return to the previous year's nest site, typically in dense vegetation; when available, kīpuka may be preferred. Females lay two to five eggs, which hatch after 30 days. Young are precocial and not fed by their parents; however, they remain with their parents for up to a year.



DISTRIBUTION: Between sea level and 2,400 meters (7,800 feet) elevation on the island of Hawai'i, Maui, Kaua'i, and Moloka'i, and a single pair was reported on O'ahu in 2014. Historically, the

species was found on all Main Hawaiian Islands and was likely widespread.

ABUNDANCE: In 1951, the wild nēnē population was estimated at 30 individuals and information on historical abundance is limited. The current population is estimated at 2,450–2,550 birds, with 550 on the island of Hawai‘i, 400 on Maui, 1,500 on Kaua‘i, 80 on Moloka‘i, and a single nesting pair reported on O‘ahu in 2014. During 2005-2010, about 224 nēnē were removed from near the Kaua‘i Airport and released at remote relocation sites on that island to reduce the risk of bird-aircraft strikes. Since 2011, the continued growth of the Kaua‘i nēnē population prompted the removal of an additional 600 nēnē from the vicinity of the Kaua‘i Airport and which were released into the wild on Hawai‘i and Maui.

LOCATION AND CONDITION OF KEY HABITAT: Nēnē historically occurred in lowland dry forest, shrubland, grassland, and montane dry forest, and shrubland. Current habitat preferences are likely biased by the location of release sites of captive-bred birds. They currently use a wide variety of habitats including coastal dune vegetation and nonnative grasslands (e.g., golf courses, pastures, rural areas), sparsely vegetated low- and high-elevation lava flows, mid-elevation native and nonnative shrubland, early successional cinderfall, cinder deserts, native alpine grasslands and shrublands, and open native and nonnative alpine shrubland-woodland community interfaces. Nesting occurs in a variety of habitats, including beach strand, shrubland, grassland, and lava rock, and at a range of elevations. On the islands of Hawai‘i and Maui, most nests are built under native vegetation, such as pūkiawe (*Styphelia tameiameiae*), ‘a‘ali‘i (*Dondonaea viscose*), and ‘ōhi‘a (*Metrosideros polymorpha*). On Kaua‘i, however, most nesting areas are dominated by nonnative species, and nēnē often nest under Christmas berry (*Schinus terebinthifolius*), shrub verbena (*Lantana camara*), and ironwood (*Casuarina* spp.). The condition of habitats occupied by nēnē varies considerably. Many of the areas used by the species are managed for conservation by the State of Hawai‘i and the U.S. Fish and Wildlife Service (USFWS).

THREATS: Historical threats included habitat loss and degradation, hunting, and predation by rats (*Rattus* spp.), cats (*Felis silvestris*), dogs (*Canis familiaris*), and the small Indian mongoose (*Herpestes auropunctatus*). Current threats include predation by nonnative mammals; exposure to diseases that can be transmitted by introduced nonnative animals such as feral and domestic cats (e.g. toxoplasmosis); nutritional deficiencies due to paucity of quality habitat, exposure stress at high-elevation habitats; a lack of contiguous lowland habitat; human-caused disturbance and mortality (e.g., road mortality, disturbance by hikers, aircraft strikes, collisions with wind turbines); behavioral problems related to captive propagation; and inbreeding depression.

CONSERVATION ACTIONS: Past and current actions include captive propagation and release of captive-bred individuals into the wild, predator control, habitat enhancement, research and monitoring, private conservation efforts, formation of the Nēnē Recovery Action Group, and public education. Other actions specific to conservation of nēnē should include the following:

- Enhance and protect habitats used by nēnē, including foraging habitat, breeding grounds, and summer flocking areas.
- Increase predator control effort and effectiveness, including use of predator-proof fences. Increase efforts to detect and remove mongooses from Kaua‘i.

- Significantly increase efforts to minimize negative human-nēnē interactions through public education and outreach focused on communities or areas where the number of nēnē are known to be increasing; continue to promote avoidance and minimization measures that will reduce the risk of collisions with vehicles , aircraft, and wind turbines.
- Develop a statewide long-range management plan for nēnē that includes all of the distinct populations and anticipates changes resulting from management actions and human interaction.
- Continue the nēnē population reintroduction efforts and establish additional populations only where risks can be minimized and habitat quality can support recovery.

MONITORING: Continue surveys to monitor abundance and distribution and annual productivity.

RESEARCH PRIORITIES:

- Standardize survey and monitoring protocols and develop a platform for data sharing.
- Conduct studies on diet and nutrition, particularly as it relates to forage quality of nonnative versus native vegetation, focusing on the needs of goslings and breeding females.
- Refine predator control and exclusion methods.
- Evaluate movement patterns and habitat use by nēnē.
- Evaluate and refine translocation and release methods that incorporates monitoring subsequent dispersal and movement patterns, survival, and reproduction.
- Investigate population genetics as a management tool to monitor the potential for inbreeding.

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Photo: USFWS

Terrestrial Mammal

ʻŌpeʻapeʻa or Hawaiian hoary bat

Lasiurus cinereus semotus

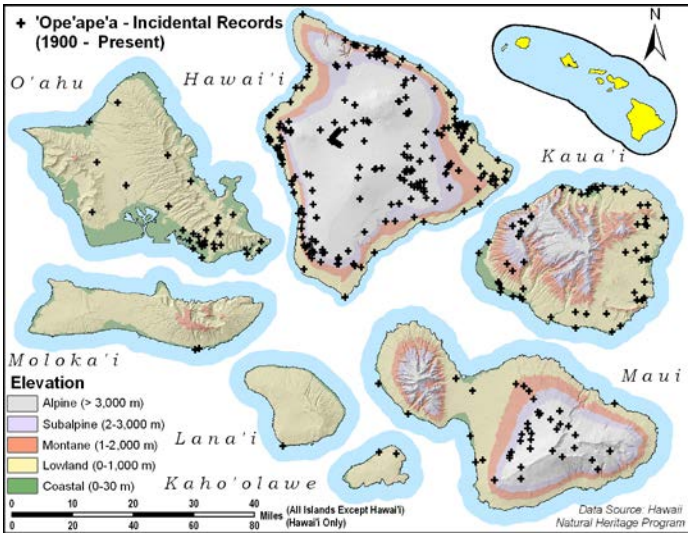
SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Indigenous (at the Species Level and Endemic at the Subspecies Level)
NatureServe Heritage Rank G5/T2 – Species Secure/Subspecies Imperiled
Recovery Plan for the Hawaiian Hoary Bat – USFWS 1998

SPECIES INFORMATION: The ʻōpeʻapeʻa, or Hawaiian hoary bat (Family: Vespertilionidae), is Hawaiʻi's only native terrestrial mammal, although sub-fossil evidence indicates that at least one other bat species was native to the islands. Additionally, the hoary bat has dispersed to the Hawaiian Islands from the mainland at least twice, forming two different populations of Hawaiian hoary bats (Russell et al. 2015). The first emigrant arrived approximately ten thousand years ago, and the more recent emigrant arrived an estimated 600 years ago (Russell et al. 2015). Both sexes have a coat of brown and gray fur. Individual hairs of the coat are tipped or frosted with white; hence the name "hoary" which means frosted. The older population of hoary bats on the Hawaiian Islands is typically chestnut brown in color with less white "frosting" of the fur tips—it has largely lost the "frosted" appearance. The more recent population comprises individuals that are more hoary ("frosted"), similar to mainland hoary bats. Males and females have a wingspan of approximately one-third of a meter (1 foot), and females are typically larger than males. The Hawaiian name refers to a half taro leaf or canoe sail shape; these being somewhat similar to the shape of the bat.

Little research has been done on the ʻōpeʻapeʻa, and little is known about its habitat requirements or population status. Fewer than 30 accounts of roosting are known statewide, but these indicate that ʻōpeʻapeʻa roost in native and non-native vegetation from 1 to 9 meters (3 – 29 feet) above ground level; the species is rarely observed using lava tubes, cracks in rocks, or human-made structures for roosting. While roosting during the day, ʻōpeʻapeʻa are solitary, although mothers and pups roost together. They begin foraging either just before or after sunset depending on the time of year; altitude also may affect activity patterns. ʻŌpeʻapeʻa feed on a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes, and termites; and similar to other insectivorous bats, prey is located using echolocation. Water courses and edges (e.g., coastlines and forest/pasture boundaries) appear to be important foraging areas; the species also is attracted to insects that congregate near lights. Breeding bats (e.g., lactating females) have been documented only on the islands of Hawaiʻi, Kauaʻi, and Oʻahu (Dave Johnston pers. obs.). Mating most likely occurs between September and December, and females usually give birth to twins during June. Mother bats likely stay

with their pups until they are six to seven weeks old. Little is known regarding dispersal or movements, but inter-island dispersal is possible.

DISTRIBUTION: The hoary bat is the most widely distributed bat in North America. In Hawai'i, 'ōpe'ape'a have been reported from all the Main Hawaiian Islands except for Ni'ihau, although specimen records exist only for Kaua'i, O'ahu, Maui, Moloka'i, and the island of Hawai'i. 'Ōpe'ape'a occur in a wide range of habitats across a wide elevation gradient. On the island of Hawai'i, bats are found primarily from sea level to 2,288 meters (7,500 feet) elevation, although they have been observed near the island's summits (above 3,963 meters or 13,000 feet). See "Location and Condition of Key Habitat," below, for distribution by seasons.



ABUNDANCE: Mostly unknown, although Pinzari et al. 2014 suggested that the population on the island of Hawai'i has been stable or is slightly increasing based on occupancy models from acoustic monitoring. Survey methods to count or estimate populations of solitary roosting bats have not been established. Although based on incomplete data, Kaua'i and the island of Hawai'i may support the largest populations.

LOCATION AND CONDITION OF KEY HABITAT: 'Ōpe'ape'a have been found roosting in 'ōhi'a (*Metrosideros polymorpha*), pu hala (*Pandanus tectorius*), coconut palms (*Cocos nucifera*), kukui (*Aleurites moluccana*), kiawe (*Proscopis pallida*), avocado (*Persea americana*), shower trees (*Cassie javanica*), pūkiawe (*Styphelia tameiameiae*), fern clumps, eucalyptus (*Eucalyptus* spp.), cook pine (*Araucaria columnaris*), and Norfolk Island pine (*Araucaria heterophylla*) stands. Recent work on the island of Hawai'i found that bat activity varied with season and altitude, and the greatest level of activity occurred at low elevations (below 1,280 meters or 4,200 feet) from April to December (Bonaccorso et al. 2015). Because warm temperatures are strongly associated with reproductive success in this and other bat species, it has been suggested that key breeding habitat is likely to occur at sites where the average July minimum temperature is above 11°C (52°F). If true, key breeding habitat on the island of Hawai'i would occur below 1,280 meters (4,200 feet) elevation (Bonaccorso et al. 2015). Because bats use both native and non-native habitat for foraging and roosting, the importance of non-native timber stands, particularly those at low elevations, should be determined. Breeding sites are known for Mānuka Natural Area Reserve and scattered areas along the Hāmākua Coast.

THREATS: Bats are affected by habitat loss, pesticides, collisions with structures, and roost disturbance. A reduction in tree cover (e.g., roost sites) might be the primary reason for the species' decline in Hawai'i. Pesticides also may have reduced populations. Bats are known to interact and sometimes collide with wind turbines. Lastly, bats of many species are affected by predation, so this may also be a problem for 'ōpe'ape'a.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations and key breeding habitats, but also to establish additional populations thereby reducing the risk of extinction (U.S. Fish and Wildlife Service 1998). In addition to common statewide and island conservation actions, specific management directed toward ʻōpeʻapeʻa should include the following:

- Conserve known occupied habitat.
- Develop and implement conservation plans and strategies that guide the management and use of forests to reduce negative effects on known bat populations.
- Support Hawaiian hoary bat research.

MONITORING: Continue surveys of population and distribution in known and likely habitats and identify key limiting factors affecting the recovery of the species.

RESEARCH PRIORITIES: Given that little is known about ʻōpeʻapeʻa any research would contribute to the understanding of and ability to conserve this species. Research priorities for the ʻōpeʻapeʻa include the following:

- Develop standard survey and monitoring methods and procedures that will allow the accurate estimation of populations and changes in activity and/or occupancy.
- Conduct occupancy surveys of all the Main Hawaiian Islands to examine distribution and population trends.
- Identify key breeding and wintering sites.
- Better describe roost site characteristics and preferences.
- Increase efforts to track and monitor movements and behaviors.
- Determine the extent to which Hawaiian hoary bats use torpor.
- Better describe threats and important factors limiting recovery such as whether depredation by introduced animals or availability of prey represent constraints for populations.
- Continue to support the development of avoidance and minimization measures that can be effectively implemented to reduce collisions with wind turbines.
- Direct research findings toward the development of conservation and management actions that address the needs and deficiencies of the species and refine these approaches using an adaptive management approach.

References:

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Appendix 6

Nēnē Population on
Kamehameha Schools Keauhou and Kīlauea Lands

Nēnē baseline survey methodology for Keauhou Safe Harbor Agreement

Timeline

Survey Dates: 17 October 2012 – 13 February 2013

Survey Schedule: Every Wednesday (total of 18 surveys)
(note: missing one Wednesday is ok as long as consecutive Wednesdays are not missed)

Monitoring

- Surveys will be conducted by a qualified biologist approved by DOFAW
- One or more personnel will conduct surveys and note any observations of nēnē, and nēnē signs (droppings, feathers, nests, nest attempts.)
- Observer will document any sightings, including location, date, time, nēnē sign, total number of nēnē seen, band combinations (or UNB for unbanded birds) and bird behavior (resting, feeding, loitering, or nesting behavior.)
- Nesting nēnē will not be approached closely except by those allowed by federal and state permit to do so.
- Nēnē nests that are found will be monitored on weekly survey visits to determine success of nests and hatching and fledgling number.
- One or two vantage points will be identified and early morning/late afternoon surveys from these strategic points will be conducted. This will increase the likelihood of observing nēnē flying between nest sites and feeding areas.

Search Area

- Previous nesting site on lower Keauhou near KBCC (Kathleen Misajon identified site)
- DOFAW nēnē sanctuary cabin site, reservoir and surrounding area.
- Original release site approximately 0.5 km east of cabin site
- Water hole near junction of power line road and NPS boundary
- Nēnē locations from Steve Hess telemetry study.

Nēnē Survey Results at Keauhou

Surveys were done for nēnē at the Keauhou I nēnē sanctuary, and surrounding Kamehameha Schools land, during the peak nēnē breeding season form October 2012 through January 2013. Once a week visits by 1-3 biologists and technicians were conducted primarily in the 8100 acre sanctuary.

The area around the DOFAW nēnē cabin predator exclosures and original nēnē release site (Map 1. 1-5) were searched each time for nēnē. Several seeps and kipukas along the Keaumoku lava flow (Map 1. 6) were searched for nēnē presence/signs but very little nēnē droppings were noted indicating only occasional visits during this time of year. On three occasions observers surveyed from the NPS boundary to one half mile east, from 7000 ft. elevation, to 5000 ft elevation. Dropping signs indicated consistent use of several grassy areas and lava rock outcroppings by small groups of nēnē (perhaps one pair).

On two occasions, one unbanded pair was seen just outside of the predator exclosure above the nēnē cabin (Map 1. 3). The area was thoroughly searched and no nest was found.

On one occasion, 2 pairs of nēnē were seen at the predator exclosure above the nēnē cabin (Map 1. 3). These were exhibiting pair behavior with one of each of the pairs being banded (bands unknown), thus believed to be different individuals than the previous unbanded pair.

On two occasions, there was a fly over, of the cabin site (Map 1. 1) by one pair of nēnē, (banding undetermined).

The reservoir at the power line road near the National Park boundary (Map 1. 7) was checked each visit, and is occasionally visited by nēnē consistent with droppings found at the site.

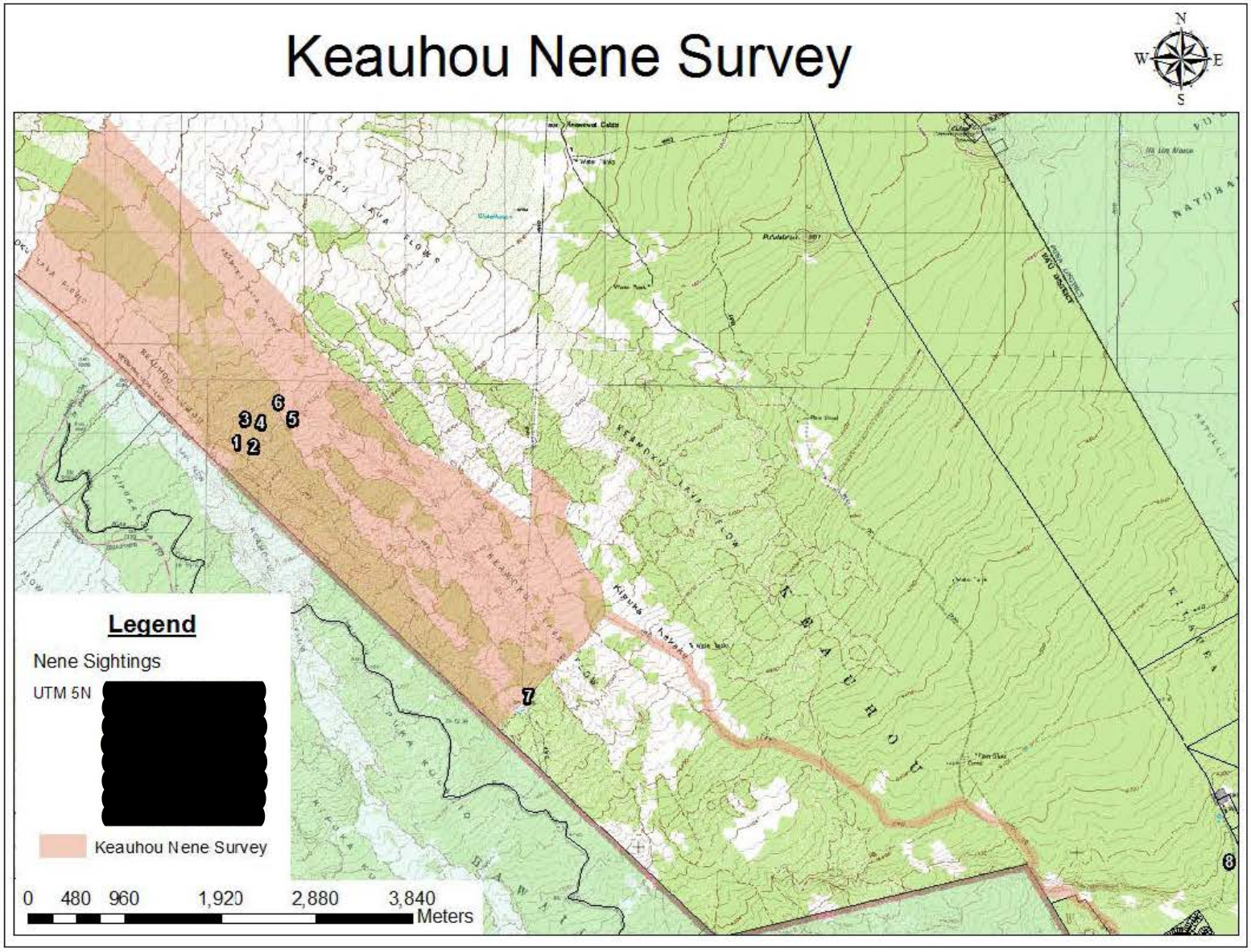
One unconfirmed report of a pair of nēnē from Three-Mountain Alliance personnel.

KBCC (Map 1. 8) was visited by NPS nēnē staff for nēnē. Since the beginning of 2012, twelve individual wild (some previously released) nēnē have been seen on the grounds at KBCC. Of these 12 individuals, 6 are documented (by NPS) breeding birds that return each year. Of the remaining 6, 4 are offspring of the aforementioned breeding pairs, so would have been introduced to the area during their first flocking season by their parents. Two of the 3 usual pairs nested at KBCC this season (the third skipped nesting altogether). One nest failed (suspect weather caused abandonment then predation based on circumstances). The second nest hatched three - the family was captured the following day and moved to Ainahou at HAVO. This strategy was worked out amongst biologists from HAVO, KBCC, DOFAW and FWS after a pair that had been captive reared (KBCC) and released (at HAVO) returned to nest at KBCC. The goal was to prevent the startup of a "wild" population amongst the buildings and parking lots of KBCC. This has been very successful in that the offspring that are moved shortly after hatching thus far have not returned to nest at KBCC and are indeed nesting in the park.

Location	# of Nēnē	Nests	Comments
.5 mile from NPS boundary, 7000 – 5000 ft	--	--	Droppings observed indicating consistent use of area
Predator exclosure 4	6	0	nēnē exhibited pair behavior but no nests were found
Reservoir at power line road near NPS boundary	--	--	Droppings indicated occasional visits by nēnē
TMA unconfirmed observation	2		Possible resighting
KBCC	12	2	1 nest produced 3 goslings that were subsequently moved to Ainahou at HAVO
Total	**18 - 20**	**2**	

The number of nēnē observed during this survey is about 18 or 20 individual and 2 breeding pairs.

For the purposes of the Kamehameha Schools Safe Harbor Agreement baseline for nēnē are 0 breeding pairs. DOFAW recommends management of nēnē at and around the nēnē cabin site. Management recommendations include monitoring nēnē, predator control around any nest sites, and maintaining short grass habitat in approximately 10 – 25 acres of habitat around the nēnē cabin site.



Map 1. Nēnē survey results. Locations of nēnē indicated by number.

Nene Survey Results at Kamehameha Schools Lease Lands (Volcano, HI)

Nene (*Branta sandvicensis*) activity and nesting surveys were conducted weekly during the peak nene nesting season, October thru February, however not all leased properties were surveyed throughout the entire season. One to four wildlife biologists and technicians conducted walking surveys between the hours of 0900hrs to 1530hrs as to increase the probability of detecting nesting nene.

Ohi'a Ranch was surveyed weekly from October 2, 2014 until February 26, 2015, with a total of 17 survey days (5 occasions were cancelled). The approximately 1,129 acre ranch is just east of the Volcano Golf Course, which has a population of nene throughout the year. Kevin McIver, the Leasee, stated that although he sees nene in the ranch most of the year, he has never seen them nesting.

During the first survey, seven nene in two different locations were spotted; five were located at or near the central water reservoir (Figure 1, 1+4), while two others were located in a separate paddock 660 m NE of the larger group (Figure 1, 2). This pair exhibited some nesting behavior and was found a week later near the same area (figure 1, 3), however they were not seen again during the survey. These locations became the baseline locations that were visited each time, with the rest of the ranch being surveyed opportunistically throughout the nesting season.

Nene were detected at varying degrees from October through December (Table 1), with the most nene (20 individuals) seen on October 16. From January through February, no nene were detected by DOFAW within the ranch, although McIver had seen a small number of nene during those weeks.

4 Boy's Ranch is located north of the Ohi'a Ranch on Mahi'ai Road in Volcano Village. The 925 acre ranch was surveyed three times in February. Contact information with the Leasee, Mr. Iranon, was not given until December 9, however Initial contact with Mr. Iranon was not made until February 3. Mr. Iranon stated that he has never seen nene in the ranch, but had seen ducks using his reservoirs in previous years. Due to a limited amount of time to conduct the survey, the surveys were conducted by walking the fenceline roads and cutting into specific clearings and watering holes that seemed likely areas nene would be found. No nene or signs of nene using the ranch (feathers, droppings, foot prints) were detected during these surveys.

Volcano Winery is located at the end of Pi'imauna Drive in the Volcano Golf Course Subdivision. The 70 acre grape and tea farm receives visits by nene on a regular basis but are usually absent during nesting season. The winery grounds were visited 10 times from December 11 through February 26, and at each occasion the planting grounds were walked. No nene were detected during the surveys, however employees at the winery had sometimes seen nene during that week. There were no signs of nene nesting in the area during our survey.

Date	Indiv. Found	Nests	Locations Visited		
			Ohi'a Ranch	4 Boy's Ranch	Volcano Winery
10/2/2014	7	0	x		
10/9/2014	2	0	x		
10/16/2014	20	0	x		
10/22/2014	11	0	x		
10/31/2014	2	0	x		
11/13/2014	0	0	x		
11/26/2014	1	0	x		
12/11/2014	0	0	x	x	
12/17/2014	9	0	x	x	
1/2/2015	0	0	x	x	
1/8/2015	0	0	x	x	
1/15/2015	0	0	x	x	
1/22/2015	0	0	x	x	
1/29/2015	0	0	x	x	
2/5/2015	0	0	x	x	x
2/12/2015	0	0	x	x	x
2/26/2015	0	0	x	x	x

Table 1. Nene were surveyed during the peak nesting season. Not all locations were surveyed throughout the entire season.

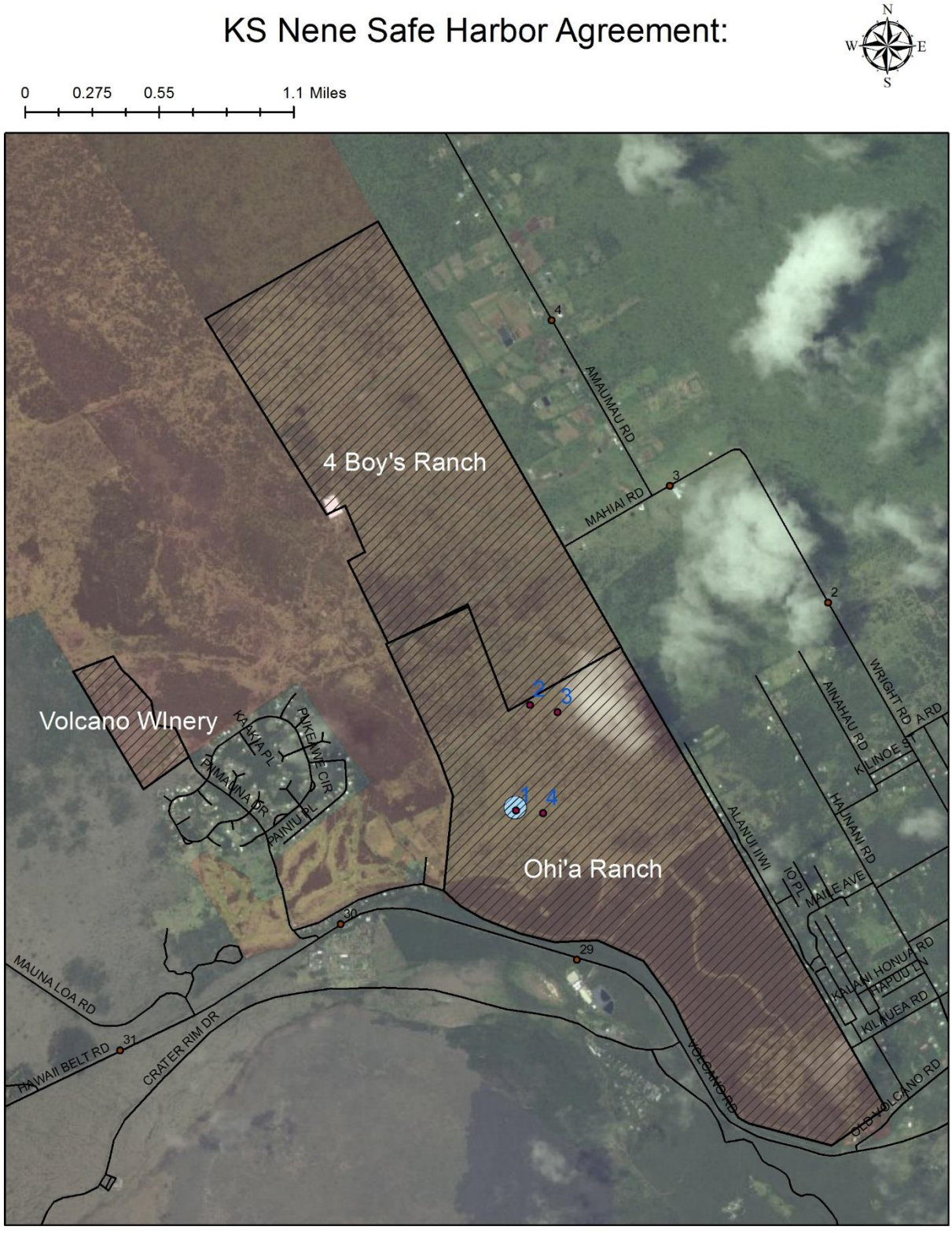


Figure 1. Nene surveys were conducted in three different leaseholds. Nene were only seen in the Ohi'a Ranch leasehold.

Appendix 7

Protocol for Handling Downed or Injured Wildlife

DOWNED WILDLIFE PROTOCOL

STANDARD PROTOCOL FOR State of Hawai'i INCIDENTAL TAKE LICENSE AND U.S. Fish and Wildlife Service INCIDENTAL TAKE PERMIT HOLDERS RESPONDING TO DEAD OR INJURED WILDIFE INCLUDING THREATENED AND ENDANGERED SPECIES AND MBTA SPECIES

Do not move wildlife unless in imminent danger.
During business hours, call DOFAW immediately for your island.

Island	Primary Contact	After business hours/weekends
Maui	(808) 984 – 8100 (808) 268 – 5087, (808) 280 – 4114	(808) 264 – 0922 (808) 280 – 4114
Molokai	(808) 553 – 1745, (808) 870 – 7598	(808) 870 – 7598
Lanai	(808) 565 – 7916, (808) 357 – 5090	(808) 357 – 5090
East Hawai'i	(808) 974 – 4221, (808) 974 – 4229	(808) 640 – 3829
West Hawai'i	(808) 887 – 6063	(808) 339 – 0983
O'ahu	(808) 973 – 9786, (808) 295 – 5896	(808) 295 – 5896, (808) 226 – 6050
Kaua'i	(808) 274 – 3433 (808) 632 – 0610, (808) 635 – 5117 [Secondary: (808) 348 – 5835 for Hokuala (Kauai Lagoons) HCP and Kauai Nene HCP; (808) 212 – 5551 for Kauai Seabirds HCP and KIUC Short-term HCP]	(808) 645 – 1576, (808) 635 – 5117

Fill out information on the downed wildlife form.

OVERVIEW

The islands of Hawai'i contain numerous native and endemic species of wildlife that are protected by strict state and federal laws. This protocol is geared towards downed (injured or deceased) wildlife and focused on the endangered Hawaiian hoary bat and avian species protected by the Endangered Species and Migratory Bird Treaty Species Acts. The likelihood of encountering injured or dead wildlife that are protected by state and federal endangered species laws should be considered equal to encountering non-listed species. Therefore, all downed wildlife should be treated with the same safeguards and care to ensure adequate response and documentation according to the following set of guidelines.

DOWNED WILDLIFE PROTOCOL

Always be prepared for discovery of downed birds and bats. Please ensure that all staff and personnel are trained in the following protocol, and that contact information, written protocols, and supplies are ready for response.

The first response for downed birds and bats is to call the local Hawai'i Division of Forestry and Wildlife (DOFAW) Office. DOFAW staff is generally able to respond by sending someone to the scene to retrieve the injured or deceased wildlife. In the event that DOFAW personnel are not able to respond right away, they may instruct those reporting the incident to provide necessary response. Please follow their directions carefully.

If DOFAW staff cannot be contacted, or if the downed animal is in imminent danger, you should be prepared to handle the animal yourself, following the protocol below, and transport them to DOFAW or a permitted wildlife rehabilitator. Again, you should only handle injured wildlife if DOFAW staff cannot be contacted or if the animal is in imminent danger.

PREPARING TO RESPOND FOR DOWNED OR INJURED BIRDS AND BATS

In all cases, ensure that all field staff is trained in the response protocol for injured birds and bats. Ensure they have read and understand the protocol, and have the protocol posted (including highlighted contact information) in a prominent location. Make sure that all staff know who to contact, and where supplies for handling injured wildlife are located. Staff should be regularly briefed on protocols, especially at the beginning of each distinct season that might correspond with a heightened likelihood of encountering downed wildlife.

At a minimum, for vehicles or foot patrols where maintaining a wildlife response kit (carrier) may be impractical, keep a copy of the protocol handy and accessible along with a large clean towel, soft cloth such as a t-shirt or flannel, several flags or tent stakes, and a pair of gloves, all of which are to be specifically designated for use in injured wildlife response.

For facilities and dedicated vehicles, please prepare and maintain one or more carriers designated for handling and transporting injured wildlife. This response kit should contain a large clean towel; soft cloth such as a t-shirt or flannel; several flags or tent stakes; several pairs of gloves (plastic/latex disposable gloves and also heavy duty gloves such as leather or heavy rubber that can be sanitized); eye protection; a ventilated cardboard box, pet carrier or other non-airtight container; and a copy of the protocol. For larger facilities (managed areas such as wildlife refuges, preserves, wetlands, or conservation areas), or areas where downed birds and bats are likely, please maintain several containers of various sizes. The container must provide enough room for the animal to comfortably move around, but also be sturdy enough to hold active birds or bats.

For small birds or bats, cardboard pet carriers or 'living world' plastic carriers work well as they have many ventilation holes and handles for easy carrying. Waxed pet carriers are preferred because they are sturdier, hold up longer, and can be thoroughly cleaned between uses. Sturdy cardboard boxes with holes punched in them to allow cross ventilation are also good. For birds, holes no wider than one inch in diameter should be punched on all four sides of the box. For bats, holes must be no larger than one-half inch diameter. A minimum of eight holes per side is sufficient. The carrier should be padded inside, well-ventilated and covered (to provide a sense of security).

DOWNED WILDLIFE PROTOCOL

Plastic dog kennels are recommended for handling larger birds, such as petrels, shearwaters, owls, hawks, ducks, stilts and geese. All cages must have towels or rags placed in the bottom to help prevent slipping and protect bird feet and keels. The towel or other cushioning material should be sufficient to cover the bottom of the container effectively

Cardboard boxes that are used for transporting injured wildlife should only be used once then discarded to avoid cross-contamination and/or disease or pathogen transfer. If plastic kennels or waxed pet carriers are used, be sure that they are adequately cleaned or sterilized between uses. Never put two animals in the same container.

Always wear personal protective equipment when handling downed wildlife. Disease and contamination exposure can work in both directions (bird or bat to person, and vice versa); always use protection against direct contact. If it becomes necessary to handle a bird, always wear disposable gloves. If multiple animals are being handled ensure that a new pair of gloves is used between each bird.

IF YOU FIND A LISTED DECEASED BIRD OR BAT:

All listed (MBTA and T&E species) wildlife found deceased must be reported ASAP upon detection to DOFAW and USFWS.

1. Mark the location with a flag or tent stake. Record the time and location of the observation including the animal species and its condition, photo documentation and call DOFAW immediately. Contact information is in prioritized order; if you don't reach the first person on the list, please call the next. If possible, have someone stay with the animal while someone else calls.

Island	Primary Contact	After business hours/weekends
Maui	(808) 984 – 8100 (808) 268 – 5087, (808) 280 – 4114	(808) 264 – 0922 (808) 280 – 4114
Molokai	(808) 553 – 1745, (808) 870 – 7598	(808) 870 – 7598
Lanai	(808) 565 – 7916, (808) 357 – 5090	(808) 357 – 5090
East Hawai'i	(808) 974 – 4221, (808) 974 – 4229	(808) 640 – 3829
West Hawai'i	(808) 887 – 6063	(808) 339 – 0983
O'ahu	(808) 973 – 9786, (808) 295 – 5896	(808) 295 – 5896, (808) 226 – 6050
Kaua'i	(808) 274 – 3433 (808) 632 – 0610, (808) 635 – 5117 [Secondary: (808) 348 – 5835 for Hokuala (Kauai Lagoons) HCP and Kauai Nene HCP; (808) 212 – 5551 for Kauai Seabirds HCP and KIUC Short-term HCP]	(808) 645 – 1576, (808) 635 – 5117

NOTE: For remote sites with spotty coverage, ground staff may need to have a planned communication system with radios, or a cell carrier known to provide adequate coverage, that will allow communication with a designated contact able to relay information to DOFAW at the appropriate numbers listed in the above table.

DOWNED WILDLIFE PROTOCOL

2. If necessary place a cover over the wildlife carcass or pieces of carcass *in-situ* (a box or other protecting item) to prevent wind, or scavenger access from affecting its (their) position(s).

3. **Do not** move or collect the wildlife unless directed to do so by DOFAW.

4. ITL and ITP holders should notify DOFAW and the USFWS as to the estimated time of death and condition of the carcass, since fresh carcasses suitable for necropsy may be handled and transported differently than older ones.

5. Downed wildlife should remain in its original position and configuration. Usually DOFAW staff will have you leave the animal in place while they come and get the animal, but dependent on the situation they may provide other instructions. Please follow their directions carefully.

1. Fill out a Downed Wildlife Form (attached). Make written notes concerning the location including GPS points, circumstances surrounding the incident, condition of the animal, and what action you and others took. This information should be reported to the appropriate official(s), including DOFAW and USFWS HCP staff, within 3 days. For DOFAW send to the following email address: dofaw.hcp@hawaii.gov.

IF YOU FIND A LISTED INJURED BIRD OR BAT WHICH IS NOT IN IMMINENT DANGER:

1. Do not put yourself in danger. Always wear personal protective equipment and clothing, including gloves and eye protection, to protect yourself when handling injured wildlife.

2. Mark the location with a flag or tent stake. Record the time and location of the observation including the animal species and its condition, and call DOFAW immediately. Contact information is in prioritized order; if you don't reach the first person on the list, please call the next. If possible, have someone stay with the animal while someone else calls.

Island	Primary Contact	After business hours/weekends
Maui	(808) 984 – 8100 (808) 268 – 5087, (808) 280 – 4114	(808) 264 – 0922 (808) 280 – 4114
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DOWNED WILDLIFE PROTOCOL

3. Usually DOFAW staff will have you leave the animal in place while they come and get the animal, but dependent on the situation they may provide other instructions. Please follow their directions carefully.

4. While waiting for DOFAW staff to arrive, minimize noise and movement in the area around the wildlife. Watch the animal so that its location is not lost if it moves away. If possible, keep sources of additional harassment or harm, such as pets, vehicles, and loud noises, away from the animal. Note any changes in the condition of the animal.

2. 5. Fill out a Downed Wildlife Form (attached). Make written notes concerning the location including GPS points, circumstances surrounding the incident, condition of the animal, photo documentation and what action you and others took. This information should be reported to the appropriate official(s) including DOFAW and USFWS HCP staff within 3 days. For DOFAW send to the following email address: dofaw.hcp@hawaii.gov.

Do not attempt to release the bird or bat yourself. Do not move injured wildlife unless explicitly instructed by DOFAW. DOFAW will need to document circumstances associated with the incident. The animal may also have internal injuries or be too tired or weak to survive. Never throw the bird or bat into the air as this could cause more injury or result in death. Let trained staff or veterinary personnel familiar with wildlife rehabilitation and care examine the animal and decide when, where, and how to proceed.

IF YOU FIND A LISTED INJURED BIRD OR BAT WHICH IS IN IMMINENT DANGER:

3. Do not put yourself in danger. Always wear personal protective equipment and clothing, including gloves and eye protection, to protect yourself when handling injured wildlife.

4. Attempt to contact DOFAW as soon as possible, in all circumstances.

Island	Primary Contact	After business hours/weekends
Maui	(808) 984 – 8100 (808) 268 – 5087, (808) 280 – 4114	(808) 264 – 0922 (808) 280 – 4114
Molokai	(808) 553 – 1745, (808) 870 – 7598	(808) 870 – 7598
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Kaua‘i	(808) 274 – 3433 (808) 632 – 0610, (808) 635 – 5117 [Secondary: (808) 348 – 5835 for Hokuala (Kauai Lagoons) HCP and Kauai Nene HCP; (808) 212 – 5551 for Kauai Seabirds HCP and KIUC Short-term HCP]	(808) 645 – 1576, (808) 635 – 5117

If the animal is in imminent danger and you are able to protect it from further harm, mark the location where it was found with a flag or tent stake.

DOWNED WILDLIFE PROTOCOL

5. Pick up the bird or bat as safely as possible. Always bear in mind your safety first, and then the injured animal. If picking up a bird, approach and pick up the bird from behind as soon as possible, using a towel or t- shirt, or cloth by gently wrapping it around its back and wings. Gently covering the head (like a tent) and keeping voices down will help the animal remain calm and greatly reduce stress. If picking up a bat, use only a soft light-weight cloth such as a t-shirt or towel (toes can get caught in towel terry loops). Place the cloth completely over the bat and gather up the bat in both hands. You can also use a kitty litter scooper (never used in a litter box before) to gently "scoop" up the bat into a container.

6. Record the date, time, location, condition of the animal, and circumstances concerning the incident as precisely as possible. Place the bird or bat in a ventilated box (as described above) for transport. Never put two animals in the same container. Provide the animal with a calm, quiet environment, but do not keep the animal any longer than is necessary. It is critical to safely transport it to a wildlife official or veterinary professional trained to treat wildlife as soon as possible. While coordinating transport to a facility, keep the injured animal secure in the rescue container in a warm, dark, quiet place. Darkness has a calming effect on birds, and low noise levels are particularly important to help the animal remain calm. Extra care should be taken to keep wildlife away from children and pets.

5. Transportation of the animal to DOFAW per coordination with DOFAW staff may be required as soon as possible.

7. Fill out a Downed Wildlife Form (attached) and report to the appropriate official(s) including DOFAW and USFWS HCP staff within 3 days. For DOFAW send to the following email address: dofaw.hcp@hawaii.gov.

6. If you must keep the bird or bat overnight, keep it in a ventilated box with a secure lid. Please keep the animal in a quiet, dark area and do not attempt to feed, handle, or release it. Continue to try to contact DOFAW staff and veterinary care facilities.

Never put birds or bats near your face. When handing a bird or bat to someone else, make sure that the head, neck, and wings are secure and in control first to avoid serious injury to handlers and to minimize injury to the animal. Never allow an alert bird with injuries to move its head freely while being handled – many birds will target eyes and can cause serious injury if not handled properly. Communicate with the person you are working with.

Never feed an injured bird or bat. The dietary needs of most species are more delicately balanced than many people realize. Most injured animals are suffering from dehydration, and attempting to feed or water the animal may kill it, as it is probably not yet able to digest solid food or even plain water. Often, when an injured animal arrives at a veterinary or rehabilitation facility, it is given a special fluid therapy for several days before attempts to feed the animal begin.

Handle wild birds and bats only if it is absolutely necessary. The less contact you have with the animal, the more likely it will survive.

DOWNED WILDLIFE FORM
LISTED SPECIES

Please be as descriptive as possible. Complete and accurate information is important.

Observer Name:	
Date of Incident:	
Date of report:	
Species (common name):	
Age (Adult/Juv), if known:	
Sex (if known):	
Incidental or Routine Search:	
Time Observed (HST):	
Time Initially Reported (HST):	
Time Responders Arrive (HST):	
General Location:	
GPS Coordinates (specify units and datum):	
Date Last Surveyed:	
Closest structure (e.g. Turbine #):	
Distance to Base of closest structure and/or nearest WTG:	
Bearing from Base of closest structure and/or nearest WTG:	
Ground Cover Type:	
Wind Direction and Speed (mph):	
Cloud Cover (%):	
Cloud Deck (magl):	
Precipitation:	
Temperature (^{o}F):	

Condition of Specimen [include a description of the animal's general condition, as well as any visible injuries, be specific (e.g., large cut on right wing tip.)]:
Probable Cause of Injuries and Supportive Evidence [attach photos and map] Be descriptive, e.g.,'teeth marks visible on upper back,' or 'found adjacent to tire marks in mud.':
Action Taken (include names, dates, and times):

Additional Comments:

IF YOU FIND DOWNED NON-LISTED WILDLIFE:

1. Do not put yourself in danger. Always wear personal protective equipment and clothing, including gloves and eye protection, to protect yourself when handling wildlife.

2. Fill out a Downed Wildlife Form for Non-listed Species (below). Make written notes concerning the location including GPS points, circumstances surrounding the incident, condition of the animal, photo documentation (if possible) and what action you and others took. This information should be reported to the appropriate official(s) including DOFAW HCP staff.

3. If you find an animal in imminent danger, following protocols above for listed species is recommended.

DOWNED WILDLIFE FORM
NON-LISTED SPECIES

Please be as descriptive as possible. Complete and accurate information is important.

Observer Name:	
Date of Incident:	
Species (common name):	
Age (Adult/Juv), if known:	
Sex (if known):	
Incidental or Routine Search:	
Time Observed (HST):	
General Location:	
GPS Coordinates (specify units and datum):	
Closest structure (e.g. Turbine #):	
Distance to Base of closest structure and/or nearest WTG:	
Bearing from Base of closest structure and/or nearest WTG:	
Condition of specimen:	
Probable Cause of Injuries and Supportive	
Action Taken:	
Additional Comments:	

Appendix 8

Reporting Template

Annual Reporting Format

The Permittee, with the assistance of the Service and/or DLNR, will prepare a report every year and will submit the report to the Parties by August 21st of each year the Agreement is in effect. Reports will include the following information:

1) Description of the methods used and results from the predator control program for ungulates, feral cats and dogs, rats, mongoose, etc.;

2) Description of rehabilitation and vegetation management activities (e.g., methods used to out plant rare and native plants and timing of the activities);

3) Description of weed monitoring and control (e.g., methods used to control weeds and and timing of the activities);

4) Description of fence construction and management activities (e.g. location of new fences, repairs, and replacement of barbed wire);

5) Description of any fire management activities and incidents of fire on the property;

6) Description of methods and results of the biological monitoring of covered species on the property and how it relates to baseline conditions;

7) Identification of the number of and description of circumstances involving any injury, mortality and incidental take of covered species; and

8) Description of adaptive management measures implemented in response to ongoing activities that were deemed by the Parties to be ineffective for the covered species or in response to new circumstances not anticipated following signing of this Agreement.

9) Silvicultural activities including plantings and harvest.

Appendix 9

Inventory/Monitoring Protocols

Nēnē

Planned Timeline

Survey Dates: October - March

- Survey Schedule by DOFAW: Planned once per month. If a nest is found, predator control around the nest site will be initiated and monitoring frequency will increase to once a week at the known nest sites.

Monitoring

- Surveys to be conducted by DOFAW
- One or more personnel will conduct surveys and note any observations of nēnē, and nēnē signs (droppings, feathers, nests, nest attempts.)
- Observer will document any sightings, including location, date, time, nēnē sign, total number of nēnē seen, band combinations (or UNB for unbanded birds) and bird behavior (resting, feeding, loitering, or nesting behavior.)
- Nesting nēnē will not be approached closely except by those allowed by federal and state permit to do so.
- Nēnē nests that are found will be monitored on weekly survey visits to determine success of nests and hatching and fledgling number.
- One or two vantage points will be identified and early morning/late afternoon surveys from these strategic points will be conducted. This will increase the likelihood of observing nēnē flying between nest sites and feeding areas.

Search Area

- Previous nesting site on lower Keauhou near KBCC
- DOFAW nēnē sanctuary cabin site, reservoir and surrounding area.
- Original release site approximately 0.5 km east of cabin site
- Water hole near junction of power line road and NPS boundary
- Nēnē locations from previous telemetry study.

Additional requirements for Nēnē surveys are included in Section 8.3 of the SHA.

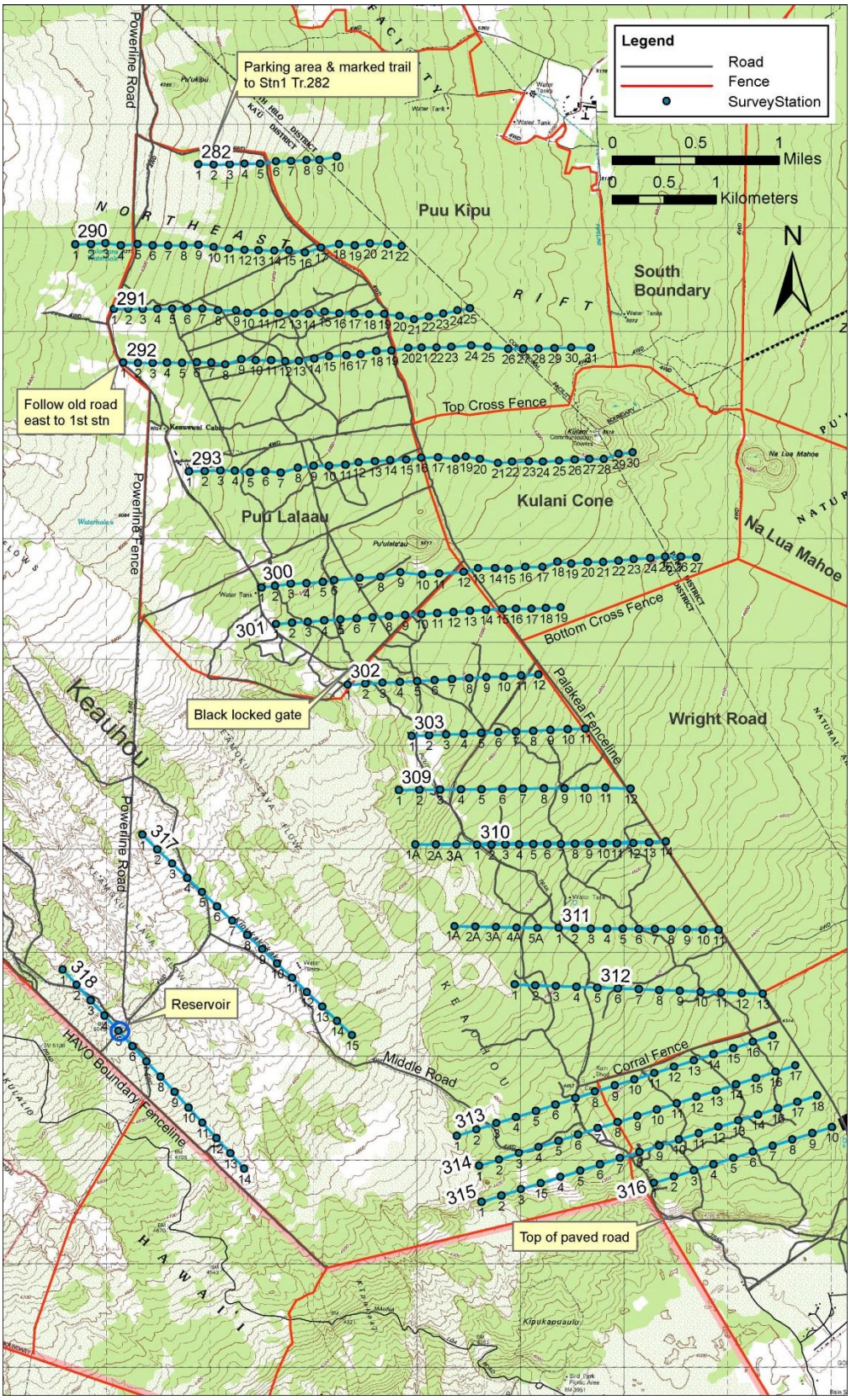
Endangered Forest Birds

Kamehameha Schools has allowed surveys of forest birds on their property since the 1960s and have worked cooperatively with the USGS and other partners since 1990 to conduct annual bird surveys on the Enrolled Property. Surveys are conducted as point-transect sampling for all forest birds species. Historically, these surveys are conducted in February and have been a multi-partner effort and have relied on many volunteer hours. In the event that government agencies are not able to conduct the surveys and monitoring, KS will be responsible for completing the surveys and monitoring at a minimum of every 5 years.

The method that has been used previously and that will be continued requires surveyors walk along set transects (See Map 1) and stop at each station, which are approximately 150 meters apart. During 8-min counts, observers record the horizontal distance from the station center point to individual birds detected and the detection type (heard, seen, or both). Birds only flying over or through the survey should be excluded. Observers also record the sampling conditions (i.e., cloud cover, rain, wind, gust, and time of day) at each station. Sampling should be conducted between 06:00 and 12:00 hr and halted when rain, wind, or gust exceeded pre-specified levels.

Under the SHA, annual surveys are planned that will include 7 transects (Transects 282-301) situated in Stratum 1. On this schedule every 5 years, a total of 19 transects (including the addition of 302-318) will be surveyed for forest birds outside Stratum 1 to ascertain the presence of the three endangered forest bird species in the lower silviculture areas. Additional requirements for forest bird surveys are included in Section 8.1 of the SHA.

A summary report will be provided each year forest bird surveys are conducted to include a map of detections and percent and number of detections for each covered forest bird species. Additional measures may be instituted if it is determined that covered species presence is declining after review from the Endangered Species Recovery Committee (ESRC).



Map 1. Forest bird transects

Hawaiian Hoary Bat

To determine presence of bats the USGS collected 5 years of baseline data on Keauhou since 2008. Two elevations were surveyed using acoustic monitors. Low-elevation transects ranged from 4,000 – 4,400 meters and high elevation transects ranged from 6,000 – 6,250 meters. Survey results showed evidence of a stable bat population on KS lands (see Appendix 3).

Monitoring under the SHA for the Hawaiian Hoary Bat will be conducted by the agencies or associated cooperating parties and agreeable to KS. The procedure will consist of acoustic monitoring every 5 years. Acoustic monitors will be deployed at both high and low elevation sites to be consistent with the USGS study. Monitors will remain in place for 2 months at both elevation sites. Data collected will be compared to the USGS baseline survey results from the same time period. Low variability in the USGS report was observed in July and September therefore efforts to monitor during those time periods will be attempted. If results from the 2 months survey efforts indicate that mean bat detections are below the lowest mean bar from the USGS baseline survey results, further monitoring will be conducted to assess if a change in population is present. Further monitoring will be discussed with the agencies and agreed upon by all parties to the Agreement. Additional requirements for bat surveys are included in Section 8.2 of the SHA.

‘Io

Monitoring surveys specific for ‘Io are planned every 5 years. Monitoring will be conducted by the agencies or associated cooperating parties and agreeable to KS. Surveys will be variable circular plot (VCP) count methodology. Each station will be sampled using playback recordings of adult and fledgling `Io. Playbacks will be conducted for 1 minute during the first, fourth, and eighth minute of a 10 minute sampling period.

Surveys will be conducted between 0900 and 1700 hours by trained observers. Age (based on juvenile, sub-adult, or adult plumage characteristics), sex (based on relative body size), detection type (auditory, visual, or both), and distance to birds detected will be recorded. Additionally, weather conditions will be recorded and sampling pauses due to weather conditions will be noted (i.e., wind and gust >20 km/hr; moderate to heavy rain). The percentage of observer’s view obstructed by vegetation, landscape, or man-made structures shall also be recorded. The responsiveness (i.e., “responded;” “did not respond;” “not recorded”) of hawks to playback calls will be recorded during the survey. Additional requirements for ‘Io surveys are included in Section 8.2 of the SHA.

Endangered Plant Species

Surveys for threated or endangered plants will follow protocols established or approved by the PEPP program. Surveys for threated or endangered plants will be conducted by biologists knowledgeable of the habitat and characteristics of the species. Surveys for the three "special-concern" plant species (*Cyanea stictophylla, Phyllostegia racemosa, and Vicia menziesii*) will be conducted by biologists with experience surveying for these three species, or similar species.

The monitoring frequency of the endangered plant species has been broken down in a 4-tier system based on a priority regime determined by botanists from the Plant Extinction Prevention Program (PEPP). Plant surveys for PEPP species will be conducted by PEPP; other species will be surveyed by the agencies or associated cooperating parties and agreeable to KS. In the event that these organizations are not able to conduct the plant surveys/monitoring, KS will be responsible for completing them at a minimum frequency of once every five years.

PEPP's mandate is to protect the rarest native plants in Hawaii from extinction. PEPP focuses on species with fewer than 50 remaining known plants in the wild. The priorities and tiers in this Agreement are based on the sensitivity, current population range, and status of the species. Below are the defined tiers and monitoring frequencies.

Tier	Description	Monitoring Frequency
1	PEPP species founders and any natural regeneration	Annual
2	Non-PEPP T&E founders and any natural regeneration	Once every 2 years or prior to specific projects or activities outlined in the HCP
3	All outplants and other T&E plants	Once every 5 years or prior to specific projects or activities outlined in the HCP

Species	Tier		Monitoring Comments/Effort
	Founder	Outplants	
Asplenium peruvianum var. *insulare*	2	5	Monitoring of clumps, estimated survey effort: ~2-3 weeks with 2-4 people
Clermontia lindseyana, ʻŌhā wai	2	5	Estimated survey effort: ~2 days
Cyanea shipmanii, Hāhā*	3	3	Estimated survey effort: ~2 weeks with 2 people (concurrent with other PEPP species)
Cyanea stictophylla, Hāhā*	3	3	Estimated survey effort: ~2 weeks with 2 people (concurrent with other PEPP species)
Phyllostegia racemosa, Kīponapona	3	3	Estimated survey effort: ~2 weeks with 2 people (concurrent with PEPP species)
Phyllostegia velutina	2	5	Populations move around and are not

Species	Tier		Monitoring Comments/Effort
	Founder	Outplants	
			long-lived, estimated survey effort: ~2 days
*Plantago hawaiensis**	1	3	Estimated survey effort: ~2 days people (concurrent with other PEPP species)
*Vicia menziesii**	1	3	Estimated survey effort: ~2-3 weeks people (concurrent with other PEPP species)
Other T&E plants	3	Various	Estimated survey effort: ~2-3 weeks

* PEPP species

It is likely that the first year of monitoring under this Agreement will be more time consuming as methodology, locations, and protocols may need to be further refined. Refinements will be included in the first annual report and subsequent years of monitoring should be less challenging as protocols become more developed.

Additional requirements for plant surveys are included in Section 8.4 of the SHA.

Appendix 10

Avoidance and Minimization Measures

Avoidance and Minimization Measures for Covered Activities

Covered Activity	Section	Specific Avoidance/Minimization Measures
Removal of Predators	6.1.1	No specific measures required
Restoration Outplanting	6.1.2	•All personnel working on forest restoration will receive training on the tasks they are performing and on avoiding impacts to Covered Species prior to starting work, or be directly overseen by an individual so-trained during field work. •Buffer distances of a minimum of 50 ft will be established where no disturbance will occur around known individual founder plants of Covered Species. •No work will occur around known nests of birds during the breeding seasons (Table 6).
Koa Silviculture	6.1.3	•Stand improvement activities (selective thinning) or harvest that will occur in young koa stands (trees smaller than a 65 cm dbh), will take place outside sensitive breeding seasons (Table 7). •Buffer distances of a minimum of 50 ft will be established where no disturbance will occur around known individual founder plants of Covered Species. •No more than two live standing old growth ʻōhiʻa and koa trees > 10 m in height and > 65 cm dbh will be cut every 10 years in the Forest Bird Stratum 1.
Fences and Ungulate Control	6.1.4	•Since Hawaiian Hoary Bats are known to be killed by barbed wire, barbed wire above grass level will not be used on any new management fences. •Remaining barbed wire will be replaced on adjacent ranch lands as leases are renewed by KS. Additionally, any barbed wire from remnant ranch fencing which remains exposed above grass will be removed by KS. •New and replacement fence routes will be planned to follow natural topographical features when possible and planned to avoid Covered Species of plants. Tree/shrub removal will be restricted as described in Table 7.
Weed Control	6.1.5	•All personnel working on weed control will receive training on the tasks they are performing and on avoiding impacts to Covered Species prior to starting work, or be directly overseen by an individual so-trained during field work. •Buffer distances of a minimum of 50 ft will be established where no disturbance will occur around known individual founder plants of Covered Species. •No work will occur around known nests of birds during the breeding seasons (Table 6). •Inside Forest Bird Stratum 1 no chemical herbicides (or chainsaws) will be used on trees with known nests of Covered Species or within 50 feet of known nest trees during the breeding season. •Inside and outside Stratum 1, no chemical herbicides or chainsaws will be used within 50 feet of known Nēnē or ʻIo nests during their breeding seasons. •Low-impact weed suppression such as herbicide spraying with a backpack may occur year-round on the Enrolled Property provided that 50 foot buffers are established near known nests of Covered Species.
Fire Threat Management	6.1.6	• Except in the situation of suppression of an active fire, tree/shrub cutting restrictions shown in Table 7 will be followed.
Response to Rapid ʻŌhiʻa Death	6.1.7	•Unless otherwise directed by the Service and DOFAW in writing, all tree/shrub cutting restrictions as shown in Table 7. •All personnel working will receive training on the tasks they are performing and on avoiding impacts to Covered Species (animal and plant) prior to starting work, or be directly overseen by an individual so-trained during field work. •To prevent the spread of Rapid ʻŌhiʻa Death the most up to date guidance will be followed. •All actions taken will avoid direct impacts to Covered Species plants.
Other Activities	6.1.8	•Helicopter landing zones will not be designated in areas where Covered Species of birds (ʻAkiapōlāʻau, Hawaiʻi Creeper, Hawaiʻi Ākepa, Nēnē, ʻAlalā, and Hawaiian hawk) are known to nest.

Covered Activity	Section	Specific Avoidance/Minimization Measures
		•Any clearing activities for trails will occur outside the breeding period for Covered Species (Table 5) and with the tree/shrub cutting restrictions listed in Table 6. •Any road construction activities would occur outside the breeding season for Covered Species within Forest Bird Stratum 1 (Table 5) and with the tree/shrub cutting restrictions listed in Table 6 and disturbance would be kept to the minimum necessary to conduct these activities. •When salvaging trees that are dead and fallen or dead standing trees any salvaging will be done outside the breeding season for Covered Species within Forest Bird Stratum 1 (Table 5) and with the tree/shrub cutting restrictions listed in Table 6. •Construction of infrastructure facilities will not occur during the breeding season of any Covered Species known to have an active nest in the area. •Natural resource management activities will comply with the tree/shrub cutting restrictions listed in Table 6.

Table 5. General breeding periods for Covered Species using forested habitats.

Species	Breeding Period
ʻAkiapōlāʻau, (*Hemignathus wilsoni*)	February – July
Hawaiʻi Creeper, (*Loxops mana*)	January – June
Hawaiʻi ʻĀkepa (*Loxops coccineus*)	March – September
ʻIʻiwi (*Vestiaria coccinea*)	January to June
Hawaiian Hawk, ʻIo (*Buteo solitarius*)	March – September
Hawaiian Hoary Bat, ʻŌpeʻapeʻa (*Lasiurus cinereus semotus*)	June – September 15

Table 6. Periods Allowed for Tree Trimming, Harvesting, and Thinning

Stratum	Period during which tree trimming, harvesting, and thinning *may occur* (outside of sensitive breeding periods)
Forest Bird Stratum 1	October 1 – December 31*
Remainder of Enrolled Property (Outside of Forest Bird Stratum 1)	Vegetation below 15-feet tall: year round Vegetation greater than 15-feet tall: October 1 – March 1**

* Outside of this time window covered bird species have their breeding seasons (see Table 5).

**Outside of this time window is the ʻIo and Hawaiian Hoary Bat breeding season (see Table 5).

Table 7. Specific Required Protective Measures for Covered Activities within the Area Requiring Additional Conservation Commitments

Required Protective Measure (indicated by checkmark)	**Covered Activity Undertaken**						
	Out-plant Restore	Koa Thin/ Cut	Soil Scarify	New/ Replace-ment Fence	Weed Pull	Herb-icide Use	Rd/Tr Const.
Training of persons conducting activity by PEPP staff or other recognized experts on species ID, habitat of special-concern plants and specific precautions.	✓	✓	✓	✓	✓	✓	✓
Before activity ensure a survey of the 50-ft buffer area around each known or known recent location of *special-concern plant* (those locations established in the Fraiola and Rubenstein (2007) report or later surveys) by a botanist familiar with their identification.		✓	✓	✓		✓	✓
Prohibit ground-disturbing machinery within a marked approximate 50- ft buffer around each *special-concern plant* or known recent location (those locations established in the Fraiola and Rubenstein (2007) report or later surveys).	✓	✓	✓	✓	✓	✓	✓
No large trees felled that would fall within the established 50 ft buffer of any *special-concern plant*.		✓		✓			✓
Conduct monitoring after a disturbance has occurred within 50 ft buffer of any *special-concern plant*; any negative results reported to PEPP and the agencies within 2 months of each survey and in annual report.	✓	✓	✓	✓		✓	✓