Annual Report for the Ecosystem Management Program
Pohakuloa Training Area, Island of Hawaii

August 2003

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MANAGEMENT SUMMARY

This summary provides brief descriptions of significant results of natural resource projects and tasks performed by the Natural Resource Staff (NRS) of the Pacific Cooperative Studies Unit from July 1, 2002 to June 30, 2003 at Pohakuloa Training Area (Figure I). Recommendations for follow-on actions based on these results are also provided.

AERIAL CENSUS AND HUNTING DATA

Only one aerial census was conducted in August 2002. Counts yielded 81 feral sheep and 219 goats. These results fall within the range of previously observed values. This stable trend continues to corroborate hunting data showing that archery hunting success rates vary little from 0.10 animals taken per hunting trip. This year there were 306 ungulates taken in the course of 1,868 hunting trips for a success rate of 0.16.

A total of 3,685 game birds were taken from PTA during the 2002 – 2003 hunting season. Game bird take increased 480% from last year. California quail increased over 700% from last year and was the largest increase for a single species.

Recommendations: As there have been no significant changes in hunting take patterns over the last few years, it is recommended that detailed collection and analysis of hunting data (for birds and ungulates) be discontinued. Hunting take can be monitored by the State and NRS can use this information to make conclusions regarding ungulate populations. Because ungulates have been removed recently from large portions of the study area, aerial census methods and area surveyed should be reevaluated.

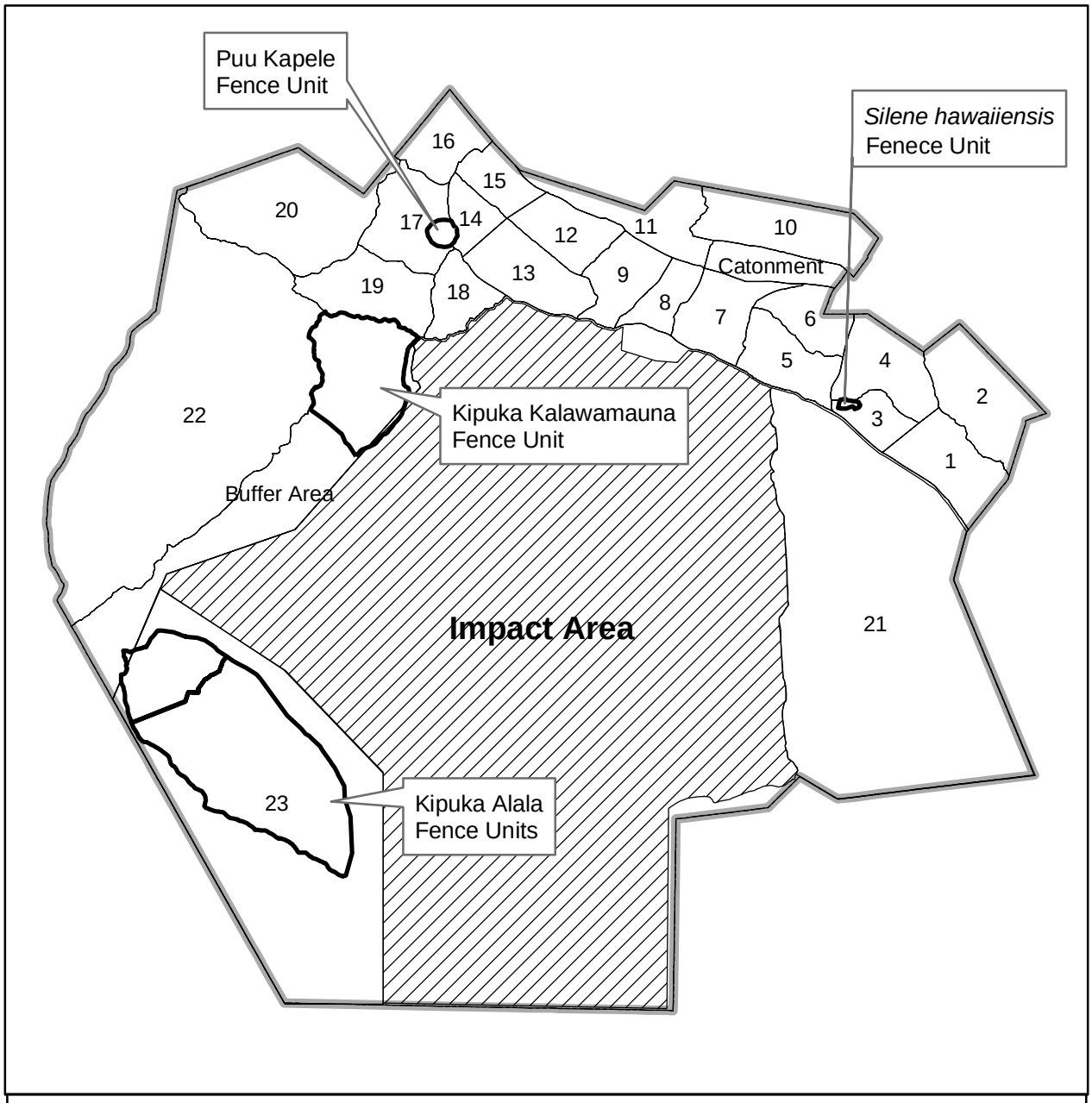
UNGULATE CONTROL

Five sheep and one goat were captured by U. S. Department of Agriculture (USDA) and fitted with radio transmitter collars. One sheep and one goat were released inside Kipuka Kalawamauna Fence Unit (KKFU). Two sheep were released inside Kipuka Alala –1 Fence Unit (KA-1 FU). Two sheep and one goat were released inside Kipuka Alala –2 Fence Unit (KA- 2 FU). These animals assist staff hunters in locating herds of animals for removal.

Staff hunting continued in KKFU. Between August 2002 and May 2003, USDA removed 25 sheep and nine goats. Aerial hunting was conducted in July 2003 and 3 sheep were removed. It is believed that one herd of less than ten goats and one herd of less than ten sheep remain inside the fence unit.

Public archery hunts were allowed within the Kipuka Alala Fence Units during September 9 -29, 2002. During this period, 26 sheep were taken in the course of 153 trips for a success rate of 0.17. From November 11 to December 6, 2002, public hunting with shotguns or black powder rifles was permitted. During this time, 15 sheep were taken in the course of 55 trips for a success rate of 0.27. After the public hunting period, USDA began staff hunting. Between December 2002 and July 2003, 60 sheep were removed from both fence units (personnel hours were not available). Aerial hunting was conducted in July 2003 and 70 sheep were removed from both fence units. It is unclear how many animals remain inside the fence units.

All large fence units were inspected during the contract period for signs of animal ingress and general damage. Combined driving and walking time required to inspect the 40 kilometers of fence line totaled 27.5 personnel-hours. Repairs, totaling six personnel-hours, were made to the Puu Kapele Fence Unit and the Puu Ahi Fence Unit.



Fence Units

Training Area Boundary

Impact Area

PTA Boundary

Figure I

Pohakuloa Training Area

0 2.5 5

Kilometers

N

1:175,000

Datum: NAD 83 July 2003
Projection: UTM Lena Schnell

Recommendations: Pursue aerial hunting in the fence units and radio collar additional sheep to aid in locating remaining animals inside the fence units. Continue to develop methods to remove pigs from Kipuka Alala fence units. Fence inspections and repairs should continue on a semi-annual basis.

RARE PLANT MONITORING

With the reidentification of species ranked as Priority Species-1 (PS-1) completed, efforts shifted to managing and reidentifying the more abundant PS-2 species. Previously and newly discovered plant locations of other Priority Species Categories were documented during field activities and surveys.

Following are the summaries of threat management and monitoring efforts for PS-1 plants.

Hedyotis coriacea. Surveys to reidentify previously recorded locations have been completed. Eleven new plants were discovered, bringing the total to 84 individuals. All new plants have been protected with small-scale emergency exclosures. Currently, all known individuals are protected. Several exclosures were expanded to protect additional habitat immediately surrounding the plants. Limited *Pennisetum setaceum* control was conducted around some exclosures. The emergency exclosures have been effective in reducing ungulate damage.

Recommendations: Monitor status of fountain grass. Implement control if it appears to threaten *H. coriacea* populations.

Neraudia ovata. Of approximately 50 seedlings that germinated under several adult plants at Site 01, about 15 seedlings remain. At Site 01, 22 personnel-hours were expended to clear *P. setaceum* from approximately 0.57 hectares (1.4 acres) surrounding the plants. At Site 02, approximately 17 personnel-hours were expended to control *P. setaceum* from 0.69 hectares (1.7 acres) surrounding the plants. A third individual was discovered in June 2003 at Site 02. A small fence was erected to protect the plant in July 2003. A total of 8 pounds of rodenticide was used for rodent control around the plants.

Recommendations: Protect plants within larger fence units to encourage recovery of habitat suitable for outplanting of new populations and to encourage natural reproduction. Continue *P. setaceum* control around plants.

Schiedea hawaiiensis. The fifteen seedlings collected last year were grown and replanted in two outplanting sites. Of the fifteen seedlings left in the field, six survived. Rodent control for this species continues.

Recommendations: Continue to protect the population from rodent and ungulate browsing. Establish new field populations using field-collected and nursery-reared stock.

Solanum incompletum. At Site 01, a new individual in a new location was discovered. This individual was protected with a small fence. *P. setaceum* was controlled for this species in conjunction with *N. ovata*. In May 2003, a new site with four individuals was discovered in northern Training Area 22. Site 02 was protected with a small fence and *P. setaceum* removed from within the fence. This brings the total known individuals to 46. A total of 2.6 pounds of rodenticide was distributed in bait stations over the year around the plant locations at Site 01.

Recommendations: Protect plants with larger fence units to encourage recovery for outplanting of new populations and to encourage natural reproduction. Continue *P. setaceum* control around plants. Survey the suitable habitat between the two recorded sites for additional individuals.

Tetramolopium arenarium* ssp. *arenarium. Control of *P. setaceum* was initiated at Site 01 during the contract period. To control *P. setaceum* over 3.0 hectares (7.4 acreage) at Site 01, 90.5 personnel-hours were expended. Because of the high potential for fire in the surrounding habitat, *P. setaceum* will be cleared within 50 meters of each plant. The short-term goal is to remove approximately 15.5 hectares (38.3 acreage) of *P. setaceum* from the site.

Recommendations: Enclose the known populations in a 750-meter by 1000-meter protective fence. Continue weed control until short-term goal is met.

***Tetramolopium* sp. 1.** Weed control has been initiated at site 01 during the contract period. Approximately, 10 personnel-hours were spent controlling *P. setaceum* over 0.61 hectares.

Recommendations: Continue weed control efforts and protect the two other previously recorded sites from ungulates.

Summaries for threat management and monitoring efforts for PS-2 plants.

Asplenium fragile var. insulare. No management actions were conducted for this species during the contract period.

Recommendations: Place concertina wire around ungulate-accessible caves where this species occurs to protect them from ungulate activity. Commence systematic monitoring during the next reporting period.

Silene lanceolata. Surveys to locate previously recorded or new individuals in Training Areas 17 and 22 were initiated. Ten personnel-days were spent surveying 45 hectares (111 acres) in Training Area 17; no plants were found. Three personnel-days were spent surveying southern portions of Training Area 22; no plants were found. However, site 0401 was reidentified in northern Training Area 22 in May 2003. The site was protected with a small fence in July 2003. A new location in Site 10 was discovered in KKFU (Site 1005).

Weed control was initiated at Sites 01, 06, 07 and 10. To control *P. setaceum* in over 1.9 hectares (4.7 acres), 227 personnel-hours were expended.

Recommendations: Continue surveying for previously recorded locations. If reidentified or newly discovered locations are not protected from ungulates, construct small exclosures to protect the plants in the short term. Continue weed control until short-term goals are met.

Zanthoxylum hawaiiensis. Surveys were conducted in northern, central and southern Training Area 22. Of the total 46 plants found, 21 were newly discovered plants. The remaining were reidentified plants. There is an estimated 300 plants at PTA. *P. setaceum* control was initiated at Site 18 and 10-personnel-hours were expended clearing about 0.40 hectares (0.99 acres). A total of four pounds of rodenticide were used at Site 18 to control rodents.

Recommendations: Revisit previously recorded locations and continue surveying in potential habitat. Initiate weed and rodent control around known locations. Protect plants within large fences to allow germination of new plants.

Summaries for threat management and monitoring efforts for PS-3 plants.

Portulaca sclerocarpa. Although no monitoring actions were specifically devoted to this priority-level 3 species in the reporting period, two new individuals were discovered along the southern fence line in KKFU.

Recommendations: Continue to monitor occurrence sites on an opportunistic basis. Of the seven recorded sites, four still need to be reconfirmed.

Haplostachys haplostachya. Two new locations were found in the course of other management activities. No management was conducted for this species during the contract period.

Recommendations: Continue to document occurrence sites on an opportunistic basis. Monitoring will be implemented according to the Priority Species rankings.

Silene hawaiiensis. This species has now been monitored at Range 8 annually for six years as a condition of an Endangered Species Act Section 7 consultation and agreement to evaluate effects of machine gun training on the firing range. Long-term trends have disclosed a declining abundance and smaller size of plants. As these effects are seen uniformly in areas with and without machine gun firing, the reduced condition of the plants is most likely caused by long-term drought and browsing by ungulates.

A study to determine the effects of ungulate exclusion on *S. hawaiiensis* inside the 13.5 hectare (33 acre) *Silene hawaiiensis* Fence Unit continued with the fourth-annual monitoring. The average height of plants inside versus outside of the fenced unit was compared. Results show that after two years of reduced ungulate browsing, plants inside the fence were larger than those outside. The average height of plants inside the fence was 46.3% (α=0.1) larger than those measured for the 1999 baseline survey. This study demonstrates that reduction of ungulate pressures on this species can have a direct positive effect on plant from the baseline obtained in 1999. Furthermore, after three years the plants inside the fence unit have greater average height than those plants outside. This study shows that reducing ungulate pressures on this species can have significant positive effects in a relatively short period of time.

Recommendations: Continue the annual monitoring of *S. hawaiiensis* at Range 8 as required by the ESA Section 7 consultation. Although the declines of the plants are not due to military use, fencing of the population should be considered to ensure continued access by the military.

Spermolepis hawaiiensis. No plants were located during attempts to reidentify Center for Ecological Management of Military Lands (CEMML) recorded locations during the 2002-2003 reporting period.

Recommendations: As future workloads allow, implement monitoring for this PS-5.

RARE PLANT PROPAGATION

Propagation of Priority Species 1

Hedyotis coriacea. Field seed production increased from last year and seed was collected from 34 individuals at seven of the ten known sites. Field-collected seeds germinate in an average of 18 days with germination rates of 70-80%. Survival rate after four months is 27%.

Recommendations: Sow seeds in early spring because of substantially better survival rates than seeds planted in winter. Perform monitoring to acquire life history and reproductive biology information.

Neraudia ovata. Seed germination is very slow and none of the 586 seeds planted in February 2003 have sprouted. From seeds planted in January 2002, the germination rate has been 23% with the greatest number of seedlings emerging between 11 and 15 months. Seedling vigor is poor with high susceptibility to stem wilt. Low winter temperatures killed several seedlings and two adult plants in the Rare Plant Propagation Facility.

Recommendations: Maintain genetic stock from all naturally occurring plants in the greenhouse to increase and facilitate seed collection. Continue with seed germination trials. Protect plants from low winter temperatures.

Solanum incompletum. Attempts to determine the correct temperature regime needed to break seed dormancy continue. Seeds were sent to the University of Kentucky where trials with varying diurnal temperature regimes are being conducted. Germination trials with field and greenhouse seed continue in the Rare Plant Propagation Facility (RPPF) with giberellic acid (GA-3). Seeds may begin germination in 7 weeks and continue sporadically for many months at rates between 0 to 24% after six months. Seedlings are generally hardy and 108 seedlings are currently in the RPPF, which should be ready for outplanting in Fall 2003.

Recommendations: Continue germination trials with and without GA-3 to determine dormancy requirements and potential seedling vigor effects. Gather more phenology data on field seed maturity and germination.

Schiedea hawaiiensis. There is one mature, naturally occurring individual known and one mature plant in the RPPF. Both plants have produced viable seeds and 528 seeds were sown. Seeds began germination at 34 days, with a germination rate of about 47% for RPPF seeds and 26% for field seeds.

Recommendations: Continue germination trials to optimize germination and seedling vigor.

Tetramolopium arenarium* ssp. *arenarium. Germination of this species occurs in eight days on average with success rates of 30% to 74%.

Recommendations: With no unusual dormancy or germination requirements, propagation efforts with *T. arenarium* spp. *arenarium* should focus on seed collection to maximize genetic diversity of propagules.

***Tetramolopium* sp. 1.** Approximately 600 seeds were sown. Germination of these species occurs in seven to eight days on average with success rates of 40 to 48%.

Recommendation: Produce propagules from a genetically diverse selection of field-collected seed for future outplanting projects.

Propagation of Priority Species Level 2

Asplenium fragile* var. *insulare. Propagation efforts at H.L. Lyon Arboretum (HLLA) have been successful and gametophytes should arrive at PTA in August 2003. The length of time necessary for acclimation to the PTA environment before outplanting has not yet been determined. Spores of this species have also been sent to botanical specialists at the Cincinnati Zoo and Botanical Garden for evaluation of long-term spore storage needs.

Recommendations: Determine protocol for acclimation of propagules from HLLA to PTA environment. Begin selection of candidate sites (caves openings) for outplanting. When propagation for outplanting commences, collect spores from diverse locales.

Silene lanceolata. Germination trials used field-collected seed from 1998 to 2002. Germination rates between the seed lots were similar. Seeds germinated in an average of 10 days with a success rate of 54%.

Recommendations: Conduct germination trials with field-collected seed from Kipuka Alala and Kipuka Kalawamauna to test for differing germination responses and seedling vigor.

Zanthoxylum hawaiiense. This species, like other species in the genus Zanthoxylum, are slow to germinate. The germination trial begun during this reporting period has yielded no germination. The germination rate for a trial begun last reporting period is 14% (3 of 21 seeds). The estimated time required from sowing seeds to outplanting is two years.

Recommendations: Collect seeds from as many different individuals as possible to increase genetic diversity. Continue germination trials.

Propagating Other Species. Germination trials were also conducted for two PS-3, five PS-5 taxa and 16 non-listed native species.

Recommendations: Germination trials should be performed with native taxa of lower priority levels as time and seed availability permit.

Maintaining Seeds in Storage. Seeds continue to be field-collected, cataloged, stored, and tested for viability. Seeds in excess of needs at PTA are sent to HLLA for seed storage protocol determinations.

Recommendations: Continue present procedures. When readily available, provide high priority-level species seeds to genetic safety net storage program members and to U.S. Department of Agriculture National Seed Storage Laboratory at Fort Collins, Colorado.

Other Activities Associated with Plant Propagation.

Mixed native species outplanting project. Outplanting has begun at seven sites. All sites are located on PTA with the exception of a site at Puu Huluhulu. Approximately 235 seedlings, representing 23 species have been outplanted. Of these 23 species, seven are endangered, four are species of concern and the rest are common natives. Plants were watered at time of outplanting, one week later, two weeks after that, and then every four to six weeks depending on natural precipitation. Overall survival of the plants was 80%.

Recommendations: Follow guidelines in the Rare Plant Outplanting Plan for Pohakuloa Training Area for future projects. Begin outplanting within PTA's fence units in early September to give outplants time to get established before the low winter temperatures.

RUSSIAN THISTLE CONTROL

Over the reporting period, about 379 personnel-hours were devoted to field control efforts. This work was concentrated in 225 hectares (588 acres) of land located primarily in northern PTA (Puu Keekee and Puu Kapele) and around the airfield and cantonment area. As compared to the previous year's data, hectares covered increased from 270 hectares (667 acres) to 313 hectares (744 acres). The discovery of new plants necessitated an increased control effort.

Recommendations: Continue aggressive program to detect, map and control Russian thistle to prevent large-scale spread into training areas, and sensitive environments, and ensure that this invasive weed does not gain foothold in rare plant habitats of western PTA. Additional contracted herbicide application efforts may be necessary to control the spread of Russian thistle following high rainfall events.

BIRD POPULATION MONITORING

In December 2002, bird monitoring on transects in Palila Critical Habitat (northeastern PTA), Training Area 22 (western PTA), and Kipuka Alala (southwestern PTA) showed results that are very similar to the 1999, 2000 and 2001 censuses. Amakihi, the most common native species in all three areas, accounted for 47%, 59% and 50% of counted birds in the three study areas, respectively. Apapane, another common native bird, comprised 4% of counted birds at Palila Critical Habitat, 6% at Kipuka Alala and only one bird in Training Area 22.

Only one Elepaio was counted in Kipuka Alala, one less than in the previous two years. Abundance of this species has declined dramatically since 1993 when surveys by R. David found them at 24% of count stations. Increased predation and effects of drought are possible causes of the decline in Elepaio abundance or alterations in their behavior and territories.

Four Nene were reported from Training Area 23 on February 12, 2003. NRS reported four birds flying overhead and calling. These birds were flying in a southwest direction. They were not seen to land.

Recommendations: Native bird monitoring should continue on an annual basis. New attempts should be made to locate and band Elepaio. Studies should be conducted to determine survivorship of Elepaio and factors that may have caused decline of their populations at PTA. If Elepaio nesting areas are found, predator control should be implemented in those areas.

ALIEN ANT CONTROL

A total of six surveys were conducted in Training Area 23 to delineate an isolated population of *Linepithema humile*, the Argentine ant. Two ant species were recorded at 127 of 578 (22%) monitoring sites. Of the 127 stations with ants, *L humile* was recorded at 117 sites (20%) and *T. melanocephalum* was recorded at ten sites (2%). The ants encompassed approximately 62 hectares (153 acres). Assuming the ants were first established at the Administration Site, the population has expanded to the north 640 meters, to the west 396 meters, to the south 508 meters and to the east 343 meters.

Recommendations: In an effort to control or eradicate the ants, granular insecticide bait should be dropped by helicopter over the entire infested area during the summer months when nutritional needs of the ant colonies are highest. A second treatment should follow two to three weeks later to kill any remaining ants and/or ants that may have emerged from eggs and/or pupa.

MISCELLANEOUS SUPPORT EFFORTS

NRS continue to support outreach programs, such as quarterly volunteer service trips, Imi Pono No Ka Aina summer and spring enrichment programs and county fair displays. NRS have also presented talks to professional groups such as the Geographic Information Systems, Hawaii Island Users Group (HIUG). Accomplishments of the Environmental Education Program directed by Ms. Kuhea Paracuelles are detailed in a separate report.

Recommendations: Outreach and interpretive efforts should continue because of their important function in informing the public and the Army command on accomplishments and issues related to resource management and stewardship at PTA.

CHAPTER 1. FERAL UNGULATE CONTROL

1.1 PCSU CONTRACT REQUIREMENTS

Requirement 5.b.1

Determine the distribution of ungulates within 35,000 acres on the western portions of PTA by conducting an aerial ungulate census twice a year along established transects.

DISCUSSION

One census was conducted in August of 2002. The numbers of sheep and goats observed in the three respective study areas were not significantly varied over a six-year period. The number of goats and sheep were similar in Kipuka Alala, but different in Kipuka Kalawamauna and Red Leg Trail over a six-year period.

REQUIREMENT 5.b.2 and 5.b.1.a (Kipuka Alala)

Monitor the distribution and movements of 6-8 selected radio-collared ungulates using radio telemetry on a quarterly basis. Findings from the census and radio tracking shall be incorporated into a report and management recommendations made.

DISCUSSION

The radio collars no longer emit signals; therefore the animals were not located during the contract period. In February 2003, USDA collared an additional six animals, which are used to monitor animal movements and aid in the removal of herds within all the fence units.

REQUIREMENT 5.b.3

Maintain and update a database containing information on hunting methods and animal harvests at PTA. Monthly reports shall be furnished to the State Department of Land and Natural Resources (DLNR). Information shall be evaluated on a quarterly basis and recommendations made for management actions (e.g., hunting guidelines, special hunts, etc.).

DISCUSSION

Mammal hunting data from January 2002 to December 2002 indicate that goats and sheep were harvested in statistically similar numbers. There was no significant difference in game numbers harvested between hunting areas.

Analysis of the data for the 2002-2003 bird-hunting season found a statistical difference in the numbers of individual species taken during the season. California Quail and Erckle's Francolin were the most frequently harvested birds. A statistical difference was not found between harvest numbers among the hunting areas.

REQUIREMENT 5.b.4

Assist in presentation of hunting data and policy information at the semi-annual hunter meetings.

DISCUSSION

The Army Natural Resource Manager organized and conducted the only public hunting meeting during the contract period. No additional meetings were held during the contract period because no new information or pressing issues developed.

REQUIREMENT 5.b.5

Inspect fence units for damage and perform repairs, as necessary, along 16 kilometers (10 miles) of fence semi-annually. The purpose of the inspection shall be to assess whether ungulates have entered or re-entered the fenced areas. Fence damage shall be repaired within two weeks.

DISCUSSION

Approximately 27.5 personnel-hours were expended inspecting and repairing fences in 2003. Repairs were made to the Puu Kapele Fence Unit and Puu Ahi people fence.

REQUIREMENT 5.b.1. (Kipuka Alala)

Identify ungulate removal methods based on distribution and movement patterns.

DISCUSSION

NRS helped organize aerial operations to capture five sheep and one goat. These animals were collared with radio transmitters and released in Kipuka Kalawamauna and Kipuka Alala fence units to assist USDA with hunting efforts.

REQUIREMENT 5.b.1.c (Kipuka Alala)

Assist the USDA, Wildlife Services, in the implementation of ungulate removal.

DISCUSSION

NRS has assisted USDA in organizing two public hunts in Kipuka Alala in 2002. NRS has also assisted with coordination for USDA staff ground hunts in Kipuka Alala and Kipuka Kalawamauna during the contract period.

REQUIREMENT 5.b.1.d (Kipuka Alala)

Create a database, which contains information on ungulate removal methods, locations and animal harvests within Kipuka Alala. Information shall be evaluated on a quarterly basis and a report prepared with recommendations made for management actions.

DISCUSSION

When requested by USDA, NRS continues to provide database support and assist with data analysis.

1.2 UNGULATE MONITORING

INTRODUCTION

To gather information on distribution and movement patterns, NRS conducted semi-annual aerial ungulate censuses. Using radio telemetry, USDA also monitors ungulate movements.

1.3a Semi-annual Aerial Ungulate Census

METHODS

In August 2002 an aerial census was conducted. The National Park Service developed the methods used (Hoshide and Fancy 1998). PTA was divided into three main study areas: Kipuka Alala, Kipuka Kalawamauna, and Red Leg Trail. These areas were chosen because of their high concentration of rare plants and high numbers of ungulates. The surveys were conducted along fixed transects (Figure 1-1). Transects were established by generating a random starting point in each study area and were then systematically placed one kilometer apart within the study area. Each transect includes sections of the impact area, training areas, and adjacent lands.

The aerial transects were monitored utilizing a Hughes 500. Counters sat in the rear of the helicopter on the left and right sides. The pilot and the fourth person in the front seat served as spotters. Flight altitude ranged from 30-60 meters (100-200 feet) above ground level and flight speeds ranged from 48-112 kph (30-70 mph) (Hoshide and Fancy 1998).

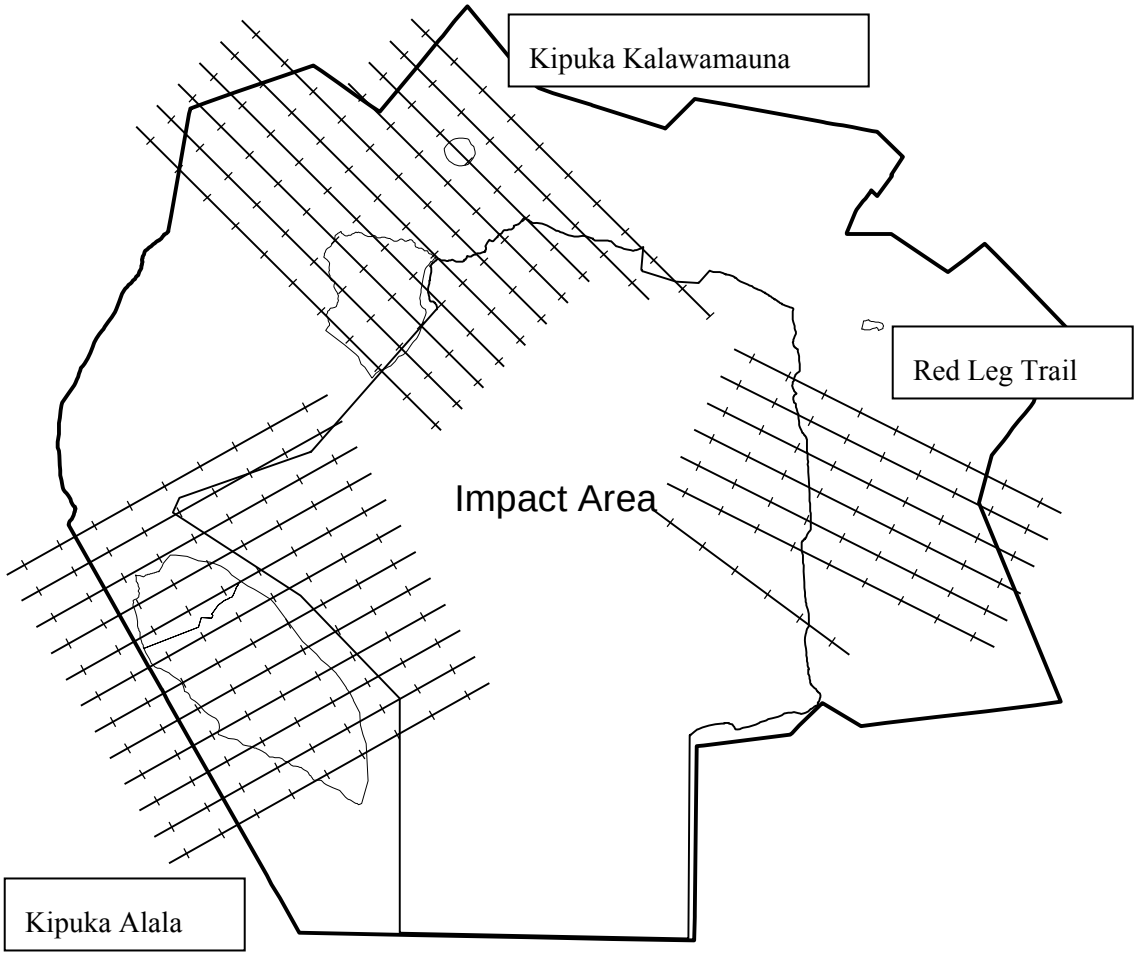
Data from 1996 to 2002 were analyzed using Minitab (13.13). When variances were equal, one-way ANOVAs were used to test differences among the data means. If the variances were not equal, a non-parametric test (Kruskal-Wallis) was used to determine differences.

RESULTS

In August 2002, most of the animals were recorded in Kipuka Alala, then Kipuka Kalawamauna and Red Leg Trail, respectively (Table 1-1).

Table 1-1. Results of the August 2002 Aerial Ungulate Census.

Area	Sheep	Goats	Total
Kipuka Alala	39	131	170
Kipuka Kalawamauna	6	81	87
Red Leg Trail	36	7	43
Year Total	81	219	300



Fence Units
PTA Boundary
Aerial Census Transects

Figure 1-1

Ungulate Census Transects

1:200,000

0 5 10
Kilometers

N

Datum NAD 83
Projection UTM

July 2003
Lena Schnell

DISCUSSION

Because trends are difficult to assess over only one year, data from 1996 to 2002 were compared. First, sighting data from within each study area was compared. Next, sighting data between study areas was compared for the six-year period. Each species was compared separately.

For feral sheep, the numbers of sightings were similar between years within Kipuka Alala and Kipuka Kalawamauna, respectively (α=0.05). In Red Leg Trail, there was no statistical difference among the numbers of sightings (α=0.05). The variances for the numbers of sightings between study areas for the six-year period were not equal. There are significant differences between the study areas for the number of sheep sighted over the six-year period (α=0.05) and sightings in Red Leg Trail were statically different than the other two areas (α=0.05).

For goats, the numbers of sightings were similar between years in Kipuka Kalawamauna and Red Leg Trail (a=0.05). The numbers of sightings were similar between years (α=0.05). The numbers of sightings of goats were statistically similar between Kipuka Alala and Kipuka Kalawamauna over the last six years (α=0.05).

In Kipuka Alala, the numbers of sightings of goats and sheep in were similar (α=0.05). However, goats were mostly sighted on the open lava flows adjacent to Kipuka Alala, while the sheep were generally sighted within the kipuka. The numbers of goat and sheep sightings in Kipuka Kalawamauna were not similar (α=0.05). This result may be due to the fact that counts were always conducted in Kipuka Kalawamauna at mid-day and sheep had probably sought shelter making it difficult to locate them. Goats tend to form herds on the Keamuku lava flow, which is relatively open and therefore easy to spot the animals. In Red Leg Trail, the numbers of sightings of Mouflon and sheep were similar (α=0.05), the sightings of goats and sheep were similar (α=0.05), but the sightings of goats and Mouflon were not similar (α=0.05). Mouflon are concentrated in Red Leg Trail and are not common in other study areas. Goat sightings are inconsistent in Red Leg Trail and the herds seen are often small compared to herds in the other study areas.

MANAGEMENT RECOMMENDATIONS

Data from the past six years indicate that the ungulate populations at PTA are relatively stable. Public hunter take also has remained relatively the same since 1996 (Evans *et al*. 2002b). To control or minimize ungulate populations at PTA, methods other than public hunting must be employed. Continuing with semi-annual census is no longer needed at PTA. Ungulates inside the Kipuka Alala fence units have been almost removed, which make counting animals unnecessary. To continue monitoring ungulate populations in the remaining study areas, goals, methods and frequency should be re-examined and a modified or new study implemented.

1.3b Monitor Animal Movement

The collars that were placed on animals in 1997 and the additional five animals collared by USDA are no longer functioning. Because there is still a need to track and monitor the movements of herds within fence units to aid in animal removal, six animals were captured and collared in February 2003 by USDA personnel.

Two animals, one sheep and one goat, were placed within the Kipuka Kalawamauna Fence Unit (KKFU). The collar on the sheep malfunctioned; the animal was removed and the collar recovered.

One sheep was placed within the Kipuka Alala-1 Fence Unit (KA-1 FU). In Kipuka Alala-2 Fence Unit (KA- 2 FU), two sheep and one goat were placed. These animals have assisted staff hunters in locating herds in the large fence units, increasing hunting efficiency.

MANAGEMENT RECOMMENDATIONS

Maintain collared animals within the fence units to assist staff hunters with hunting efforts. A collared sheep should be placed inside KKFU. Old collars should be sent to the manufacture to be refurbished.

1.4 HUNTING PROGRAMS

Public hunters have access to PTA for hunting during weekends and State holidays depending on military training activities. Mammal archery hunting is year-round except during bird season, which is November to January. In 1996, NRS began tracking data to assess if management activities such as increased access affected game harvest numbers. To facilitate data analysis, PTA was divided into six hunting areas: Ahi, Bobcat, Humuula, Kapele, Menehune, and Mauna Kea (Figure 1-2)

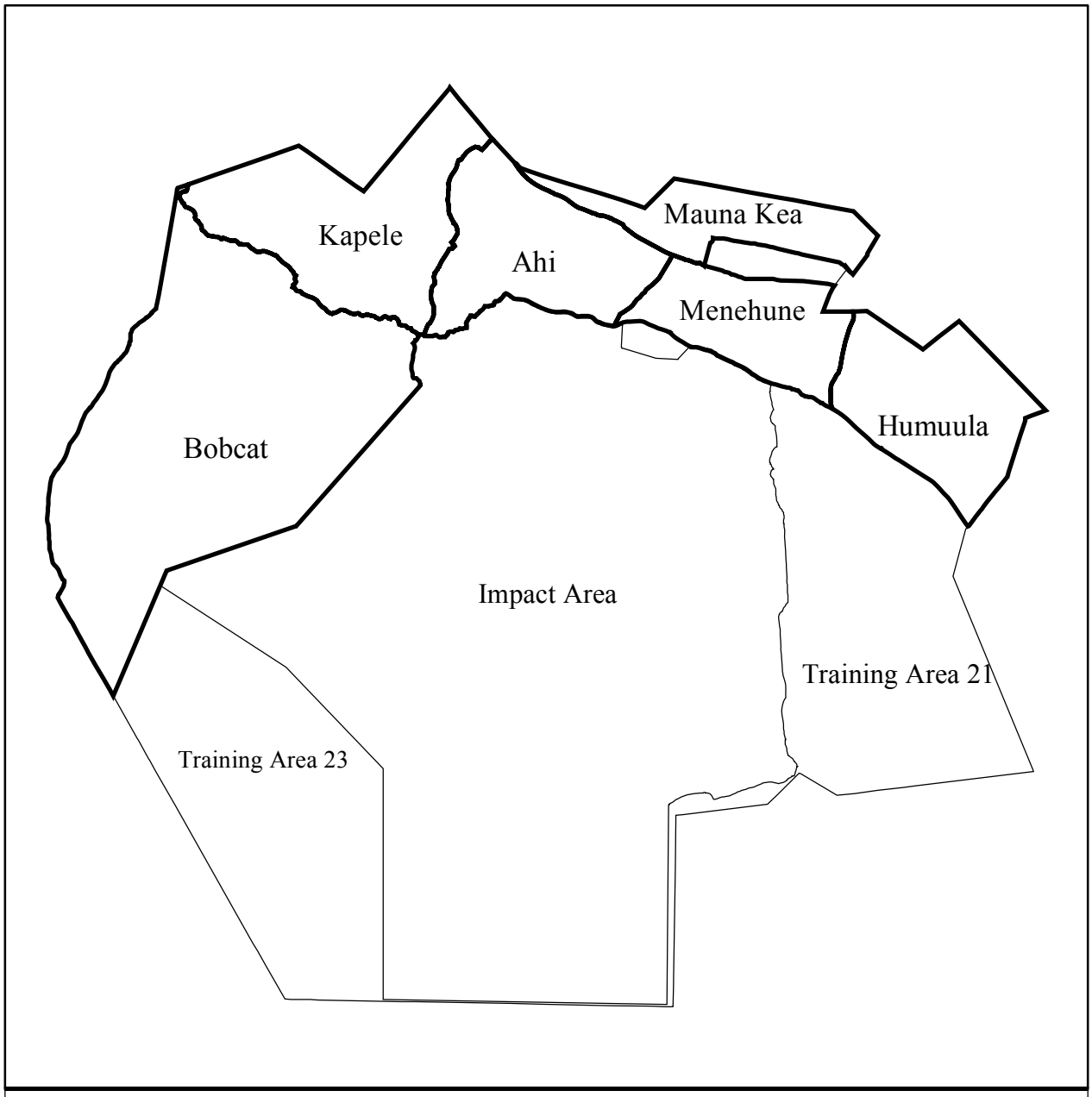
1.4a Public Mammal Hunting

METHODS

Public hunters provide information for each hunting trip made at PTA. Hunters are required to sign in and out on a check-in sheet located at the Department Of Defense (DOD) Police station. This information is used to count hunter trips and calculate the number of hours spent hunting. If an animal is harvested, hunters are required to provide information about the area of capture, species, sex and number of animals harvested on the PTA Big Game Mammal Report Card. This information is stored in databases and analyzed annually.

To compare data between years, numbers of hunter trips, available hunting days, animals harvested and hours spent down range are summarized. The hours spent is derived from the total number of hours spent down range by hunters. The hours spent include activities other than hunting such as eating, resting, waiting and commuting to hunting areas. To compare hunter effort between periods, the capture time is computed by dividing the hours spent by the number of animals harvested. To compare hunter success, the capture success (animals per hunter) is computed by dividing the number of animals harvested by the number of hunter trips.

To more effectively integrate hunting results with other agencies, data are based on the calendar year instead of the contract period. Data for 2002 were analyzed using Minitab (13.13). When variances were equal, one-way ANOVAs were used to test differences among the data means. If the variances were not equal a non-parametric test (Kruskal-Wallis) was used to determine differences.



Hunting Areas

Figure 1-2

Hunting Areas at PTA

Scale 1:175,000

5 2.5 0 5

Kilometers

N

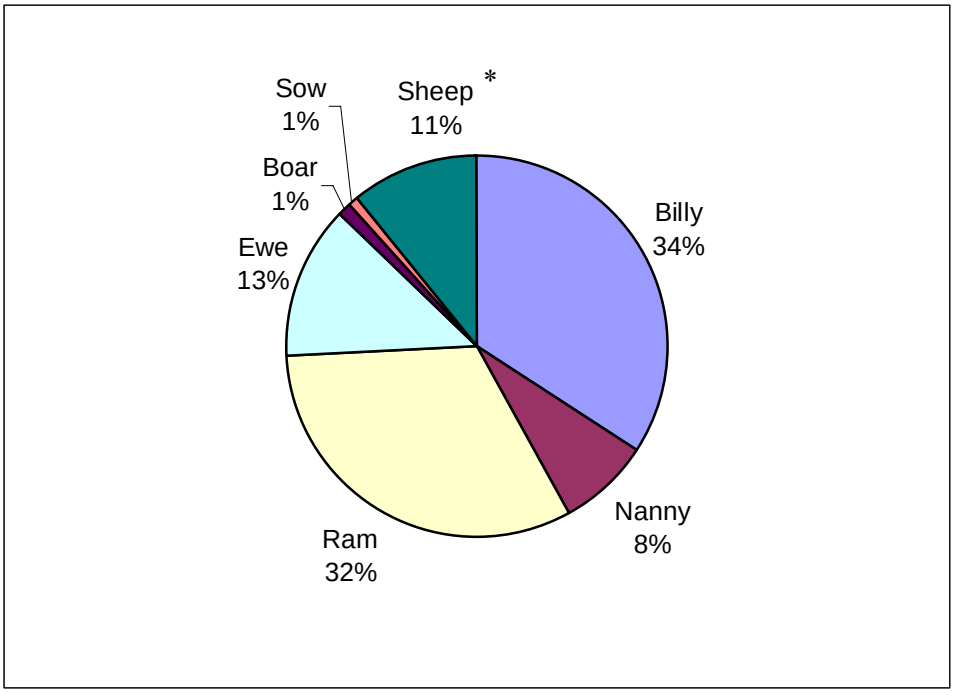
RESULTS

Between January and December 2002, 96 days were available for hunting (Table 1-2). During this period, 16,190 hours were expended on 1,868 hunter-trips to capture 306 animals. Of the 1,868 hunter-trips only 285 (15%) were successful. The capture success was 0.16 animals per hunter-trip. The average capture time was 53 hours per animal.

Table 1-2. Mammal Hunting Summary

Days	Hunter Trips	Successful Trips	Hours	Animals	Capture Time (Hrs)	Capture Success
96	1,868	285	16,190	306	53	0.16

Sheep comprised the majority of the 2002 harvest (Figure 1-3). The goat and sheep harvest was statistically similar (α=0.05). Pigs only comprised 2% of the total harvest in 2002 (Figure 1-3). Harvest totals were not significantly different from previous years (α=0.05).



*Hunters did not report the sex for these sheep

Figure 1-3. 2002 Hunting Totals by Species

The mean harvest of the different species and sexes for 2002 was not statistical different (α=0.05) (Table 1-3 and Figure 1-4[1]). Fifty sheep were harvested this year from Kipuka Alala during the special archery and black powder hunts (Table 1-3).

Table 1-3. 2002 Public Hunting Results

	Ahi	Bobcat	Humuula	Kapele	Menehune	Kipuka Alala	Other	Total
Billy	43	32	0	21	4	0	2	102
Nanny	11	7	0	4	1	0	0	23
Ram	18	38	4	1	18	12	5	96
Ewe	2	23	3	1	3	7	0	39
Sheep*	0	0	0	0	0	31	1	32
Boar	1	0	0	1	1	0	0	3
Sow	2	0	1	0	0	0	0	3
Total	77	100	8	28	27	50	8	298

*Hunters did report the sex for these sheep.

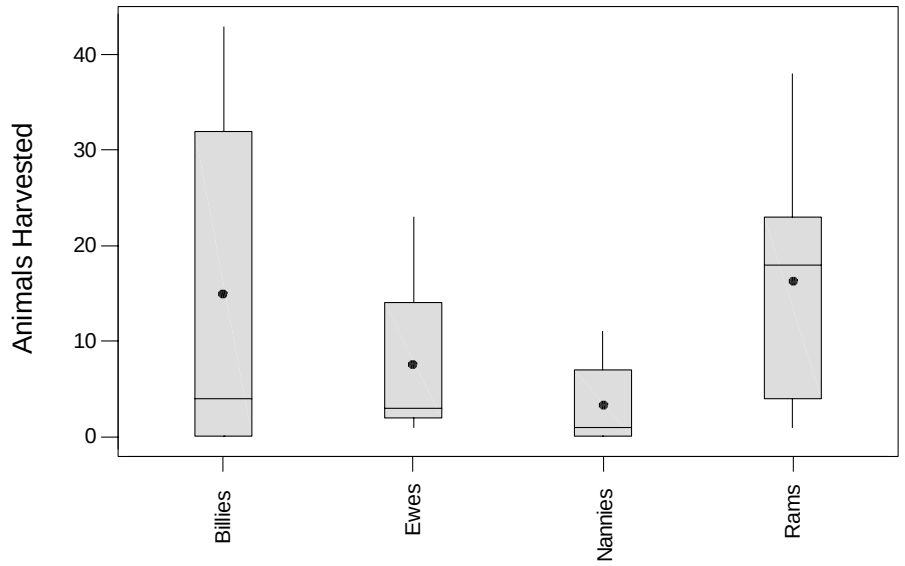


Figure 1-4. Box Plot of 2002 harvest by Species

[1] An explanation of the box plot diagram is in Appendix 1.

The majority of the game was harvested from Bobcat, Ahi and Kipuka Alala (Figure 1-5). Although these three areas account for 76% of the total harvest, game harvest was similarly in all training areas (α=0.05).

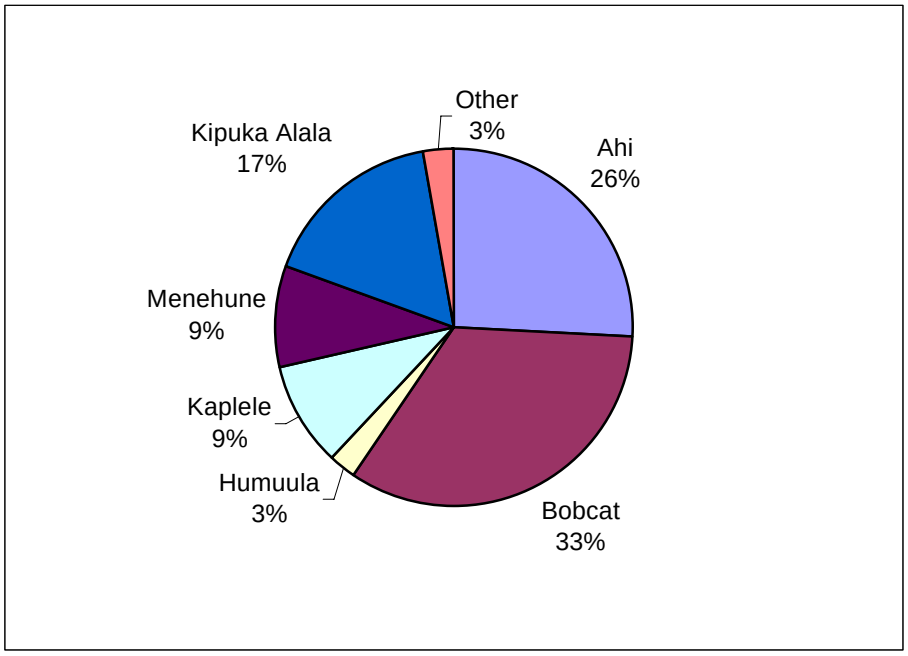


Figure 1-5. 2002 Hunting Results by Hunting Areas

DISCUSSION

The total harvest for all species did not significantly vary from other years, indicating that hunter success has remained statistically unchanged since 1996 even with droughts, increased access, and special hunts (α=0.05). In 2002, special archery and black powder hunts were organized in both Kipuka Alala fence units in an effort to have public hunters remove as many game animals as possible before staff hunting commenced in the fence units. Public hunters removed fifty animals.

The harvest totals for billies, rams, nannies and ewes were statistically similar in 2002. Evans *et al*. (2002b) demonstrated using only a year's data that there was no statistical trend with respect to species or sex of animals harvested. When data from 1996 to the present were analyzed, there was a significant preference for billies and rams (α=0.05).

Again game was harvested most frequently from the western hunting areas than from northern areas. This result was not significant for one year, but when several years were analyzed game harvest from the western hunting areas was significantly higher than from northern areas (Evans *et al.*2002b).

MANAGEMENT RECOMMENDATIONS

Public hunting for recreational purposes should be continued. The data collection and analysis should be returned to the State.

1.4b Public Bird Hunting

METHODS

This report covers the 2002 bird season. Data recorded and analyzed includes birds taken, areas from which they were taken, numbers of hunter trips, available hunting days, and hunting hours. Hunters report the hours they spend in each hunting area. Because not all hunters report hours spent hunting, the average reported hours is multiplied by the total number of hunter trips to obtain the total estimated hours spent hunting.

RESULTS

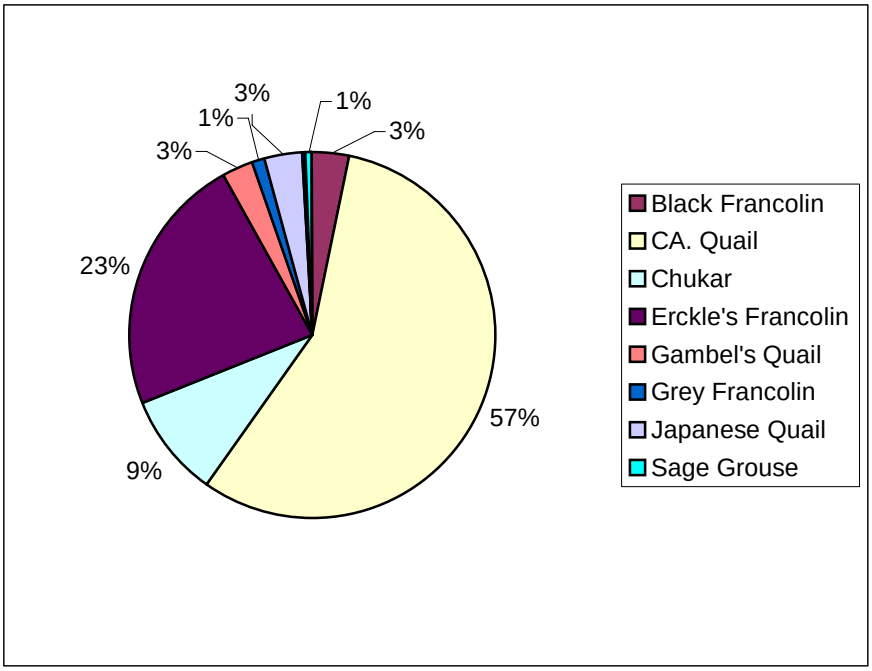
Between November 2002 and January 2003, 27 days were available for hunting. During this period, hunters expended approximately 11,800 hours on 2,064 hunter trips to capture 3,685 birds.

There was a statistical difference between birds species harvested this season (α=0.05). California Quail was the most commonly harvested bird and accounted for over half the harvest total (Table 1-4 and Figure 1-6). Erckle's Francolin accounted for just under a quarter of the harvest and all other species combined account for just under a quarter of the harvest.

There was no statistical difference in game harvested from hunting areas (α=0.05) (Figure 1-7).

Table 1-4. 2002-2003 Bird Hunting Results

	Ahi	Bobcat	Humuula	Kapele	Menehune	Mauna Kea	Other	**Total**
Barred dove	1	0	0	0	0	0	0	**1**
Black Francolin	27	91	19	27	15	8	25	**212**
CA. Quail	490	345	437	199	226	327	41	**2,065**
Chukar	79	22	41	16	62	11	24	**255**
Erckle's Francolin	200	147	213	106	93	80	44	**883**
Gambel's Quail	23	8	32	24	16	14	3	**120**
Grey Francolin	11	8	7	6	12	11	2	**57**
Japanese Quail	28	13	2	10	11	6	5	**75**
Lace Neck Dove	1	0	0	0	0	0	0	**1**
Kelij	0	0	1	0	0	1	0	**2**
Ring N. Pheasant	1	0	0	1	0	3	2	**7**
Sage Grouse	5	0	1	0	0	0	0	**6**
Turkey	0	1	0	0	0	0	0	**1**
Total	866	635	753	389	435	461	146	3,685



*Species Less than 1% were not included on the chart.

Figure 1-6. Bird Hunting Results by Species

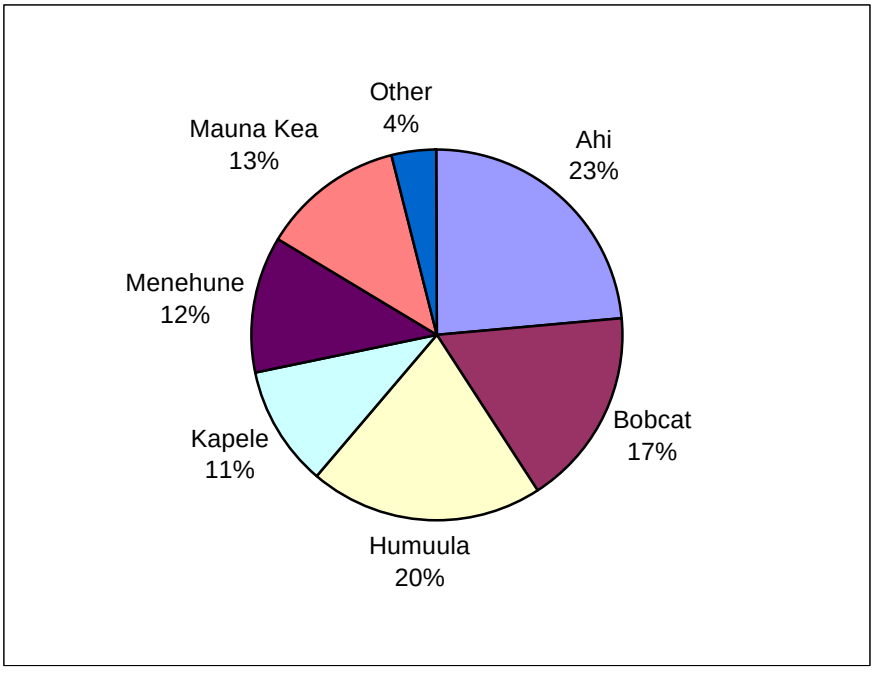


Figure 1-7. Bird Hunting Harvest by Hunting Areas

DISCUSSION

The total harvest for the 2002-2003 bird-hunting season increased 480% from last season's harvest totals. California Quail and Erckle's Francolins were the most commonly harvested birds, which is similar to trends from other years (Evans *et al.* 2002b). The California quail harvest increased over 700% from last year (255 birds) to this year (2,065 birds). Although other species were also harvested more frequently this year, no other species showed such a dramatic increase.

Hunters appeared to harvest game equally among the hunting areas, which is similar to previous seasons (Evans *et al.* 2002b). Unlike mammal harvest, which is statistically higher in the western hunting areas, bird harvest is fairly uniform over the hunting areas.

MANAGEMENT RECOMMENDATIONS

Because bird hunting remains relatively consistent and this office conducts no management for game birds, the recording and reporting of birds harvested should be returned to the State.

1.5 FENCE CONSTRUCTION, INSPECTION, AND REPAIR

Currently, twelve federally listed endangered or threatened plants are found at PTA. An additional eleven species are classified as species of concern. To protect these rare native plants from the damaging effects of pigs, goats and sheep, four large fence units have been constructed at PTA.

Because the fence units are large, animals get trapped inside when the fence units are completed. To protect native species effectively within the fence unit, these animals must be removed. Animal removal methods are being developed and implemented by USDA personnel and many animals haven been recently removed from the fence units. Although a few animals are still inside, the fence units must be inspected periodically for damage and signs of animal ingress to prevent additional animals from breaching the fence units.

METHODS

Fence lines were examined semi-annually on foot and while driving in vehicles. Inspection report forms were used to record damage to the fence units and standardize the type of information collected by various inspectors. A database was used to store information collected on the data forms.

1.5a Kipuka Kalawamauna Fence Unit

The KKFU perimeter is approximately 12 kilometers and encompasses about 754 hectares (1,863 acres). The fence unit was completed in early 1998.

A total of two personnel-hours were spent conducting a fence inspection of KKFU in January 2003. No damage was noted.

1.5b Kipuka Alala-1 Fence Unit

The KA-1FU is approximately 9 kilometers long and encompasses 423 hectares (1,045 acres) in Training Area 23. The fence unit was completed in early 1999.

Three and a half personnel-hours were expended conducting a fence inspection in January 2003. Two low spots were filled with rocks.

1.5c Kipuka Alala-2 Fence Unit

KA-2 FU was completed in April 2001. The fence is approximately 18 kilometers long and encompasses approximately 1,637 hectares (4,045 acres) of Kipuka Alala. The fence unit abuts KA-1FU and together both fences protect approximately 2,060 hectares (5,090 acres).

Approximately 10 personnel-hours were expended inspecting the fence in January 2003. No damage was observed.

1.5d *Silene hawaiiensis* Fence Unit

The *Silene hawaiiensis* (SHFU) fence perimeter of 2.42 kilometers, encompassing approximately 13.5 hectares (33.3 acres). The fence unit was completed in April 1999.

Two personnel-hours were spent inspecting the fence in January 2003. No damage was found.

1.5e Puu Kapele and Puu Ahi

Puu Kapele Fence Unit encompasses 45 hectares (111 acres) and was erected by the State in 1981 on Parker Ranch lands. A single-strand barbed wire "people" fence was constructed by the Army in 1996 near Puu Ahi and encloses approximately 100 hectares (247 acres).

Four personnel-hours were spent repairing vehicle damage to Puu Kapele Fence Unit. Six personnel-hours were spent repairing vehicle damage to Puu Ahi Fence Unit.

DISCUSSION

Approximately 27.5 personnel-hours were expended inspecting and repairing fences in 2003. Both Puu Kapele and Puu Ahi fence units were inspected for the first time this year and both fence units will be inspected as part of the semi-annual inspections. The only damage to both fence units was old damage, which was repaired.

MANAGEMENT RECOMMENDATIONS

Because of the relatively small amount of damage that occurs, fence inspections should be continued on a semi-annual basis.

1.6 ANIMAL REMOVAL FROM FENCE UNITS

Large fence units have been erected at PTA to protect native vegetation from browsing ungulates. Many of these larges fence units have ungulates trapped inside. Removing these animals has been a top priority at PTA.

1.6a Kipuka Kalawamauna Fence Unit

From August 2002 to May 2003, USDA conducted staff hunts inside KKFU whenever military training permitted. NRS activities were scheduled to maximize USDA hunting opportunities. A total of 25 sheep and nine goats were removed from KKFU during this period.

In July 2003, USDA conducted aerial hunts in KKFU over two days. Three sheep were removed the first day and no animals were found the second day.

MANAGEMENT RECOMMENDATIONS

Continue aerial hunting and if necessary supplement with ground-based staff hunting until animals re removed from the fence unit. Quarterly aerial hunts should be conducted and at the end of the first year the frequency should be examined and adjusted, if necessary, to maintain maximum hunting success.

1.6b Kipuka Alala Fence Units

PUBLIC HUNTS

In 2002, access to the Kipuka Alala fence units for a special public hunt was granted. From September 9, 2002 to September 29, 2002, 18 days were available for archery hunting (Table 1-5). Hunters were required to make reservations in advance. For this hunt, 348 reservations were made, but only 153 (44%) hunter trips were actually completed. Approximately 1,870 hours were expended to capture 26 sheep.

Table 1-5. Kipuka Alala Public Hunting Results

Hunting Type	Days	Hunter trips	Hours	Animals	Capture Time (Hrs)	Capture Success
Archery	18	153	1,870	26	72	0.17
Muzzle Loader	12	55	520	15	35	0.27

From November 11, 2002 to December 6, 2002, 12 days were available for muzzleloader hunting (Table 1-5). Advanced reservations were required for access and 184 reservations were made. Only 55 (33%) hunter trips were completed. Approximately 520 hours were expended to capture 15 sheep.

STAFF HUNTING

USDA began ground hunting in both Kipuka Alala fence units in December 2002 after the public hunts ended. Between December 2002 and July 2003, USDA removed 60 sheep.

In July 2003, USDA conducted aerial hunts over two days. On the first day a total of 2.5 hours were spent hunting and 59 sheep in both fence units (the total hours includes time spent at KKFU). On the second day, a total of 3.5 hours were spent to remove an additional 11 sheep from both fence units (the total hours include time spent over KKFU).

MANAGEMENT RECOMMENDATIONS

Continue aerial hunting and if necessary supplement with ground-based staff hunting until animals re removed from the fence unit. Quarterly aerial hunts should be conducted and at the end of the first year the frequency should be examined and adjusted, if necessary, to maintain maximum hunting success.

CHAPTER 2: RARE PLANT MONITORING

2.1 PCSU CONTRACT REQUIREMENTS

REQUIREMENT 5.b.6

Monitor approximately eight *Silene hawaiiensis* (threatened plant) sites at Range 8 on an annual basis and provide a report. The report shall compare current observations to observations made in the course of past monitoring events, and shall recommend management actions.

DISCUSSION

The average height and number of the *S. hawaiiensis* found at Range 8 has decreased (α=0.1) in the years following the initial monitoring in 1997. There are now 75% fewer individuals than there were in 1999 when the greatest number of plants was recorded. Since 1997, the average plant height has also decreased by 70% (α=0.1). Possible causes of the observed decline are: training impacts, environmental conditions, and ungulate browsing. Past and present results indicate that the factors affecting the plants continue to be environmental changes and, most importantly, ungulate impacts.

REQUIREMENT 5.b.7

GPS coordinates shall be obtained for all vegetation and endangered species plots and entered into the GIS database.

DISCUSSION

GPS coordinates have been collected for vegetation plots, rare plant locations and monitoring plots. The previous coordinates proved to be inaccurate; therefore, when locations are identified or newly recorded, accurate coordinates are collected. This has increased the efficiency of monitoring and management efforts.

REQUIREMENT 5.b.8

Monitoring populations of listed plant Priority Species (PS) 1 and 2 (9 species) on a semi-annual basis. Performing cursory inspections of the same populations on a quarterly basis. Monitoring activities shall be used to assess changes in the population structure (numbers of reproductive adults versus seedlings), and vigor (length of longest stem, stem diameter) in response to ungulate grazing pressure. Collecting of fruits shall be done, if available, at the time of monitoring. Results from the monitoring shall be evaluated and recommendations made for management actions. The report shall contain monitoring results from past years to provide an overall assessment of trends of each species and shall include photographs.

DISCUSSION

Past efforts have resulted in the reidentification of recorded locations and the discovery of new, unrecorded locations of PS-1 plants. This year's focus has shifted to reidentifying PS-2 plants and managing known locations of PS-1 and PS-2 plants. Photos were taken and archived for reference.

REQUIREMENT 5.b.9

Monitoring populations of Priority Species (PS) 3, 4 and 5 (5 species) on an annual basis. Monitoring activities shall be used to assess changes in the population structure (numbers of reproductive adults

versus seedlings), and vigor (length of longest stem, stem diameter) in response to ungulate grazing pressure. Collecting of fruits shall be done, if available at the time of monitoring. Results from the monitoring shall be evaluated and recommendations made for management actions. The report shall contain monitoring results from past years to provide an overall assessment of temporal trends of each species and shall include photographs.

DISCUSSION

Following the reconfirmation of plant locations and the implementation of a monitoring schedule for PS-1 plants, PS-2-4 species locations will be reconfirmed and monitored. Photos taken will be archived for reference.

A monitoring program for endangered and threatened species ranked PS-3-5 will be implemented. Once a monitoring program for endangered and threatened species has been implemented, species of concern ranked as PS-3-5 will be monitored biannually rather than annually. Higher management priority and greater monitoring frequency must be given to those species listed as endangered or threatened because of the need to provide accurate information to regulatory agencies.

2.2 INTRODUCTION

With the reidentification of species ranked as PS-1 completed, efforts shifted to managing and reidentifying the more abundant PS-2 species. Because of the large volume of data, this effort required data be well organized. GIS data were completely reorganized to better assess and track plant sites, locations, and individuals. In addition, a database was developed in Microsoft Access to organize monitoring and management data. This database integrates GIS data with plant monitoring and management data. This is the first comprehensive database developed for rare plant monitoring and management at PTA.

2.3 RARE PLANT MONITORING AND MANAGEMENT

INTRODUCTION

Due to PTA's land use history and isolation, access to the area has been limited. As a result PTA harbors unique ecosystems and vegetation. For example, PTA is one of the largest intact sub-alpine dryland forests remaining in the state. Not only is the ecosystem itself rare but so are many of its components. For example, at PTA there are eleven endangered species, one threatened species, and eleven species of concern, including one undescribed species. Six of these plant species are found only at PTA and two species are found at PTA and only one or two other locations in the State.

A Priority Species (PS) list was developed to prioritize monitoring and management actions. *Schiedea hawaiiensis* and *Tetramolopium* sp. 1 are the only PS-1 plants, which are not listed as endangered. These species of concern are included because *S. hawaiiensis* has less than 20 naturally occurring individuals and *T.* sp. 1 has less than 100 known individuals. Therefore, they receive the highest priority for management actions. The Priority Species list has been defined and species assigned as follows:

Priority Species of Pohakuloa Training Area

Priority Species 1 (PS-1) – Plants species with fewer than 500 individuals and/or 5 or fewer populations remaining statewide.

Hedyotis coriacea (E)

Neraudia ovata (E)

Solanum incompletum (E)

Schiedea hawaiiensis (SOC)

Tetramolopium arenarium ssp. *arenarium* (E)

Tetramolopium sp. 1 (SOC)

Priority Species 2 (PS-2) – Plant species with 500 - 1,000 individuals and/or 6 - 10 populations remaining statewide.

Asplenium fragile var. *insulare* (E)

Silene lanceolata (E)

Zanthoxylum hawaiiense (E)

Priority Species 3 (PS-3) – Plant species with 1,000 – 2,000 individuals and/or 10 - 20 populations remaining statewide.

Festuca hawaiiensis (SOC)

Portulaca sclerocarpa (E)

Priority Species 4 (PS-4) – Plant species with 2,000 – 5,000 individuals and/or 20 - 40 populations remaining statewide.

Eragrostis deflexa (SOC)

Priority Species 5 (PS-5) – Plant species with more than 5,000 individuals and/or more than 40 populations remaining statewide.

Chamaesyce olowaluana (SOC)

Cystopteris douglasii (SOC)

Dubautia arborea (SOC)

Exocarpos gaudichaudii (SOC)

Haplostachys haplostachya (E)

Melicope hawaiiensis (SOC)

Portulaca villosa (SOC)

Silene hawaiiensis (T)

Spermolepis hawaiiensis (E)

Stenogyne angustifolia (E)

Tetramolopium consanguineum ssp. leptophyllum (SOC)

The term population is one that is often difficult to define in functional terms. Several of the species at PTA are found in isolated clusters of plants, which occupy only a fraction of the species' historic range. Other species appear abundant because they have a large absolute number of individuals at PTA, but their distributions are restricted to PTA and they are found no where else. Due to the differences in the distribution of species, they cannot easily be broken into populations on spatial terms. The most effective means of defining a population is through genetic information that is largely lacking for the species found at PTA. Therefore; the term population is used infrequently in the following text. The term site is used to

roughly identify aggregations of plants as being associated for biotic, abiotic, and management reasons. The term location is used to describe the one to many clusters of plants within a site. The location is the unit that is used for mapping purposes and each has a coordinate associated with it. The term individual describes a single representative of a particular species. There are one to many individuals at a given location.

METHODS

MONITORING

Monitoring units are belt transects with a base stake and end stake identifying the beginning and end of the plot. Extending a measuring tape between the base and end stakes delineates the centerline of the plot. The belt is typically six meters wide, three meters on either side of the centerline. The length of the belt varies depending on the distribution of the plants at the site being monitored. However, it is typically 10 meters long.

Once laid out, the locations of all rare plants within the belt are mapped. This is accomplished using an x- and y-coordinate system. The distance along (y-axis) and out (x-axis) from the meter tape is determined and recorded in meters.

Information collected on each plant consists of height, phenological state, age class, vigor, and presence of animal damage. The height or length of the longest stem of the plant is measured in centimeters or meters and is measured from the base of the plant to the apical meristem of the longest portion of the plant.

The phenological state is classified as: Vegetative, not currently flowering or fruiting; Reproductive, viable flowers are present on the plant; Fruiting, fruit is present on the plant from the most recent flowering event.

A seedling is a plant with apparently functional cotyledons present. A juvenile is classified as a plant that has lost its cotyledons or if present they are apparently non-functional and it has not flowered. An adult is a plant that has flowered in its lifetime, regardless of its current phenological state.

The vigor of the plant is classified as healthy when the plant is producing new leaves, most living leaves are green, and the plant appears is generally robust and thriving. The vigor is moderate when the plant is producing fewer new leaves, the living leaves are not quite as green as compared to a healthy plant, and the plant appears viable but not as robust or thriving to the extent that a healthy plant is. The vigor is poor when the plant is producing few, if any, new leaves. Those leaves present may be pale green and/or the edges are brown. In some species the leaves may have little chlorophyll and be red with photo-protective pigments.

Browse is indicated by portions of the plant showing signs of being consumed by ungulates. Browse is further classified as recent browse when the browsed portions of the plant have not healed over. In addition, the browsed portions may be white and there is no new growth above the browsed portions. The browsed portion of the plant having healed over indicates old browse and there is new growth above the browsed portions. No browse is classified as no parts of the plant have been consumed by ungulates.

Seed collection follows the restrictions outlined in the collection permit issued by the USFWS.

MANAGEMENT

Small-scale exclosures are used to provide for the immediate protection of individuals. When possible the exclosure is of sufficient size to include the plant's habitat. These small exclosures address the immediate needs of individuals, but do not provide for the long-term viability of the population and its habitat. Only large-scale fence units can protect enough habitat for conserving populations.

A variety of materials are used for emergency exclosures and include plastic construction fencing, hogwire, or concertina wire. Posts include; T-posts, form stakes and metal conduit, or dead tree branches. Materials selected are based on available resources and are site dependent.

Short-term goals for weed control are meant to address the immediate needs of individuals and provide limited benefit to the surrounding habitat. These are general guidelines and will be adjusted to address the short-term needs of a site. Factors considered are substrate, vegetation cover, topography, and fire threat. The guidelines are not long-term goals for an individual plant, site, or population, but instead address immediate threats.

General guidelines for short-term alien plant control include: control within a distance of 25-50 meters of listed plants depending upon substrate, vegetation cover, topography, and fire threat. Weeds are manually removed within one meter of a listed plant. Beyond one meter weeds may be mechanically controlled using gas-powered weed trimmers. Weeds are completely removed manually or mechanically within three meters of a listed plant and no herbicide is used within three meters of a listed plant. Herbicide may be used beyond three meters of listed plants during calm weather conditions. Broadleaf species such as *Kalanchöe tubiflora* and *Solanum pseudocapsicum* are chemically controlled using the herbicides Garlon 3A and 2,4-D.

Pennisetum setaceum is typically cut with weed whackers to remove dormant and dead vegetation. The young, actively growing portions are sprayed with Round-Up following resprout. Control of *P. setaceum* requires a great deal of time and effort. Control requires the manual or mechanical removal of the dead and/or dormant portions of the plant. When the plants resprout one to two weeks later the young, actively growing shoots are treated with herbicide. A single treatment is typically not effective in killing all plants treated. Complete kill requires repeated treatments to ensure all individuals have been killed. Although this is labor and time intensive, it is currently the most effective method of control. Fortunately, once an area has been successfully treated, *P. setaceum* does not quickly reinvade.

2.3a *Hedyotis coriacea*

INTRODUCTION

Efforts over two and a half years have resulted in the reidentification of all but three *H. coriacea* locations. Previous records indicated that there were nine sites with 31 locations and 33 to 43 individuals. NRS has identified ten sites with 58 locations and 84 individuals. New individuals continue to be found during surveys and management actions. In addition to surveying efforts, all individuals have been protected with emergency exclosures or are within large-scale fence units. Protecting these plants has allowed them to recover vegetatively from ungulate damage and many have been able to produce seed, some for the first time. With reidentification efforts complete, habitat management will commence.

RESULTS

No additional individuals have been reidentified at Site 01 (Figure 2-1) within the KKFU.

At Site 02, within Training Area 22 (Figure 2-1), three previously unrecorded individuals were discovered. There have been 27 individuals recorded at this site; however, four have died, reducing the total number of living plants to 23. The new individuals have been protected with emergency exclosures. Seed was collected from four individuals.

A tenth individual was found within the emergency exclosure at Site 03 (Figure 2-2). All individuals at this site are within emergency exclosures. Seed was collected from three of the ten individuals.

Currently there are a total of five living plants at Site 04 (Figure 2-2). Emergency exclosures were enlarged during the 2002-2003 reporting period. A single exclosure protects plants 01 and 02. Plant 04 is solitary within an enlarged exclosure. Plants 05 and 06 are found together within a newly enlarged exclosure. No seed was collected from these plants during the reporting period. *P. setaceum* immediately surrounding the plants was manually removed.

The plants at Site 05 (Figure 2-2) continue to do well because of their protection. The emergency exclosure protecting plant 02 was enlarged. Seed was collected from seven of the nine plants at this site.

Plant 01 at Site 06 is a solitary individual (Figure 2-1). It is protected by an emergency exclosure. *P setaceum* was removed from the immediate vicinity of the plant.

Seed was collected from two of the three individuals at Site 07 (Figure 2-1).

Seed was collected from plant 01 at Site 09 (Figure 2-2); this is the first seed collected from this now solitary individual.

Seven newly recorded individuals were found at Site 10 (Figure 2-2). Four plants found outside the KA-1FU were protected with emergency exclosures. A fifth plant found during the previous reporting period was protected as well. Three of the new plants were found inside of the KA-1FU, emergency exclosures were not placed around these plants because of the relatively low number of ungulates within the fence unit. This population now consists of 31 individuals. All individuals are protected with emergency exclosures or are found within the KA-1FU.

DISCUSSION

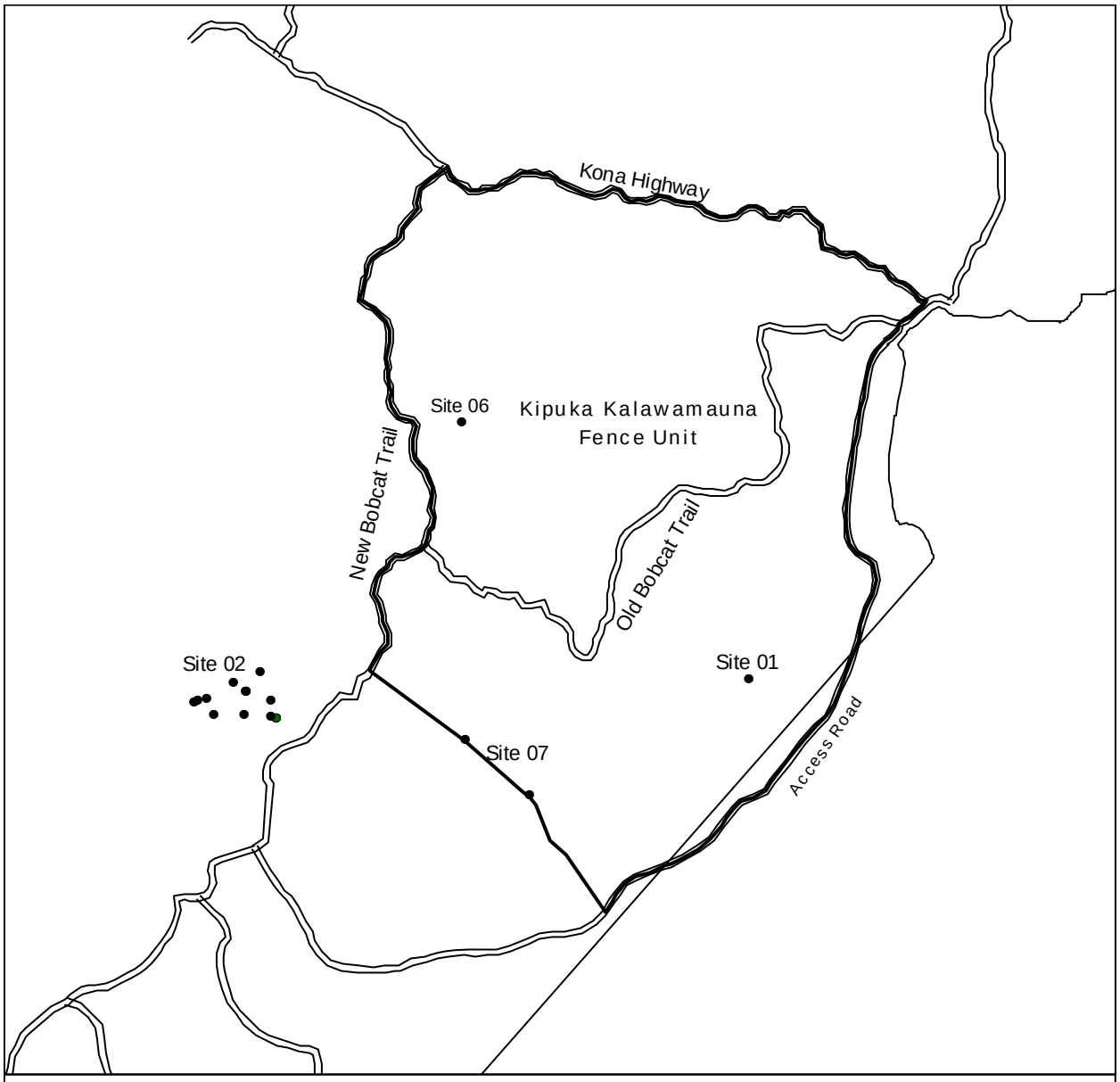
All but three previously recorded plant locations have been reidentified or other wise accounted for. During the 2002-2003 reporting period 11 individuals were newly recorded. Surveys and management for this species has increased the total number of known, living individuals at PTA to 84. When found outside of large-scale fence units, new individuals were protected with emergency exclosures and all known individuals have been protected by emergency exclosures or large-scale fence units.

Reidentification of previously recorded plant locations is complete. The remaining unconfirmed locations will be surveyed during routine monitoring of the other individuals in the site. Efforts will now shift from reidentification to comprehensive monitoring and inspections as well as habitat management. The majority of individuals are found in habitats that haven't been heavily invaded by *P. setaceum;* therefore it may be possible to control this threat and prevent it from further invading the habitat and jeopardizing individuals. Control of *P. setaceum* around individuals and within their habitat benefits the plants and species by reducing the fuel load, which increases fire risk as well as by reducing competition for space, water, and nutrients.

MANAGEMENT RECOMMENDATIONS

P. setaceum is present in the areas where *H. coriacea* is found at low but increasing densities. *P. setaceum* should be controlled within 25 meters of known plant locations.

Large-scale fence units are necessary for the long-term viability of the species. The widely scattered distribution of *H. coriacea*, its longevity, and its low recruitment suggest that it may require a substantial area to maintain and increase its population size. Other than one plant on Maui, PTA is the only locale with known individuals. This species cannot be recovered or even sustained without large-scale fence units designed to protect the habitat in which the species is naturally found.



Hedyotis coriacea
● Plant Locations

Roads
Kipuka Kalawamauna Fence Unit

Figure 2-1

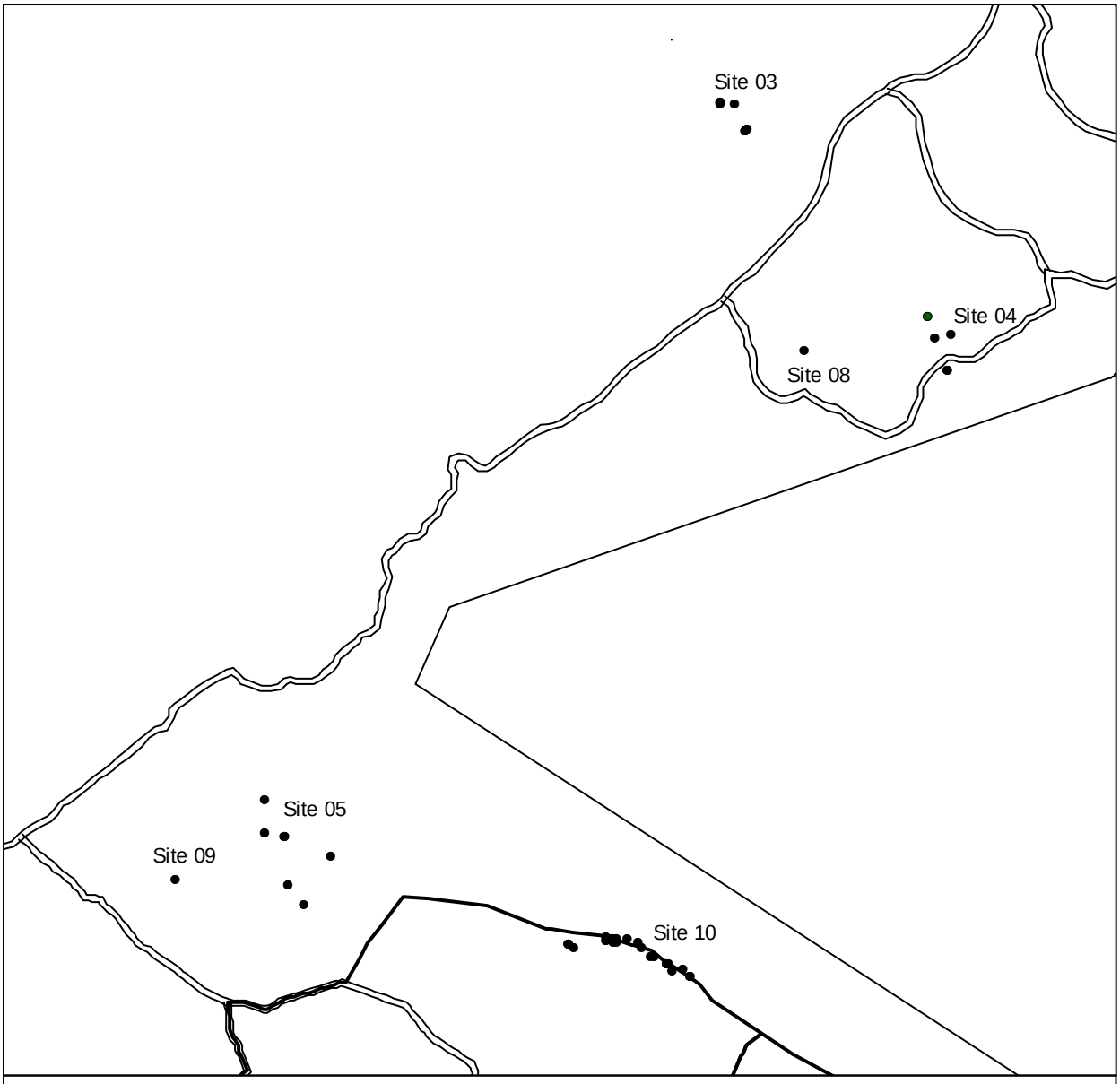
Locations of Sites 01, 02, 06, 07.

Scale 1 : 35,000

500 0 500

Meters

N



Hedyotis coriacea
Plant Locations

Roads
Kipuka Alala Fence Units

Figure 2-2

Locations of Sites
03, 04, 05, 08, 09, 10.

Scale 1 : 35,000

500 0 500

Meters

N

2.3b *Neraudia ovata*

INTRODUCTION

Neraudia ovata is a critically endangered member of the Stinging Nettle family (Urticaceae). The loss of its stinging hairs may be due to the lack of native mammalian herbivores in Hawaii. Consequentially, the introduced ungulates in Hawaii have reduced its distribution to four known sites with a total of nine adult individuals. Four adults are found within PTA's borders and three individuals are found on State land immediately adjacent to PTA. A single individual is found within the State of Hawaii's Manuka Natural Area Reserve in south Kona. In addition, a solitary individual is found on private lands in north Kona.

RESULTS

Monitoring and inspections have continued with positive results from emergency exclosures. In the fall of 2002, rain enabled germination from the seed bank under several adult plants at Site 01. From the initial flush of approximately 50, 15 juvenile plants remain. Germination occurred beneath plant 0101, which was recorded as dead in September of 1999. The 15 juveniles are being cared for through supplemental irrigation on an approximately monthly basis.

Approximately 22 personnel-hours have been spent manually, mechanically, and chemically controlling *P. setaceum, Kalanchöe tubiflora,* and *Solanum pseudocapsicum* in approximately 0.57 hectares (1.4 acres) of habitat for *N. ovata* and *Solanum incompletum* coexisting in the area (Figure 2-3).

At Site 02 the emergency exclosures of concertina wire did not adequately protect the two plants. Ungulates were breaching the exclosure and browsing the plants. The plants were further protected with plastic construction fencing and the concertina wire was moved outside and adjacent to the construction fencing. No further browse has been observed and the plants have vegetatively recovered.

Approximately 17 personnel-hours have been spent manually, mechanically and chemically controlling *P. setaceum* in 0.69 hectares (1.7 acres) at this site (Figure 2-4). *P. setaceum* also is being controlled in areas down slope of the plants to prevent the possibility of fire moving upslope and reaching the plants.

A third, newly recorded, individual was found at this site while conducting management actions in the area in June 2003. The plant was protected in July 2003 using the plastic construction fencing. *P. setaceum* is present in the area surrounding the plant.

Plant Locations
- • *Neraudia ovata*
- ○ *Solanum incompletum*
- Short-term Control Goals
- Area Controlled

Figure 2-3

Short-term Control Goals and Control Efforts.

S. incompletum Stie 01

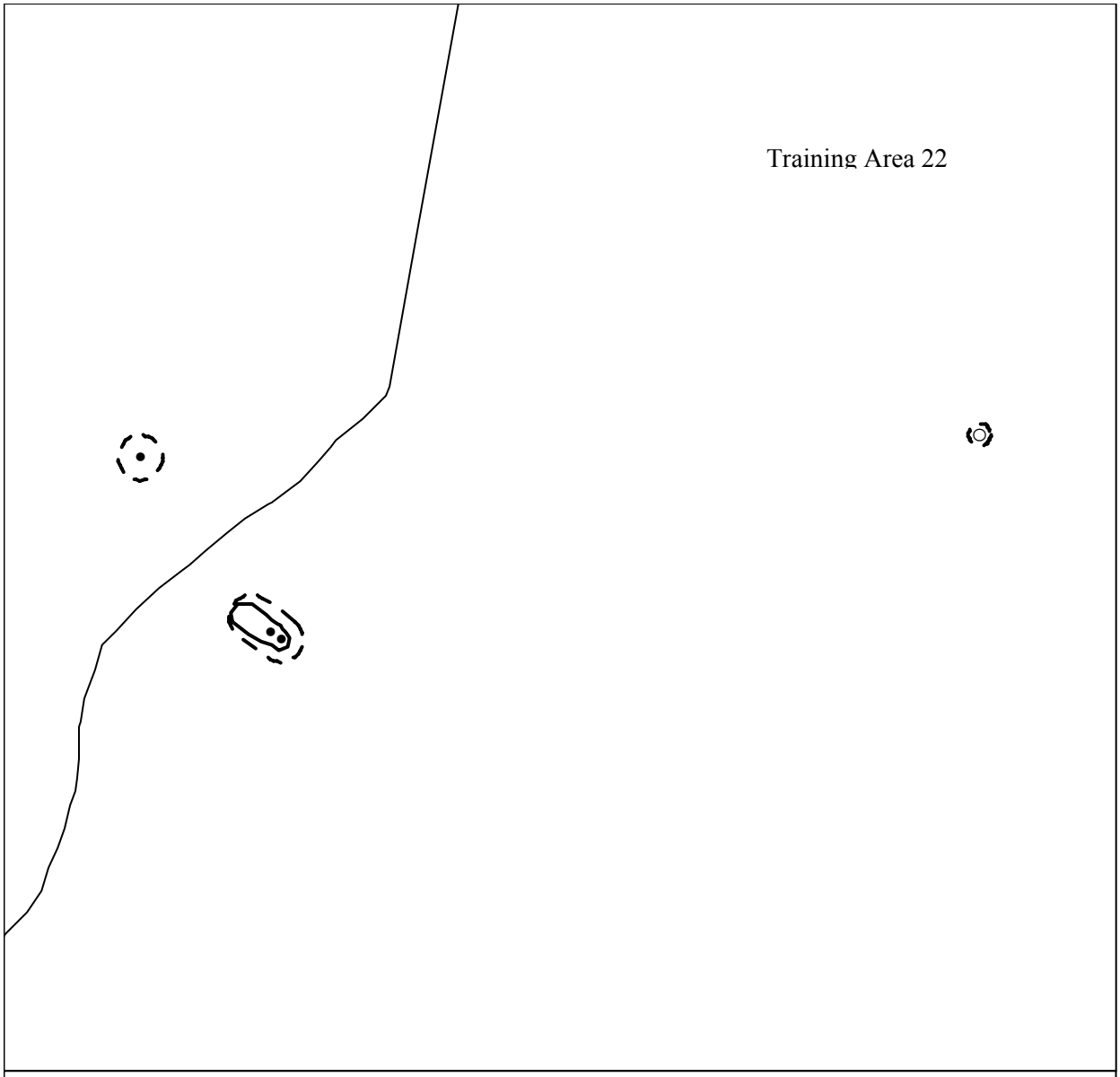
N. ovata Site 01

Scale 1 : 5,000

50 0 50

Meters

N



Plant Locations
- *Neraudia ovata*
- *Solanum incompletum*

Short-term Control Goals
Area Controlled

Figure 2-4

Short-term Control Goals and Control Efforts.

S. incompletum Stie 02

N. ovata Site 02

Scale 1 : 15,000

200 0 200

N

Meters

DISCUSSION

Needed recruitment of this long-lived perennial has occurred at Site 01. The adult plants are in excess of ten years of age and their lifespan is unknown. It is therefore very important to make every effort to ensure that the seedlings survive.

Weed control has been effective in controlling alien species around individual plants. This has reduced fuel loads and competition. Ungulate exclusion together with weed control may have contributed to the germination observed.

Emergency exclosures and weed control have reduced the immediate threats to the individual plants. However, ungulates remain in the area and three weed species are also present. The presence of ungulates and alien plant species continues to degrade the habitat in which *N. ovata* is found. PTA is home to the most intact occupied habitat for this species. The plants at PTA and in adjacent lands are vital to the recovery of this species.

MANAGEMENT RECOMMENDATIONS

Further surveys need to be conducted in areas where plants have been recorded as well as in areas identified as having potentially suitable habitat. Every individual found benefits this species that has a total of nine mature individuals.

All known plants have been protected with emergency exclosures. Emergency exclosures protect individuals, but ungulates and/or alien plant species continually degrade the habitat in which the plants are found. Large-scale fence units must be constructed to effectively protect this species and its habitat from the deleterious impacts caused by feral ungulates. Furthermore, large-scale fence units would provide protected areas in which outplanting can be conducted to augment existing populations and/or establish new ones. Until these can be constructed, expansion of the exclosures to protect an area of approximately 500 square meters around each plant would allow for potential recruitment beyond the immediate canopy of the adult plants and provide additional area where other native species may regenerate.

The short-term goals for the weed species found at these sites are illustrated in Figure 2-3 and Figure 2-4. Control of alien plant species will continue and short-term goals will be achieved. The new *N. ovata* individual is in an extremely fire prone area and *P. setaceum* control is a high priority; therefore control of alien plant species is absolutely necessary to achieve short-term goals.

Cooperative efforts with state and other federal agencies have been made to reintroduce this species to portions of its historic range outside of PTA (Chapter 5). These efforts are vital to ensure that any catastrophic events at PTA do not jeopardize the continued existence of this species. These efforts should continue and be expanded to include other responsible agencies and surrounding landowners.

2.3c *Solanum incompletum*

INTRODUCTION

PTA is the only known locale at which this species is found. This species is managed for rodents, ungulates, and weeds, which have severely impacted the habitat. At Site 0101, the large shade cloth canopy and the 500-600 m^2 hogwire exclosure constructed during the previous reporting period have been effective in reducing solar radiation and preventing ungulate damage. Recruitment has been observed as

well as improvement in the vigor of the plants. The larger exclosure has allowed the vegetation in the immediate area surrounding *S. incompletum* to recover towards a natural state.

RESULTS

Known sites continue to be monitored and inspected to assess the needs and threats to the plants. Weed control efforts of *P. setaceum*, *K. tubiflora*, and *S. pseudocapsicum* have begun. As discussed in the Results section of *N. ovata*, approximately 22 personnel-hours have been spent manually, mechanically, and chemically controlling weed species in approximately 0.57 hectares (1.4 acres) of habitat for *N. ovata* and *S. incompletum* (Figure 2-3). This figure also graphically illustrates the short-term weed control goals and progress towards them for this area.

During weed control efforts at Site 0101, a new *S. incompletum* individual was found (Figure 2-4). The solitary individual was immediately protected with a small emergency exclosure. There are now seven known locations at this site.

A new site was found during a survey in the northern part of Training Area 22. Four individuals were found in late May 2003 and were protected with an emergency exclosure in early July 2003. Fountain grass was manually removed from within the exclosure. Unfortunately, the plants had been browsed between the time of discovery and their protection six weeks later.

There are currently 46 known naturally occurring *S. incompletum* individuals within eight locations and two sites at PTA. All individuals are protected by emergency exclosures. In addition, outplanting efforts have established new sites at PTA and within the species historic range (Chapter 5).

DISCUSSION

Constructing a larger hogwire exclosure at Site 0101 has improved the protection of the plants within it. The habitat within the exclosure is improving and management is more effective. Weed management is also occurring on a larger scale in the kipuka and on the adjacent lava flow where this species and *N. ovata* are found. *S. pseudocapsicum* is of particular interest for control because this introduced species is in the same genus as the endangered *S. incompletum*. Control of *S. pesudocapiscum* may reduce the possibility of cross-fertilization, insect damage, or disease transmission.

MANAGEMENT RECOMMENDATIONS

All known *S. incompletum* have been protected with emergency exclosures or small exclosures intended for immediate protection of individuals from ungulate damage. The need for habitat protection for critically endangered species was discussed in the Management Recommendations for *N. ovata* and is applicable to *S. incompletum* as well. Recovery of a critically endangered species with reduced population size and distribution cannot be accomplished by protecting individual plants and the small area around them. Currently, less than a quarter acre of this species' habitat is protected. Weed control is being conducted; however, ungulates have free access to the plant's habitat. To prevent increasing habitat degradation by ungulates, large-scale fence units must be erected. Recovery efforts will probably be more successful in habitat that is intact and requires less management than degraded areas.

Weed control has begun and will be vital for the recovery of the habitat for the species. This species is found in and adjacent to a degraded Naio kipuka that has been invaded by *P. setaceum* and short-term control is vital to reduce the immediate threat. Future long-term efforts in this area will control *P. setaceum* on the adjacent lava flow and within the kipuka occupied by both *N. ovata* and *S. incompletum*. Weed control is needed at the newly recorded site as well.

The newly discovered site suggests the need for increased surveys of areas that may contain suitable habitat for the species. Initial surveys should target the area between known sites and expand into suitable habitat in other areas.

2.3d *Schiedea hawaiiensis*

INTRODUCTION

In 1997, *S. hawaiiensis* was discovered at PTA, the species' only known location. At that time there were two extant individuals, one of which subsequently died. Great effort has been made to protect these plants from the browsing damage of feral ungulates as well as rodents. Ungulate and rodent exclosures and lethal control have been used to minimize browse. Eliminating the threats to the individual plants and favorable rains enabled successful recruitment from the seed bank and approximately 30 seedlings emerged during the contract period. Fifteen closely spaced individuals were collected since they were likely to die due to competition with each other.

RESULTS

Fifteen of the original 30 seedlings collected from the field and grown out in the Rare Plant Propagation Facility were subsequently reintroduced at sites within the Kipuka Kalawamauna Fence Unit. Details on this effort can be found in Chapter 5. The other 15 seedlings remained in the field and six have survived.

DISCUSSION

Intensive management against ungulate and rodent impacts has been successful in protecting existing plants as well as enabling limited regeneration from the seed bank. These new individuals will be a source of new genetic material that can be used to augment the natural site and establish new sites.

Expanding the distribution of this species has been accomplished at PTA through the collection of seeds, cuttings, and field-collected plants. The plants resulting from these collection methods are subsequently reintroduction into new areas. In addition, cooperative efforts with the State of Hawaii have increased the distribution of this species outside of PTA (Chapter 5).

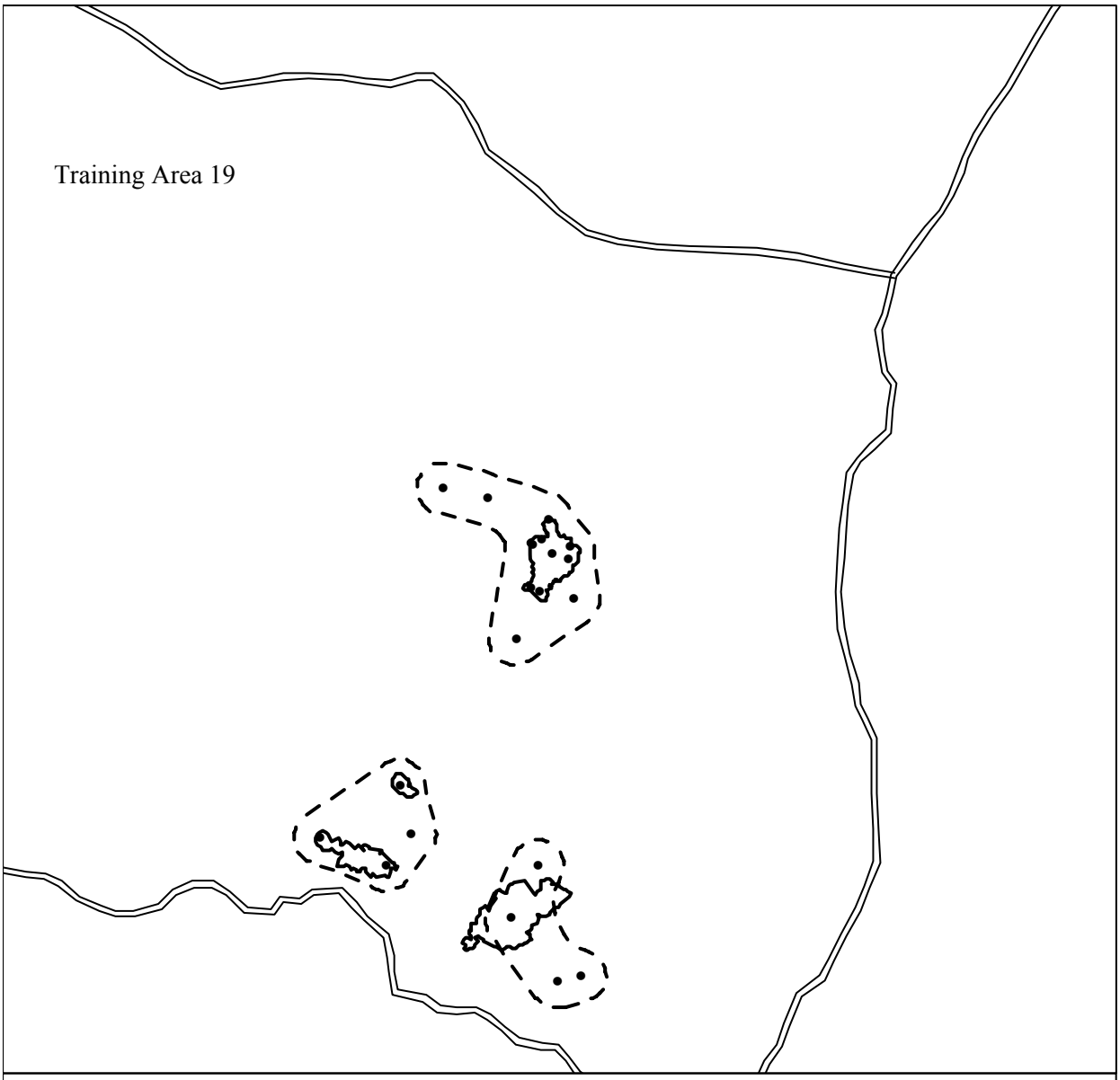
MANAGEMENT RECOMMENDATIONS

The management of rodent and ungulates must continue to ensure the survival of *S. hawaiiensis.* Efforts should continue to establish new sites to enhance the long-term viability of the species. Because ungulates are extremely detrimental to this species and its habitat, it would benefit from a large-scale fence unit to protect its only known location.

2.3e *Tetramolopium arenarium* ssp. *arenarium*

INTRODUCTION

T. arenarium is a species found only at PTA and its distribution is limited to one site (Figure 2-5). All known locations are being managed for *P. setaceum* within 50 meters of plant locations. In addition, control areas will be linked together to form contiguous areas (Figure 2-5). Although *T. arenarium* is found in the fire-prone native habitat of a *Dodonaea viscosa* shrubland, the control of *P. setaceum* may reduce the fuel load as well as reducing the competition for space, nutrients, and water with *T. arenarium*.



Tetramolopium arenarium
- Plant Locations
- Short-term Control Goals
- Area Controlled

Figure 2-5

Short-term Control Goals and Control Efforts.

Site 01

Scale 1 : 13,000

100 0 100 200

Meters

N

RESULTS

Approximately 90.5 personnel-hours have been spent on manual, mechanical, and chemical control of *P. setaceum* in 3.0 hectares (7.5 acres) in and around *T. arenarium* locations (Figure 2-5).

DISCUSSION

Control of *P. setaceum* is going well and will continue until the short-term goal of clearing 15.5 hectares (38 acres) is met.

MANAGEMENT RECOMMENDATIONS

Control of *P. setaceum* is a high priority and will continue into the future beyond short-term goals. *P. setaceum* remains the greatest threat to the ecosystem in which *T. arenarium* is found. An important step to increase the long-term viability of the species is to coordinate outplanting and management within its historic range both inside and outside of PTA's borders.

2.3f *Tetramolopium* sp. 1

INTRODUCTION

T. sp. 1 is an undescribed species that is found only at PTA in three locations. The greatest threats to this species are degradation of its habitat and increasing fire risk from *P. setaceum*. Management efforts have increased for this undescribed species during this reporting period.

RESULTS

Approximately 10 personnel-hours have been spent manually, mechanically, and chemically controlling *P. setaceum* in 0.61 hectares (1.5 acres) at Site 0301.

MANAGEMENT RECOMMENDATIONS

Control of *P. setaceum* will continue for this species. Although ungulates do not seek out this plant, the two unprotected sites should be protected to prevent accidental trampling by ungulates.

2.3g *Asplenium fragile* var. *insulare*

Monitoring and management have focused on other species during the reporting period.

2.3h *Silene lanceolata*

INTRODUCTION

Efforts to identify new and reidentify previously recorded Priority Species-1 are almost completed. NRS has expanded survey and management efforts to PS-2 plants. *S. lanceolata* populations have been declining at PTA in recent years. *S. lanceolata* is considered a high priority species for surveys and management. Efforts to reidentify locations of *S. lanceolata* have increased during the 2002-2003 reporting period. Surveys have been conducted in Training Areas 17 and 22. In addition, management actions that were begun last reporting period continue and have been expanded to other sites.

Surveys in Training Area 17 were conducted due to its potential use as a military maneuver area. In addition, this was an area where *S. lanceolata* had been previously recorded, and reidentifying individuals in this area was a priority. A survey was also conducted in Training Area 22 to reidentify previously recorded locations of *S. lanceolata* and *Zanthoxylum hawaiiense*.

Surveys were designed in ArcView. Transects were spaced ten meters apart in Training Area 17 and fifteen meters apart in Training Area 22. Waypoints for the beginning and ending of the transects were loaded into GPS units. Personnel walked the survey area north and south between waypoints. The actual route walked was recorded by the GPS (Figure 2- 6).

Field observations indicate that *S. lanceolata* sites are severely impacted by *P. setaceum*, which is the greatest weed threat at PTA and one of the highest priorities for rare species management. The increasing density of *P. setaceum* crowds out *S. lanceolata* and increases fuel loads. High densities of *P. setaceum* around *S. lanceolata* caused the loss of individuals during the 1994 and 1999 Puu Anahulu/Kipuka Kalawamauna fires. During the 2002-2003 reporting period, efforts have been made to reduce the risk through manual, mechanical, and chemical control of *P. setaceum*.

RESULTS

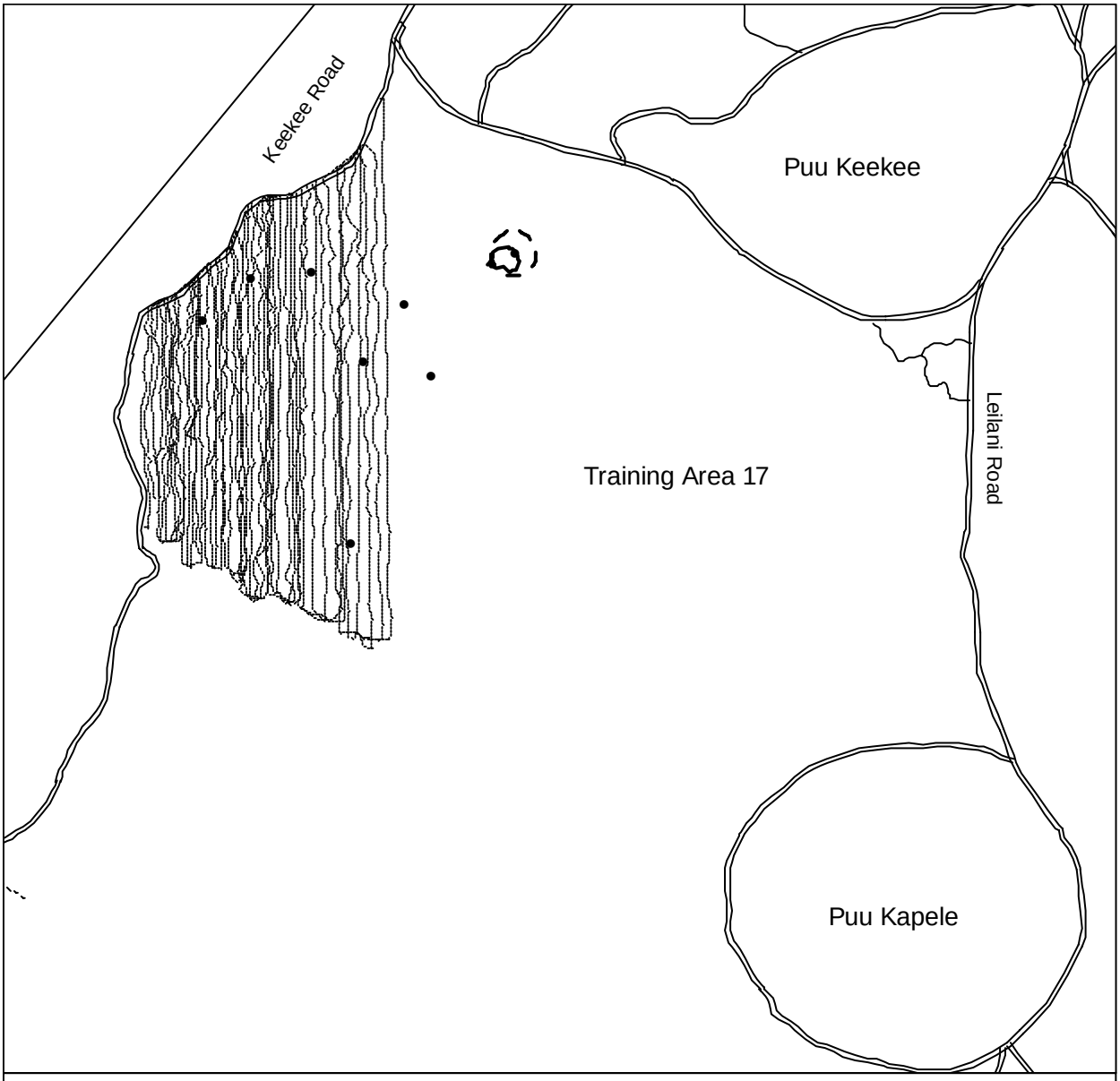
Approximately ten personnel-days were spent surveying 45 hectares (110 acres) of approximately 100 hectares (250 acres) of habitat in which the species had been recorded in Training Area 17 (Figure 2-6). No *S. lanceolata* or other listed species were found.

Three personnel-days were spent on an initial survey for *S. lanceolata* and *Z. hawaiiense* in the southern portion of Training Area 22. Again, no *S. lanceolata* were found within the area surveyed. Results for *Z. hawaiiense* will be discussed in later sections. During a survey in northern Training Area 22, NRS was able to reidentify a previously recorded *S. lanceolata* location (0401) and has subsequently been protected with an emergency exclosure.

A newly recorded location (1005) was found during management actions within the KKFU and is currently being managed for ungulates.

Approximately 227 personnel-hours were expended in manual, mechanical, and chemical control of P. *setaceum* over 1.9 hectares (4.7 acres) at PTA during the contract period. Personnel involved included volunteer groups from three educational and community groups. PTA's Environmental Educator, Kuhea Paracuelles, organized volunteer groups. These groups concentrated their efforts on manually removing *P. setaceum* within 1 meter around *S. lanceolata* individuals and other native plants. After this initial removal near the plants, gas-powered weed trimmers were used in more open areas.

Control of *P. setaceum* has focused around four sites. Approximately 0.25 hectares (0.63 acres) at Site 01 (Figure 2-6) have been controlled. At Site 06 approximately 0.45 hectares (1.1 acres) have been treated (Figure 2-7). The majority of *P. setaceum* control has been conducted at Site 07 (Figure 2-8) and Site 10 (Figure 2-9). Approximately 0.65 hectares (1.6 acres) have been controlled at Site 07. Approximately 0.6 hectares (1.5 acres) have been treated at Site 10.



Silene lanceolata

- Plant Locations
- Surveyed Area
- Short-term Control Goals
- Area Controlled

Figure 2-6

Survey Area,
Short-term Control Goals,
and Control Efforts.

Scale 1 : 15,000

100 0 100 200

Meters

N

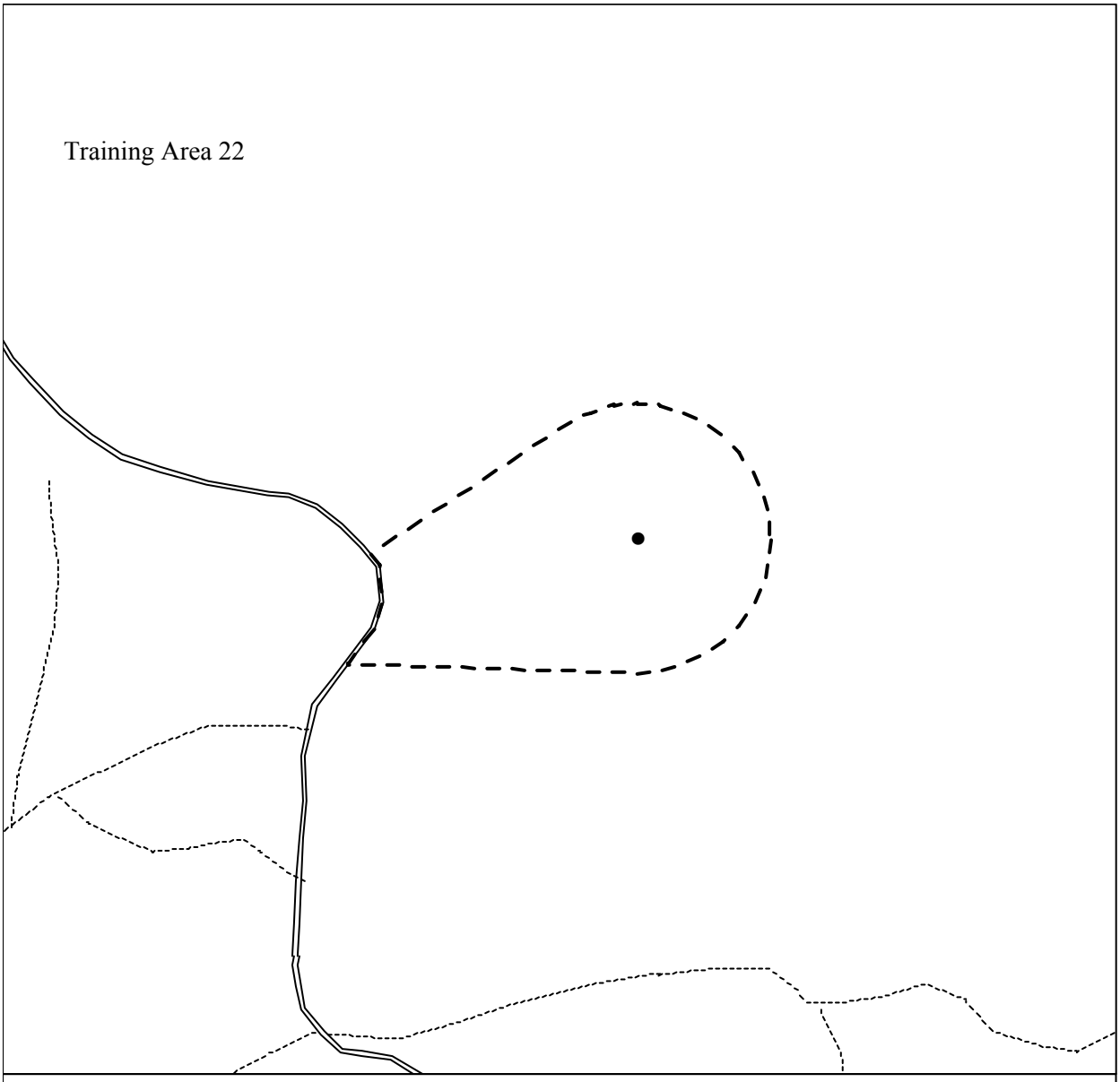
DISCUSSION

Training Area 17 has been severely impacted by *P. setaceum* invasion and there was evidence of fire in the area. These factors may account for the difficulty in reidentifying previously recorded locations. All potential *S. lanceolata* habitats in the area have yet to be surveyed. Further work in the area may reveal areas that haven't been as severely impacted by *P. setaceum* and fire.

A single day of survey work has been conducted in southern Training Area 22 to reidentify the previously recorded locations in that area. Not enough area has been surveyed to draw any conclusions from the results obtained thus far. The reidentified location in northern Training Area 22, 0401, has been protected. Unfortunately, ungulates had browsed the plants in the intervening time between their discovery and protection six weeks later. This exemplifies the need for large-scale fence units to protect listed species and their habitat. Only complete exclusion of ungulates from endangered and threatened plant habitat will be effective in preventing ungulate damage to these species. Without complete exclusion, using large-scale fence units, ungulates would have unrestrained access to endangered and threatened plant species. Field observations show that a small number of ungulates can do a great deal of damage to unprotected plants in a very sort period of time. This type of situation will continue to jeopardize the long-term existence of these species.

MANAGEMENT RECOMMENDATIONS

Surveys to reidentify previously recorded locations and to identify new locations will continue. Once found, locations will be protected from ungulates and weed species will be controlled. Plants and their habitat must be protected and improved to sustain viable populations. The most effective method for preserving the viability of populations is their protection from ungulates using large-scale fence units. In addition, weed species must be controlled on a scale sufficient to preserve the ability of populations to naturally expand into suitable habitat.



Silene lanceolata

- Plant Locations
- Short-term Control Goals
- Area Controlled

Figure 2-7

Short-term Control Goals, and Control Efforts.

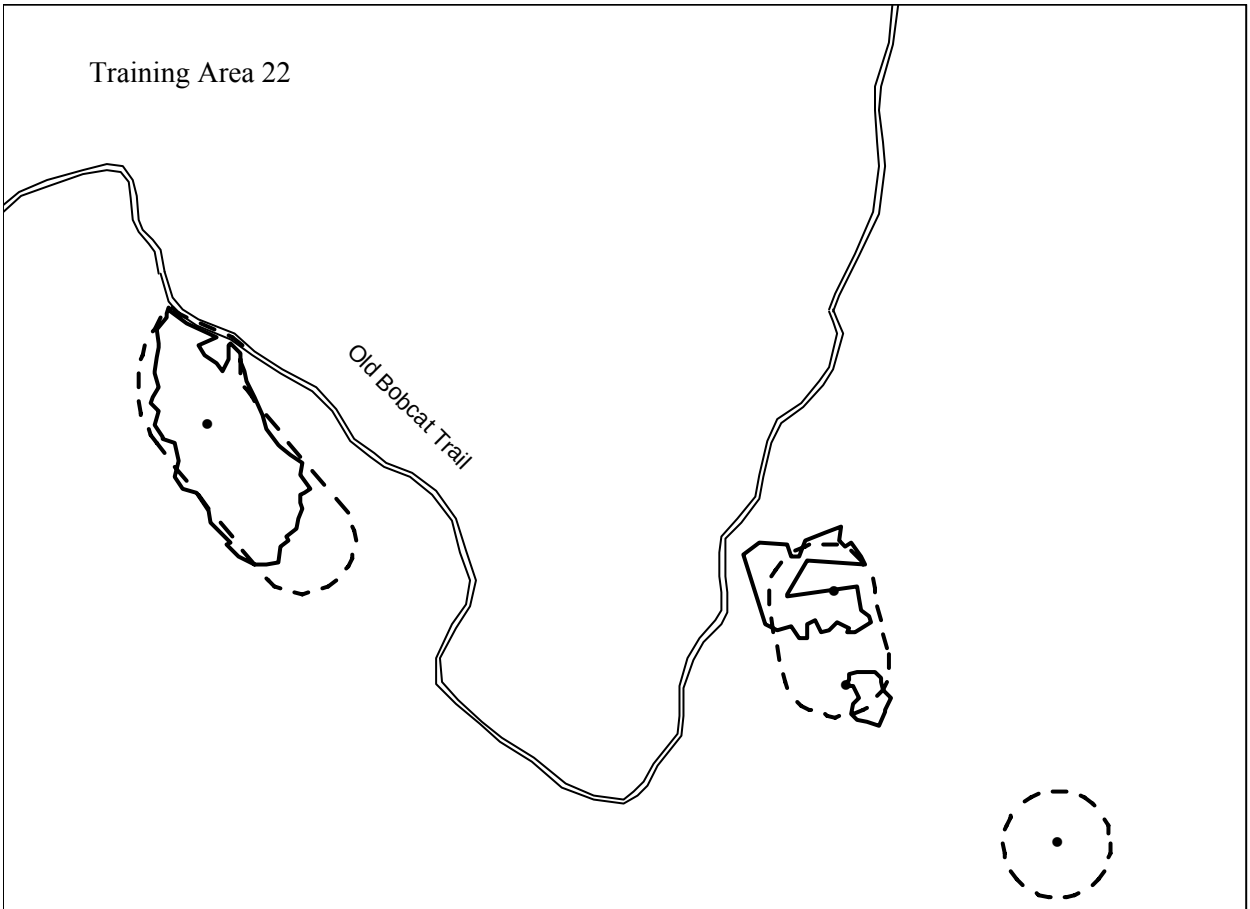
Site 01

Scale 1 : 2,500

25 0 25

Meters

N



Silene lanceolata

- Plant Locations
- Short-term Control Goals
- Area Controlled

Figure 2-8

Short-term Control Goals, and Control Efforts.

Site 06

Scale 1 : 3,500

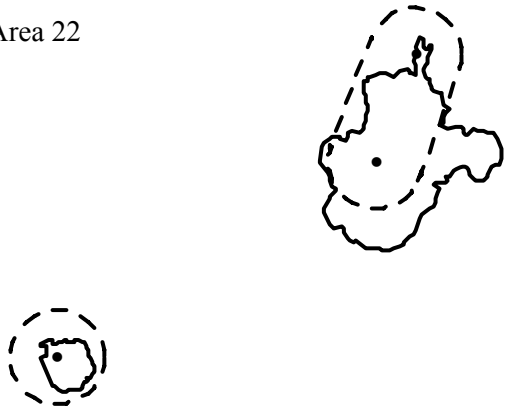
50 0 50

N

Meters

Figure 2-

Training Area 22



Silene lanceolata

- Plant Locations
- Short-term Control Goals
- Area Controlled

Figure 2-9

Short-term Control Goals, and Control Efforts.

Site 10

Scale 1 : 4,000

50 0 50

N

Meters

2.3i *Zanthoxylum hawaiiense*

INTRODUCTION

Z. hawaiiense, a Priority Species-2, was a priority species for surveys and management during the 2002-2003 reporting period. This species is at risk from introduced weed species, rodents, and ungulates. Seed recruitment may be severely impacted by rodents and ungulates. Rodents are believed to consume seeds once they have fallen to the ground. Ungulates will consume any plants or parts that are less than two meters in height. Introduced weed species impact *Z. hawaiiense* by increasing fuel loads and the potential for more frequent fires. Surveys to identify new and reidentify previously recorded locations have been conducted during the 2002-2003 reporting period.

RESULTS

Approximately 46 previously or newly recorded individuals have been found during the 2002-2003 reporting period. These individuals were found in the northern, central, and southern portions of Training Area 22 as well as one reidentified location within the Kipuka Kalawamauna Fence Unit.

Twenty individuals were found during four personnel-days of surveys of Site 09 in the small *Metrosideros polymorpha* mixed-tree kipuka of Site 09 in central Training Area 22 (Figure 2-10). Four of the 20 are believed to be reidentified individuals. All individuals are adults and are of sufficient height to be out of browse range of ungulates. However, they are at risk from bark stripping and such damage was recorded on four individuals.

Three individuals, within Site 13, were found during surveys of Sites 13 and 20 in the southern portion of Training Area 22 (Figure 2-11). Two individuals were from previous records and one was a newly recorded individual. All individuals were adults of sufficient height to be out of browse range.

Twenty-three individuals were found during surveys within Site 17 (Figure 2-12) as well during management actions in the area (Figure 2-13). Only two of the 23 individuals were the reidentified from previously recorded individuals. The other 21 were newly recorded individuals.

Weed control was conducted at Site 18 in Training Area 18. Approximately 0.40 ha (one acre) of *P. setaceum* was mechanically controlled (Figure 2- 14). The area controlled will be expanded to account for topography and fire threats to this site.

DISCUSSION

Previous surveys documented 155 locations of *Z. hawaiiense* at PTA. The surveys conducted during the 2002-2003 reporting period have expanded and filled in the distributional range of this species at PTA. There are now 216 recorded locations with 64 of them being re-identified or newly recorded locations. This increases the estimated number of individuals at previously and newly recorded locations to approximately 300.

Surveys during the reporting period show that Site 09 has a high density of *Z. hawaiiense*. In addition, this kipuka is the best example of the *Metrosideros polymorpha* mixed-treeland vegetation type found at PTA. The understory is of high quality with an apparently full complement of native understory species, unlike other examples of this vegetation type. The density of *P. setaceum* is very low and vegetation types and lava flows surrounding the habitat are conducive to controlling weed species within the kipuka.

Training Area 22

Zanthoxylum hawaiiense

- Plant Locations
- Previously Recorded Plant Locations

------ Area Surveyed

Figure 2-10

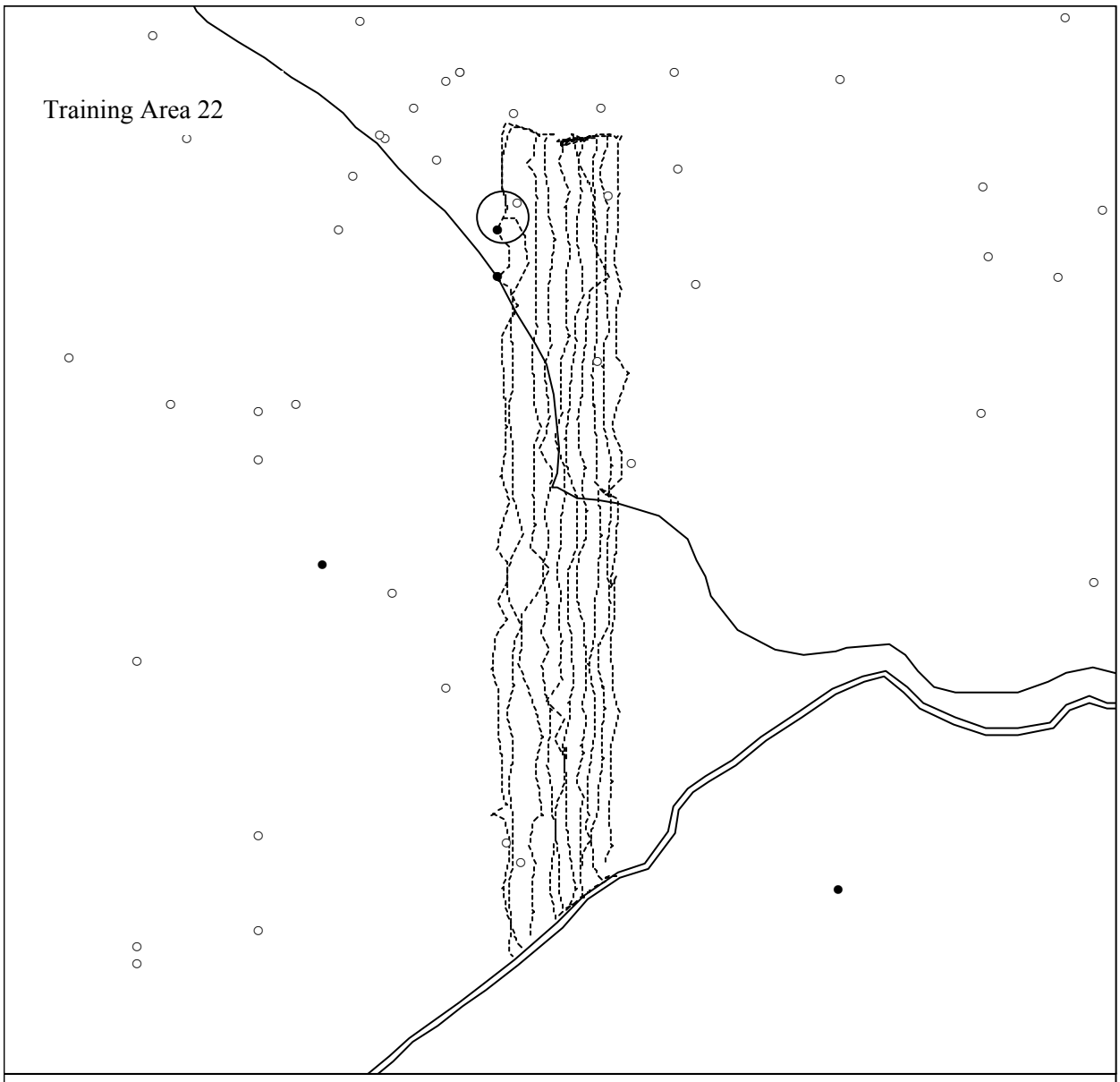
Site 09 Survey Results.

Scale 1 : 15,000

200 0 200

Meters

N



Zanthoxylum hawaiiense

- • Plant Locations
- ○ Previously Recorded Plant Locations
- ------ Area Surveyed

Figure 2-11

Site 13/20 Survey Results.

Scale 1 : 10,000

100 0 100 200

N

Meters

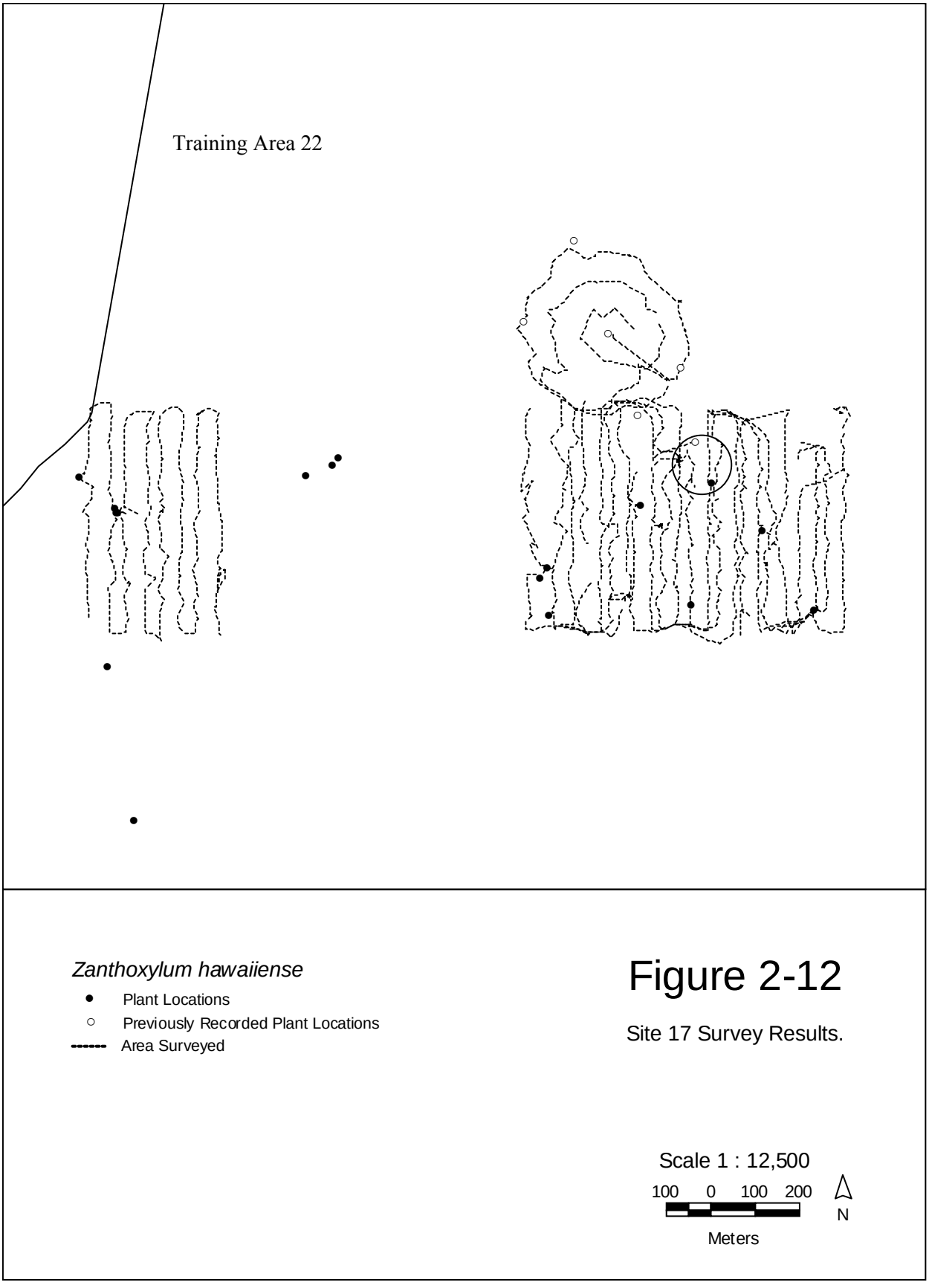
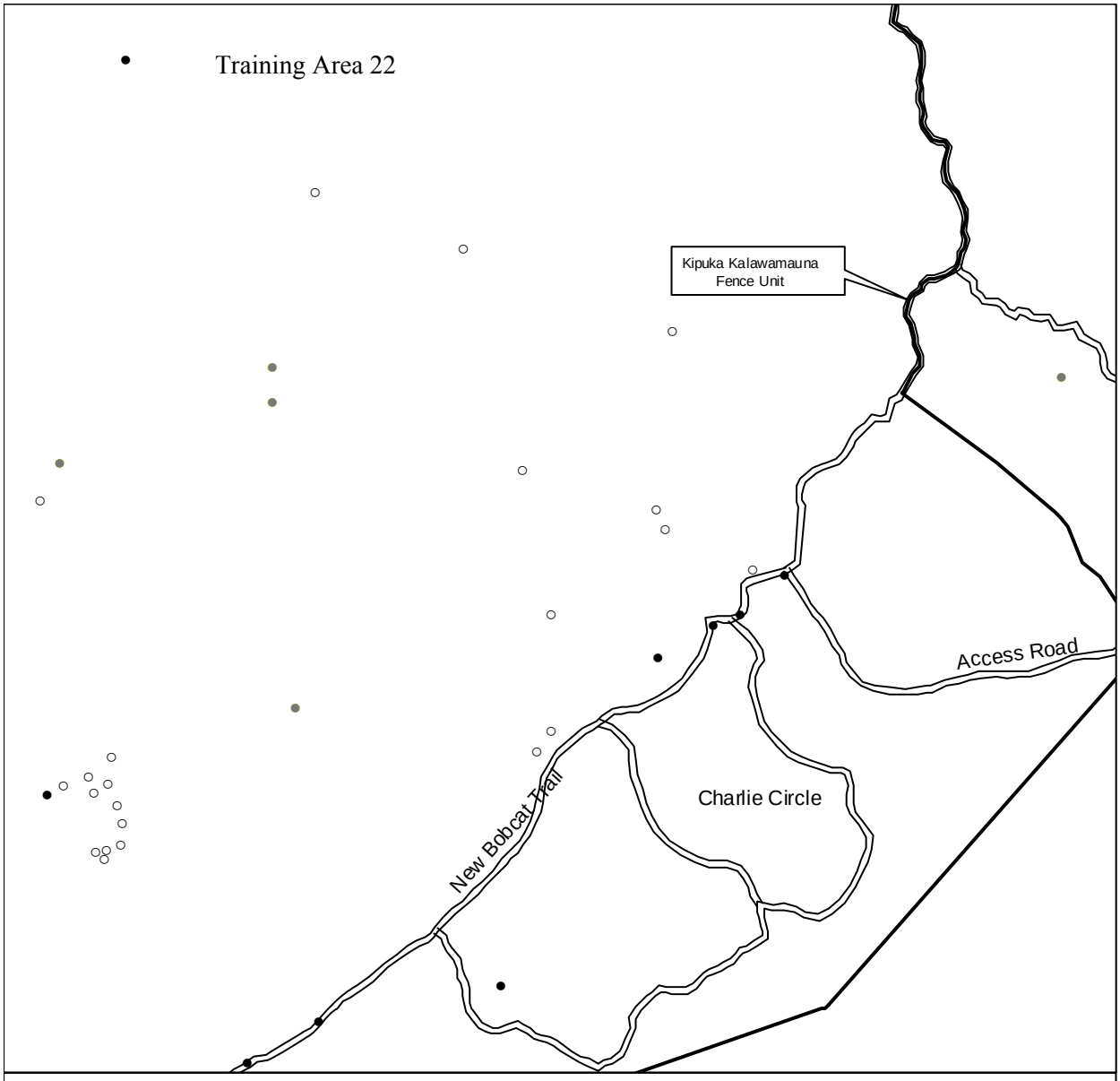


Figure 2-12

Site 17 Survey Results.



Zanthoxylum hawaiiense

- Plant Locations 2002/2003
- Plant Locations
- Previously Recorded Plant Locations

Figure 2-13

Site 17 Results.

Scale 1 : 35.000

500 0 500 N

Meters

Training Area 17

Site 18

MANAGEMENT RECOMMENDATIONS

Surveys have been successful in reidentifying previously recorded locations as well as recording new locations. Surveys to accurately document the distribution and population size of this species at PTA will continue.

There is little to no regeneration occurring in the field. Rodents are believed to impact the seed bank and ungulates consume newly emerged seedlings and any individuals within their reach. These destructive species must be controlled in *Z. hawaiiense* habitat to enable the populations to regenerate and sustain themselves at PTA. Aerial broadcast application of rodenticide is being investigated by Federal and State agencies for use in large-scale management. Upon approval, aerial bait broadcasting this should be implemented at PTA to control rodents in endangered species habitats. Control of rodents will greatly improve germination. However, ungulates must be excluded from plant habitats to ensure that enough seedlings are able to complete their lifecycle to become reproductive adults. The most effective method for ungulate exclusion is the construction of large-scale fence units around plant habitats. Any other methods leave the PTA populations at risk.

2.3i *Portulaca sclerocarpa*

RESULTS

No reidentification efforts specific to *P. sclerocarpa* have been made during the reporting period; however two new individuals were discovered along the southern fence line within the Kipuka Kalawamauna Fence Unit.

DISCUSSION

Seven site have been reconfirmed or newly recorded and 26individuals are known from these sites. There are four additional sites to be reconfirmed. Shaw (1997) estimated the number of individuals found at PTA to be less than 30. The numbers of individuals found at the seven reconfirmed or newly recorded sites and the potential numbers to be found at the four sites that have not been reconfirmed suggests that the number of individuals found at PTA is approximately 30-40.

2.3k *Haplostachys haplostachya*

RESULTS

No surveys or management actions were conducted specifically for this species. Two locations were found during the 2002-2003 reporting period during surveys and management for other species.

MANAGEMENT RECOMMENDATIONS

This species has a PS-5 ranking, therefore, reidentification, monitoring, and management will be prioritized according to the PS rankings or as circumstances necessitate.

2.3l *Silene hawaiiensis*

INTRODUCTION – Range 8

In 1996, the Army approached the USFWS to request a formal consultation on the effects of adding two machine-gun firing lanes at Range 8. This federal action had the potential to negatively impact the

threatened species *S. hawaiiensis*. As part of the consultation process, the Army was required to identify and protect *S. hawaiiensis* locations at Range 8 against damage resulting from the maintenance and use of the range. In addition, an annual monitoring of the known locations was agreed to and the NRS initiated monitoring of all known *S. hawaiiensis* locations at Range 8 in 1997.

RESULTS

Table 2-1 shows changes in the average height and number of the plants at Range 8. The results reported represent the annual monitoring of those adult individuals that were initially recorded in 1997. The number of individuals remaining from the initial monitoring has consistently declined. Thus, the results that were reported in previous reports were typically smaller due to the change in the decreased number of plants used to calculate the average height. The average height and number of the plants has decreased since the first monitoring in 1997.

Table 2-1. Average height of *Silene hawaiiensis* at Range 8.

	1997	1999	2000	2001	2002	2003
Average Height* (cm)	15.8	13.5	12.5	7.5	10.2	4.8
Number of Individuals**	101	105	96	61	58	26
Percent Damaged***	75.3	87.0	71.9	75.0	12.1	32.3

* The average height of adult plants present at Range 8 since 1997.

** The total number of individuals present during that year's monitoring.

*** The percentage of adult plants with signs of ungulate damaged.

DISCUSSION

The average height and number of the *S. hawaiiensis* found at Range 8 has decreased in the years following the initial monitoring in 1997 (Table 2-1). Evans et al. (2002a, 2002b) discussed the possible causes for the observed changes in the plants at Range 8. The discussion considered the potential and real impacts from military training, ungulate browse, and environmental factors. It was concluded that military training was not responsible for the observed changes. In fact, the portion of the range where two-thirds of the plants are found hasn't been used since 1992-1993. However, there have been significant impacts to the plants over this time period. The two additional machine-gun firing lanes at the time of this writing have yet to be utilized and are not operational. Therefore, the factors affecting the plants at the Range continue to be observed environmental changes and most importantly ungulate impacts.

INTRODUCTION – *Silene hawaiiensis* Fence Unit

In April of 1999, a 13.5-hectare (33.4 acres) fence unit was completed in Training Area 3 to protect *S. hawaiiensis*. In May of 1999, monitoring plots were established to assess the effects of ungulate exclusion on this species. The initial monitoring in 1999 serves as a baseline to which subsequent years of monitoring can be compared. Ten plots were established outside and inside of the fence unit. Plots were established in the two locations to test the effects of ungulate exclusion. Monitoring has been conducted annually since 1999.

Four years after fence completion, monitoring and analysis demonstrated that in 2002 the average plant height was greater inside of the fence unit than it was outside. In addition, average plant heights inside the

fence unit in 2001 and 2002 increased from the baseline average in 1999. During the same time period, the average height for plants outside the fence unit remained similar. These differences were attributed to higher browse frequencies on plants outside the fence unit. The lack of protection for plants outside the fence unit leaves them vulnerable to ungulates. The study has shown that the reduction of ungulate pressures on this species can have significant positive effects in a relatively short period of time.

RESULTS

Browse by location for each year is summarized in Table 2-2. A Chi-Square Analysis with Yates Correction for Continuity was used to test differences in browse between locations for each year. The analysis indicates that browse frequency was statistically similar for both locations in 1999, when the fence was completed. Browse frequency in 2000, 2001, 2002, and 2003 was greater outside the fence than it was inside.

Table 2-2. Summary of Browse by Location for Each Year. Results of the Chi-Square Analysis with Yates Correction for Continuity. Results are reported at the 90% confidence level.

Year	Location	Total Plants	Browsed	No Browse	Test Statistic	Critical Value
1999	Outside	50	36	14	1.6070	2.706
1999	Inside	97	80	17		
2000	Outside	42	22	20	23.3281	2.706
2000	Inside	80	9	71		
2001	Outside	33	19	14	32.9369	2.706
2001	Inside	84	6	78		
2002	Outside	36	9	27	5.6536	2.706
2002	Inside	92	7	85		
2003	Outside	27	15	12	28.8645	2.706
2003	Inside	72	4	68		

The average heights from four years of monitoring, 1999 to 2002, of plants inside and outside the fence unit are summarized in Figure 2-15.

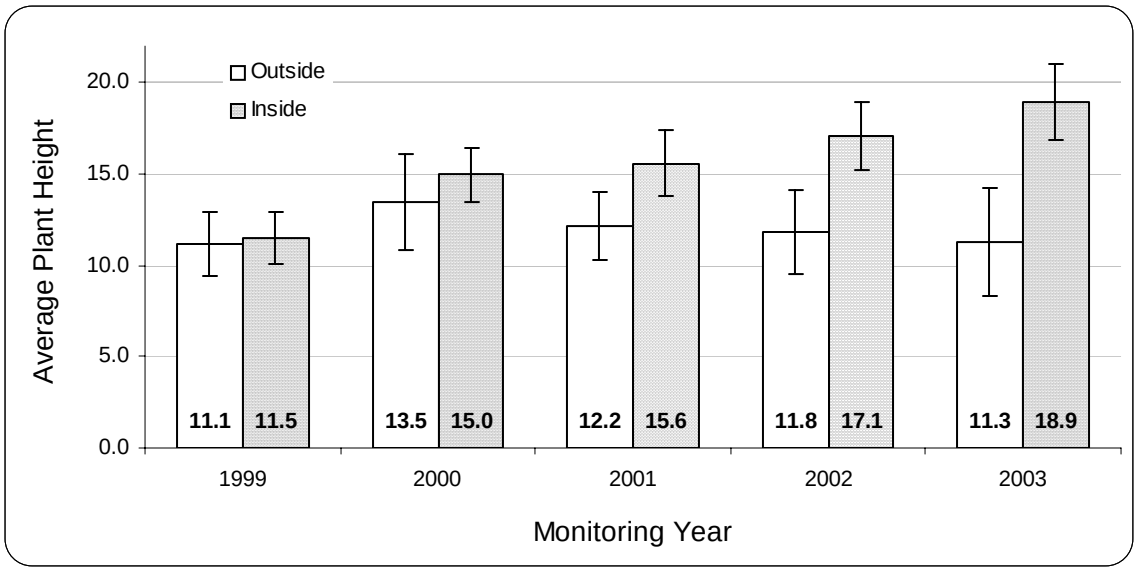


Figure 2-15. Average Plant Height by Location of the *Silene hawaiiensis* Fence Unit in Each Year. Results are reported at the 90% confidence level.

Results of the individual analyses of variance (ANOVA) for each year (Table 2-3) indicate the average plant height between locations is statistically similar from 1999 to 2001. Average plant height between locations was statistically different in 2002 and 2003, with greater average height being found for the plants inside the fence unit (Figure 2-7).

Table 2-3. ANOVA Results Comparing Plant Heights between Locations for Each Year. P-values less than 0.1 indicate statistical significance at α=0.1.

	Degrees of Freedom	F-value	P-value
1999	1	0.08	0.780
2000	1	0.61	0.435
2001	1	3.30	0.072
2002	1	7.31	0.008
2003	1	8.43	0.005

An ANOVA indicated there were no statistically significant differences in the average height of plants outside the fence unit between years. However, there were statistically significant differences in the average height for plants inside the fence unit between years (Table 2-4).

Table 2-4. ANOVA Results Comparing Plant Heights between Years for Each Location. P-values less than 0.1 indicate statistical significance at α=0.1.

	Degrees of Freedom	F-value	P-value
Outside	3	0.47	0.755
Inside	3	7.22	<0.001

The Tukey Test compared, in a pair-wise fashion, the results of the 1999 monitoring to those of the other years (Table 2-5). The results indicate that the average plant height is similar between 1999 and 2000. There was a statistically significant difference between the 1999 results and the results from 2001, 2002, and 2003. The plants in these three years had statistically significant greater average heights than were found in 1999.

Table 2-5. Tukey Pair-wise Comparisons Identifying the Differences in Height between Years for Plants Inside the Fence Unit. P-values less than 0.1 indicate statistical significance.

	T-value	P-value
2000	2.256	0.0959
2001	2.837	0.0193
2002	3.982	0.0003
2003	4.977	0.0000

The Tukey Test also detected differences when the 2000 monitoring was compared to subsequent years. The average plant height in 2003 was greater than in 2000 (Table 2-6).

Table 2-6. Tukey Pair-wise Comparisons Identifying the Differences in Height between Years for Plants Inside the Fence Unit. P-values less than 0.1 indicate statistical significance.

	T-value	P-value
2001	0.5253	0.9848
2002	1.5619	0.5220
2003	2.6678	0.0588

DISCUSSION

Monitoring and analysis have demonstrated that in 2003 the average plant height was greater inside the fence unit than it was outside. In addition, average plant heights inside the fence unit in 2001, 2002, and

2003 have increased from the baseline average in 1999, while the average height for plants outside the fence unit have remained similar.

The lack of protection for plants outside the fence unit has continued to leave them vulnerable to ungulates. This is most likely why plant height has not changed significantly since the initiation of this study. The average height for plants inside the fence unit has increased by an average of 64.3% over the same time period.

The greater heights for plants inside the fence can be explained by the results of the browse frequency analysis. In 1999, the browse frequencies were statistically similar by location. This was expected because the monitoring was conducted within one month of the fence unit's completion. However, browse frequency was statistically different in subsequent years, with higher browse frequencies on plants outside the fence unit.

Such results demonstrate that after two years of reduced ungulate browsing, the plants inside the fence unit have increased their average height from the baseline obtained in 1999. Furthermore, after three years the plants inside the fence unit have greater average height than those plants outside. This study shows that reducing ungulate pressures on this species can have significant positive effects in a relatively short period of time.

MANAGEMENT RECOMMENDATIONS

Fencing of the plants at Range 8 is needed to attempt to recover this population. It is likely that this population will be extinguished in the next few years, if browsing damage is allowed to continue.

In SHFU, four of the five years of this study have been completed. Results have already demonstrated the positive effects of ungulate exclusion for *S. hawaiiensis*. It is recommended that this study be concluded and that monitoring focus on a population viability analysis (PVA). A PVA would demonstrate the number of individuals necessary to protect a population for long-term sustainability.

2.3m *Spermolepis hawaiiensis*

RESULTS

Two attempts were made to reidentify CEMML recorded locations of this species during other monitoring or management actions during the 2002-2003 reporting period. No plants were located.

MANAGEMENT RECOMMENDATIONS

S. hawaiiensis is a PS-5 ranked species; a systematic monitoring will be implemented for this species according to the PS rankings.

2.3n *Stenogyne angustifolia*

RESULTS

No reidentification efforts or management actions specific to this species have been made during the 2002-2003 reporting period. Unrecorded locations were identified occasionally throughout the year during surveys for other species. These findings have been incorporated into the Rare Plant Database and GIS.

MANAGEMENT RECOMMENDATIONS

S. angustifolia is one of the more abundant endangered or threatened species found at PTA and is categorized as PS-5. No monitoring has been initiated for this species because of its low PS ranking. Once monitoring has been implemented for the higher ranked species, monitoring will be implemented for this species.

CHAPTER 3. WEED CONTROL

3.1 PCSU CONTRACT REQUIREMENTS

REQUIREMENT 5.b.10

Performing weed control of Russian thistle (*Salsola kali*), banana poka (*Passiflora mollissima*), Jerusalem cherry (*Solanum pesudocaspicum*), German ivy (*Delairea odorata*), and other incipient infestations on approximately 30 acres. Areas of focus shall be centered in biologically sensitive areas, fenced areas and roadsides with particular emphasis at Puu Kapele and Puu Keekee. Weed control to be conducted throughout the year depending upon the phenology of the plants. A report shall be prepared describing species targeted, method used and effectiveness, area covered, analysis and management recommendations. The report shall include photographs.

DISCUSSION

Control efforts have been effective in reducing Russian thistle densities in the core areas such as Puu Keekee and Puu Kapele. However, resources still need to be expended in this effort since new infestations have been identified, most likely introduced by military activities. As a result, control efforts for Russian thistle increased by 25 hours over last year, a 7% increase in personnel-time.

REQUIREMENT 5.b.2.b.4 (Kipuka Alala)

Identifying areas where weed densities are high and prioritizing these areas for weed control. Performing localized weed control (herbicide and/or manual) and monitoring in priority areas. Results from the identification, application of weed control, and monitoring shall be evaluated and recommendations made for management actions.

DISCUSSION

No progress on this task was made because Russian thistle and fountain grass control around listed plant species were the focus of control efforts during the reporting period.

3.2 INTRODUCTION

The aim of alien plant species management at PTA is to control incipient infestations and reduce the spread of established species into biologically sensitive areas. Incipient infestations are targeted and controlled to prevent them from becoming large management problems. The advancement of established species is slowed through control along roadsides and disturbed areas leading to or near biologically sensitive areas. Roadside control is important because roads are disturbance corridors that enable alien species to spread from degraded areas into undisturbed and more sensitive habitats. In addition, alien plant species are also controlled in and around rare plant locations. Control efforts in these very sensitive areas serve to reduce competition with rare native species as well as preventing the degradation of the habitat.

3.3 WEED CONTROL

Methods

Methods and equipment used vary depending on the plant and/or circumstances, which includes manual and chemical control. Manual control is performed within 3.0 meters of rare plant locations. Manual

control is consists of hand pulling, cutting with serrated sickles, cutting with gas-powered line-trimmers, or removing seeds or portions of the plant capable of vegetative reproduction. Chemical control utilizes backpack sprayers or a truck-mounted spray system. Chemicals are applied to the entire plant with a foliar spray. Chemical methods are not used within 3.0 meters of rare plant locations or in the vicinity of rare plant locations during poor weather conditions. Herbicides used include 2,4-D, Garlon 3A, and RoundUp. Application rates and restrictions are followed according to those specified on the manufacturer's label.

3.3a Russian thistle (*Salsola kali*)

INTRODUCTION

Control efforts began in 1997 with a combination of contractor and in-house resources. Intensive in-house control efforts commenced in August 1997 with personnel being tasked specifically to control Russian thistle. Concentrated control efforts have been successful in reducing the density and distribution of Russian thistle in some areas while only moderately successful in others. Conversely, Puu Keekee continues to be a problem, which requires more time and effort because of the large seed bank and constant regeneration. New populations continue to be found throughout PTA, especially along roadsides and in areas where vehicular activity is common.

METHODS

A monitoring strategy using ArcView and its associated database has been developed to better manage time, resources, and Russian thistle. These tools give a more complete and accurate assessment of Russian thistle control and monitoring efforts at PTA. After an area has been treated with herbicide, the perimeter is mapped with a GPS unit. The data are downloaded into ArcView and added to the database. As a result, more accurate comparisons of treated area, volume, type and concentration of herbicide applied can be compared temporally and spatially.

Russian thistle sites are visited as frequently as needed or as often as time allows. When plants are found they are manually removed or treated with herbicide. New control sites are located by reconnaissance of roadways that are connected to or pass through known sites frequented by military or military support vehicles.

RESULTS

Table 3-1 shows that approximately 379 in-house hours have been spent on control efforts from July 2002 through June 2003. Figure 3-1 shows that the work has been concentrated in approximately 225 hectares (588 acres) around Puu Keekee, Puu Kapele and the cantonment. Repeated treatments in these areas resulted in the equivalent of spraying approximately 301 hectares (744 acres).

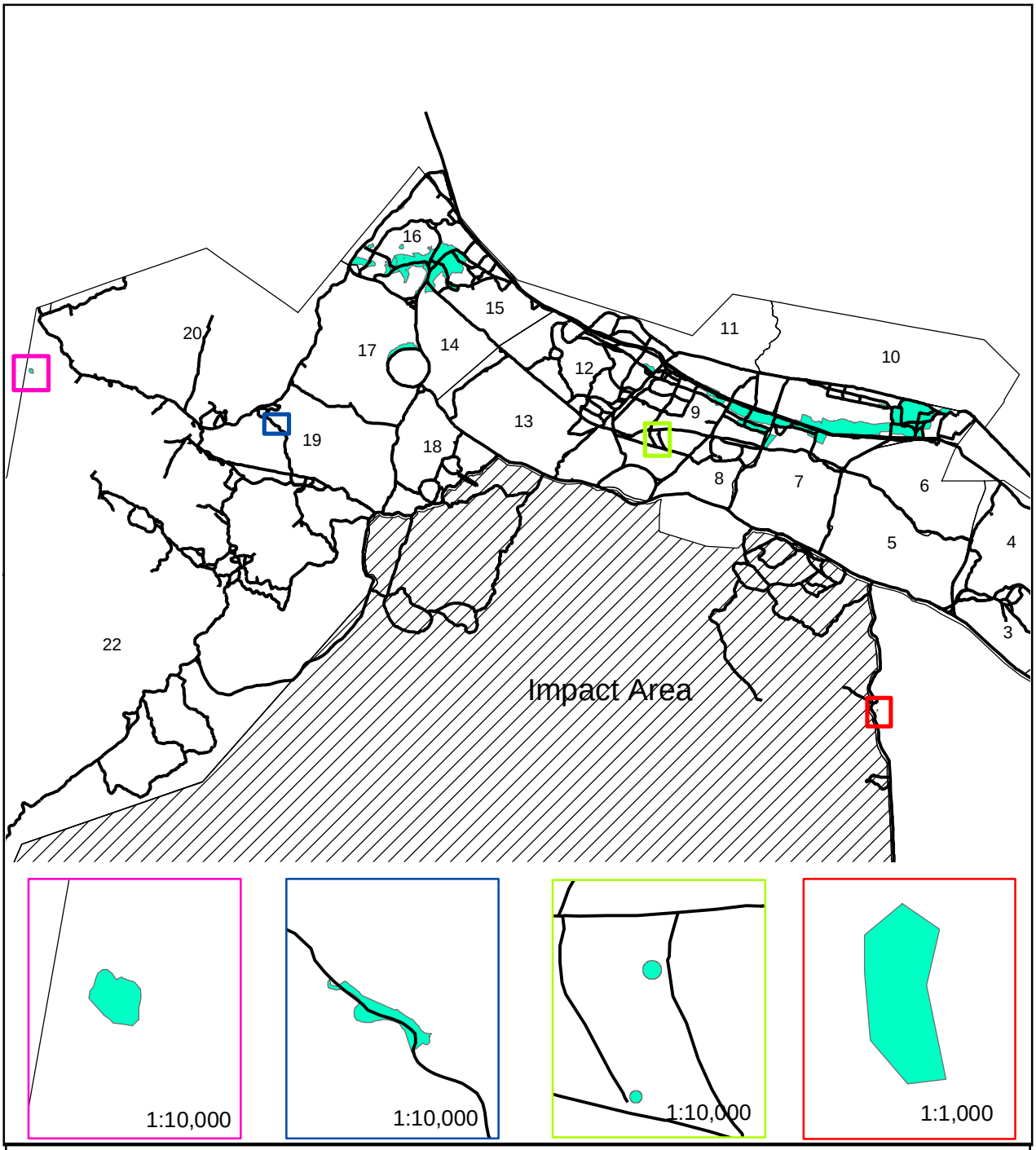
Table 3-1. Russian Thistle Control Efforts July 2002 to June 2003.

Month	Acres	Hectares	Amount Applied (gallons)	Hours
July 02	77.8	31.5	42.25	46.75
August 02	58.5	23.7	134.0	57.3
September 02	142.0	57.5	101.25	82.0
October 02	192.0	77.7	89.8	66.0
November 02	132.7	53.7	36.8	56.0
December 02	8.6	3.5	8.5	3.5
January 03	10.0	4.0	---	6.0
February 03	23.8	9.6	---	5.5
March 03	16.2	6.6	---	10.0
April 03	54.0	22.0	---	15.0
May 03	79.1	32.0	---	26.0
June 03	8.0	3.2	---	5.0
Totals	744.0	301.1	412.6	379.0

Table 3-2 shows the personnel-hours and amount of herbicide applied in Russian thistle control effort since 1997.

Table 3-2. Control Efforts of Russian Thistle Since 1997.

Year	Amount Applied (gallons)	Hours
1997	176	71
1998	1086	238
1999	920	287
2000	201	93.5
2001	767	290
2002	503	355
2003	412.6	379



Impact Area
Roads
Training Area Boundary
Thistile Control Sites 2002

Figure 3-1

Locations of Russian Thistle Treatment Locations

1:118,000

0 2.5 5
Kilometers

N

Datum NAD 83
Projection UTM
July 2003
Lena Schnell

DISCUSSION

Control efforts since 1997 have reduced core control areas so they are now best managed with backpack sprayers instead of the truck-mounted power sprayer. Efforts have reduced the density of Russian thistle in core control areas; however the plants have spread into new areas. The total area treated during the current reporting period was 225 hectares (588 acres), but because some areas were sprayed more than once the equivalent of 301 hectares (744 acres) was sprayed. These are increases from 175 total hectares (432 acres) and 270 equivalent hectares (666 acres) during the previous reporting period.

The majority of the Russian thistle seed bank remains viable for one year but some seed can persist for up to three years, and it responds well to small amounts of precipitation (Howard 1992, Young 1991). It was an extremely dry winter and a significant amount of precipitation didn't occur until June 2003. The total rainfall from January to June 2003 was approximately 2.0 inches. The result has been a substantial decrease in the amount of Russian thistle germinating across PTA as compared to last season. As a result, monitoring from January to June 2003 control sites didn't require any spraying and mature plants that were left over from the previous season were pulled.

MANAGEMENT RECOMMENDATIONS

The key to control is to prevent the plants from setting seed. Because seeds readily germinate after rain events, additional monitoring should be conducted following rain events to intercept plants before they set seed. To effectively control Russian thistle, the area should be revisited every two months to ensure early detection and removal. This is impossible to accomplish with limited staff and large area to cover (588 acres). Our continued effort will focus on satellite populations and the areas around Puu Kapele and Puu Keekee while visiting other areas less frequently.

Mature plants were picked and bagged to reduce dissemination of seeds. The bags were then disposed of in rubbish dumpsters on the cantonment. Because the seeds are miniscule, it is impossible to prevent them from falling out of holes made in the bags by the plants. To prevent the accidental spread of seeds on the cantonment and along roadways, bagging the plants was ended.

3.3b Fountain grass (*Pennisetum setaceum*)

INTRODUCTION

P. setaceum is an alien grass introduced to the Islands in the early 1900's (Wagner *et al.* 1999). It is highly invasive and competes with native species for water, nutrients, and space. It alters ecosystems by forming a nearly complete ground cover, causing a dramatic alteration of fire regimes (Smith and Tunison 1992). *P. setaceum* at PTA has the greatest distribution and density of any alien plant species. It is by far the greatest threat to listed and rare species as well as the ecosystems in which they are found.

METHODS

A combination of manual and chemical control is used for *P. setaceum* (see section 3.3 Weed Control Methods for more detail). The plant is first cut back with gas-powered line-trimmers and then, once new growth emerges, the plant is sprayed with herbicide usually 2% RoundUp.

RESULTS

Over 350 personnel-hours were spent controlling *P. setaceum* at endangered and threatened plant locations as well as outplanting sites. Control efforts occurred at and around the following species locations:

Haplostachys haplostachya	*Silene lanceolata*
Hedyotis coriacea	*Solanum incompletum*
Neraudia ovata	*Tetramolopium arenarium ssp. arenarium*
Schiedea hawaiiensis	

Details on control efforts are found in Chapter 2.

DISCUSSION

NRS performed weed control as needed during scheduled rare plant monitoring and at high-priority plant species sites. Once *P. setaceum* was removed, the site was revisited to ensure plants had not resprouted or reestablished. Removal of *P. setaceum* from around rare plant populations was done to reduce competition and enhance the possibility of natural recruitment. Once the immediate area around rare plants is cleared, NRS will expand the control area to provide a 25 to 50 meter fuel break around the plants.

MANAGEMENT RECOMMENDATIONS

Removal of invasive species from rare plant populations must continue with removal of weeds from the immediate area of the rare plans using the already established control methods. Weeds can then be more quickly and efficiently controlled in surrounding areas using gas-powered line-trimmers followed by herbicide application.

CHAPTER 4. ANIMAL MONITORING AND MANAGEMENT

4.1 PCSU CONTRACT REQUIREMENTS

REQUIREMENT 5.b.11

Plan and implement annual surveys of the avian population in forested areas of Kipuka Alala (7 transects (each transect length approximately 2-2.5 km)), Palila Critical Habitat (four transects (each transect length approximately 3.5 km))and two Forest Bird Survey transects in Training Area 22 (approximately 5.5 and 7 km in length).

DISCUSSION

Bird populations were monitored in Palila Critical Habitat, Kipuka Alala, and Training Area 22 on a total of 15 transects in December 2002. Amakihi was the most abundant bird recorded. Species composition varied between study areas.

REQUIREMENT 5.b.12 and 5.b.6 (Kipuka Alala)

Monitoring and mapping territories of approximately 15-20 banded Elepaio present in Training Area 23. Identification of individual birds shall be accomplished by bands. If additional birds are banded, morphological measurements shall be taken of the bill, tarsus and wing. Body color shall be determined using Munsel color charts. Color-banded birds shall be monitored once a year. Predator control shall be implemented over bird territories during breeding season.

DISCUSSION

All Elepaio work was conducted in Training Area 23. No additional birds were banded during the 2002-2003 contract period. Predator control was implemented in April 2003 at two Elepaio territories. One pair was monitored during the breeding season, but no nests were discovered.

REQUIREMENT 5.b.13 and 5.b.7 (Kipuka Alala)

Establish a trial rodent control program for plants and animals, using toxic and non-toxic materials over a 1,000 square meters in Kipuka Alala. Grid patterns shall be monitored every month to determine effectiveness.

DISCUSSION

Rodent control was conducted in two Elepaio territories. Bait was placed in the territories in April 2003 and not checked again during the contract period due to access issues.

REQUIREMENT 5.b.14

Surveying possible areas of seabird habitation in May-June, especially for the Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*).

DISCUSSION

Monitoring was not conducted during the contract period.

REQUIREMENT 5.b.5 (Kipuka Alala)

Implementing alien ant control in identified areas within Kipuka Alala and monitoring effects. Results/findings from control methods and monitoring shall be evaluated and recommendations made for management actions.

DISCUSSION

The Argentine ant, *Linepithema humile,* population was surveyed and its extent mapped. Research and coordination for control methods continue.

4.2 INTRODUCTION TO ANIMAL MONITORING AND MANAGEMENT

NATIVE ANIMAL MONITORING

Historically, fifteen species of native Hawaiian birds occurred at PTA (Shallenberger 1977). Of these, nine are listed as endangered and the other five are non-listed species. Presently no endangered species are known to reside on PTA. Some endangered species such as Nene, Palila, and Akiapolaau have populations that border PTA and these species are known to occasionally use the resources located on PTA.

Areas with potential habitat resources for endangered birds such as Palila Critical Habitat are monitored annually for endangered birds. Annual monitoring is also conducted in Training Area 23 (Kipuka Alala), a Saddle Road Realignment mitigation site, where it is important to track the history and health of the avian community in anticipation of the possible reintroduction of Palila. Seven monitoring transects are located in Training Area 23 (Kipuka Alala), and four are located in Training Areas 1-4 (Palila Critical Habitat) (Figure 4-1). These monitoring areas cover the majority of the Mamane/Naio (*Sophora/Myoporum*) forests on PTA. Two monitoring transects are located in Training Area 22, which is Ohia (*Metrosideros*) forest (Figure 4-1).

INTRODUCED ANIMAL MONITORING AND CONTROL

In Training Area 23 (Kipuka Alala), a potential Palila reintroduction site, it is important to determine if a native bird population with low density can be effectively protected from rats. Introduced predators are believed to be limiting a small Elepaio population in Training Area 23. Introduced predator control has been implemented because they are known to have a significant negative impact on native birds. Rats, especially the black rat (*Rattus rattus*), are known to depredate nests (Atkinson 1977). Cats have been seen on video depredating a Palila nest (Banko pers.com.). To test the effectiveness of baiting techniques, toxic baits were used in areas with breeding Elepaio to control predators.

Although rodents damage native plants by browsing foliage and eating seeds and seedlings, their impacts on plants are poorly understood (Cole *et al*. 1998). Many of the endangered and threatened plants at PTA have fleshy fruits, which may be attractive to rodents (Clark 1986). Because some of the endangered species occur in low numbers, it is critical to protect as many seeds as possible, so rodents are controlled around these plant populations.

Alien insects such as ants, bees and wasps can negatively affect the native arthropod fauna (Oboyski *et al.*2002). Two arthropod surveys have been conducted at PTA, but little is known about native arthropods (Oboyski 1996, Oboyski *et al*. 2002). Very little is known about the native pollinators of PTA's endangered species. Because the native arthropod fauna evolved without social insects, especially

predators such as the Argentine ant, these alien insects could have a devastating impact on native arthropods (Reimer 1994).

4.3 BIRD POPULATION MONITORING

Several studies of the avian resources at PTA have been conducted over the past twenty years. Shallenberger (1977) conducted a cursory study of birds and mammals. In 1993, The Nature Conservancy conducted a yearlong population study in Training Area 23 (Gon *et al.* 1993). David *et al.* (1995) conducted a survey in Palila Critical Habitat (PCH). Cooper *et al.* (1995) conducted a rare bat and seabird study. Hawaiian Forest Bird Survey transects in PCH have been monitored for the past 18 years. The majority of the studies have taken place in the Mamane/Naio (*Sophora/Myoporum*) forests of PTA.

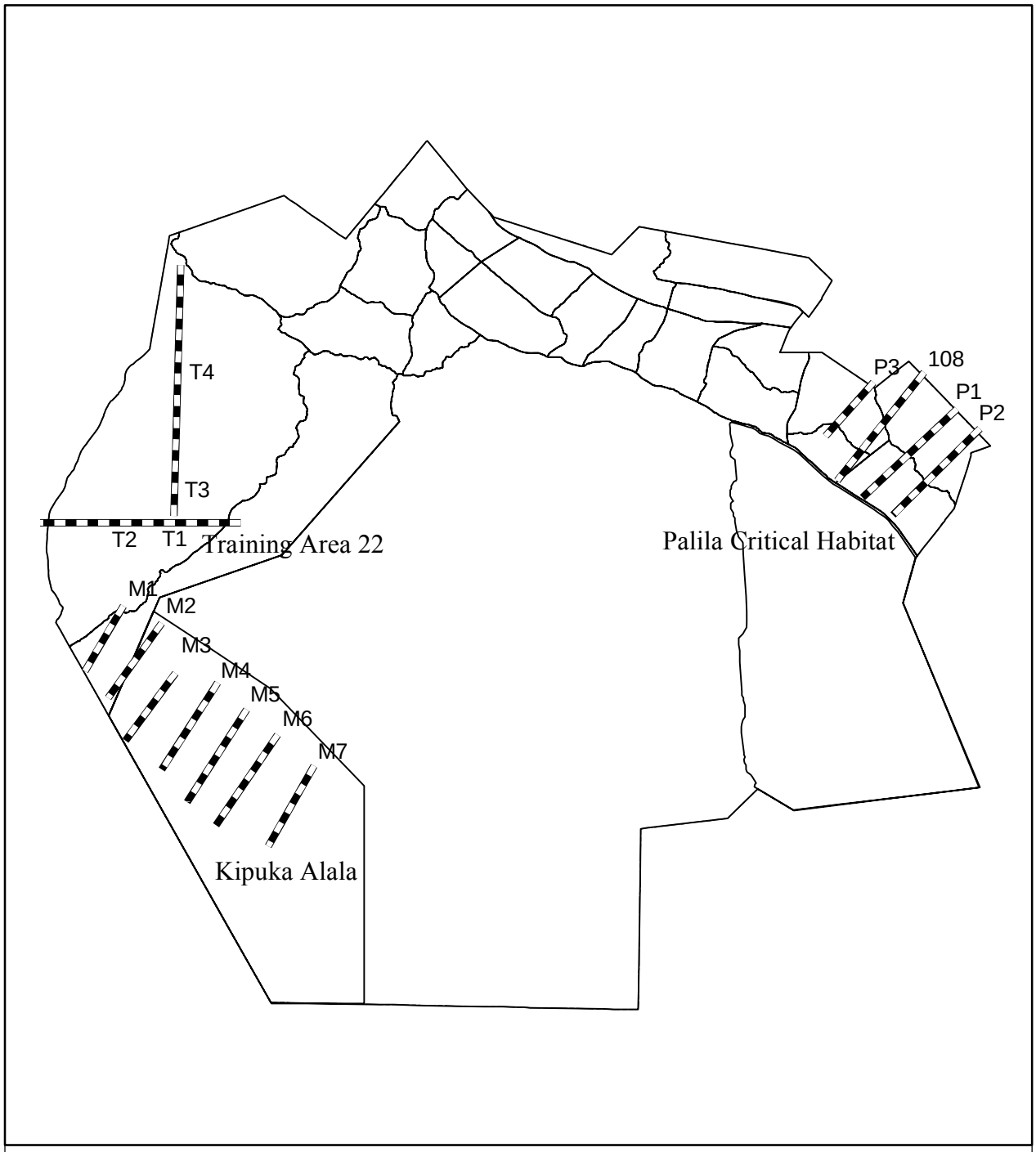
4.3a Bird Population Monitoring

Count Methods

Bird population monitoring transects have been established in Kipuka Alala, PCH, and Training Area 22 (Figure 4-1). The seven transects in Kipuka Alala are each approximately 2,500 meters in length. Four transects have been established in PCH and each is about 3,600 meters in length. Two transects have been established in Training Area 22 and are approximately 5,500 meters in length.

Counting stations are located along a line transect every 150 meters. The counting method is based on the US Fish and Wildlife Service Hawaiian Forest Bird variable circular-plot (VCP) survey methods (Scott *et al.*1986). Counts at each station are conducted for six minutes between 0545 and 1100 hours. Every bird of each species heard or seen is recorded. The distance to every bird detected is recorded in meters. Weather conditions are also noted on the monitoring form.

The survey was conducted in December 2002 over a two-week period. Three NRS, Lena Schnell, Jeff Trainer and Aubrey Kelly, were the primary counters and Kathy Kawakami assisted on remote transects for safety purposes. Counts were not conducted on days when the weather was not within established protocol guidelines (Scott *et al.*1986).



Bird Monitoring Transects

Training Area Boundary

Figure 4-1

Annual Bird Monitoring Transects

Scale 1:175,000

5 2.5 0 5

Kilometers

N

RESULTS

Palila Critical Habitat

A total of 558 birds were recorded over four transects in PCH. The Hawaii Amakihi (*Hemignathus virens virens*) was the most numerous and widely dispersed bird, indicating that the population is doing well (Table 4-1). Japanese White-eye (*Zosterops japonicus*) and House Finch (*Carpodacus mexicanus*) were the second and third most numerous birds. Apapane (*Himatione sanguinea*) accounted for 4% of the total birds counted and they were present at 17% of the stations sampled.

Table 4-1. Bird Monitoring – 2002 December Census Results in Palila Critical Habitat.

Common Name	Species	Number Counted	Percent of Total	Percent Occurrence
Hawaii Amakihi*	*Hemignathus virens virens*	248	47%	92%
Japanese White-eye	*Zosterops japonicus*	100	19%	58%
House Finch	*Carpodacus mexicanus*	84	16%	47%
Skylark	*Alauda arvensis*	36	7%	24%
Erckle's Francolin	*Francolinus erckelli*	29	5%	28%
California Quail	*Callipepla californica*	26	5%	25%
Apapane*	*Himatione sanguinea*	23	4%	17%
Northern Cardinal	*Cardinalis cardinalis*	4	1%	4%
Pueo*	*Asio flammeus sandwichensis*	4	1%	4%
Red-billed Leiothrix	*Leiothrix lutea*	3	1%	4%
Warbling Silverbill	*Lonchura malabarica*	1	<0.1%	1%

* Native Hawaiian bird species.

Kipuka Alala

A total of 881 birds were recorded over seven transects in Kipuka Alala. Hawaii Amakihi accounted for over half the birds counted and were present at 97% of the stations (Table 4-2). Japanese White-eyes were the next most common birds and were present at over half the counting stations. Apapane, the third most common bird, was present at 28% of the counting stations. The remaining birds recorded were a combination of introduced species except for the native Elepaio (*Chasiempis sandwichensis*). Only one Elepaio was recorded and the species accounted for less than 0.1% of the total species recorded.

Table 4-2. Bird Monitoring – 2002 December Census Results in Kipuka Alala

Common Name	Species	Number Counted	Percent of Total	Percent Occurrence
Hawaii Amakihi*	*Hemignathus virens virens*	524	59%	97%
Japanese White-eye	*Zosterops japonicus*	157	18%	62%
Apapane*	*Himatione sanguinea*	54	6%	28%
California Quail	*Callipepla californica*	41	5%	18%
Erckle's Francolin	*Francolinus erckelli*	30	3%	19%
Northern Mockingbird	*Mimus polyglottus*	29	3%	20%
Kalij Pheasant	*Lophua leucomelanos*	13	1%	6%
Yellow-fronted Canary	*Serinus mozambicus*	11	1%	7%
Warbling Silver Bill	*Lonchura malabarica*	7	1%	4%
Common Mynah	*Acridotheres tristis*	3	<0.1%	2%
Northern Cardinal	*Cardinalis cardinalis*	3	<0.1%	2%
Chukar Partridge	*Alectoris Chukar*	3	<0.1%	2%
House Sparrow	*Passer domesticus*	3	<0.1%	2%
House Finch	*Carpodacus mexicanus*	2	<0.1%	2%
Elepaio*	*Chasiempis sandwichensis*	1	<0.1%	<0.1%

* Native Hawaiian bird species.

Training Area 22

A total of 532 birds were recorded in Training Area 22. Hawaii Amakihi accounted for over half of the birds recorded and were present at 95% of the counting stations (Table 4-3). Yellow-fronted Canaries (*Serinus mozambicus*) were the second most abundant birds and they were recorded at 41% of counting stations. This year, one Apapane was recorded during the survey.

Table 4-3. Bird Monitoring – 2002 December Census Results in Training Area 22

Common Name	Species	Number Counted	Percent of Total	Percent Occurrence
Hawaii Amakihi*	*Hemignathus virens virens*	298	70%	95%
Yellow-fronted Canary	*Serinus mozambicus*	85	10%	41%
Japanese White-eye	*Zosterops japonicus*	60	8%	44%
House Finch	*Carpodacus mexicanus*	91	6%	38%
Warbling Silver Bill	*Lonchura malabarica*	110	3%	35%
Northern Mockingbird	*Mimus polyglottus*	5	1%	6%
Erckle's Francolin	*Francolinus erckelli*	5	1%	6%
Apapane*	*Himatione sanguinea*	1	<0.1%	1%

* Native Hawaiian bird species.

DISCUSSION

Palila Critical Habitat

The results of the 2002 census were very similar to results from the previous censuses for PCH (Evans *et al.* 2002b). Most species had similar percent occurrences over all years, indicating that populations were similar to the previous year. Other species that were common and well distributed over the study area include House Finch, Japanese White-eye, Skylark and Erckle's Francolin

Kipuka Alala

As in the PCH, Amakihi were the most abundant birds. However, the species composition of Kipuka Alala appeared to differ from PCH. Japanese White-eye, Apapane and Erckle's Francolin represented a larger proportion of the avian community in Kipuka Alala. Apapane are more common in Kipuka Alala than PCH. This may be due to the proximity of the Ohia and Mamane/Naio forests. Apapane utilize nectar from both Ohia lehua and Mamane blossoms. Only one Elepaio was heard during the census, which is one less than the two previous censuses (Evans *et al.* 2002a, 2002b).

Training Area 22

Amakihi were the most common species recorded in Training Area 22. The remainder of the species composition differed from both Kipuka Alala and PCH. The next most common species was the Yellow-fronted Canary. House Finches and Japanese White-eyes were also relatively common in this area. One Apapane was heard and was the only other native bird heard during the 2002 survey.

SUMMARY DISCUSSION

Amakihi accounted for 47%, 59% and 70% of the total birds counted in PCH, Kipuka Alala, and Training Area 22, respectively. They were present at 92%, 97% and 95% of all counting stations in the three study areas, respectively. The numbers indicate that the densities of birds were high and they were well dispersed within the three study areas. It was encouraging to find a native bird in such abundance on PTA.

Most species were found in all three study areas, but the percent occurrence of certain birds varied with study area. For example, Yellow-fronted Canaries were scarce in PCH, more common in Kipuka Alala and very common in Training Area 22. Most birds were common in one study area and scarce in another except Amakihi, which was common in all the areas.

MANAGEMENT RECOMMENDATIONS

It is recommended to continue monitoring bird populations at PTA on an annual basis. Personnel should receive training on the statistical program **DISTANCE** (Research Unit for Wildlife Population Assessment, University of St. Andrews) so population estimates can be calculated. Monitoring Elepaio populations and predator control should continue because of the low numbers of birds remaining in Kipuka Alala.

4.2b Rare Bird Monitoring

Four Nene were reported in Training Area 23 on February 12, 2003 (Figure 4-2). NRS observed four birds flying overhead and calling. The birds were flying in a southwest direction. They were not seen landing.

4.3c Elepaio Monitoring

A total of 35 Elepaio have been banded in Kipuka Alala since 1996. The typical breeding season for Elepaio is January to June and juveniles remain with their parents for several months (Vanderwerf, pers. com.). Out of the 35 birds captured only two were juveniles with their parents, indicating that very few juveniles are present in the population. Of the 35 birds banded in Kipuka Alala, only one banded in 1998 is known to be alive.

The low number of juveniles and the disappearance of adult birds are alarming indicators that the Elepaio population is in serious trouble. Rodents may be limiting Elepaio populations in Hawaii Volcanoes National Park and on Army Lands (Sarr *et al.*1997, Rohrer pers. com.). It is unclear if other native bird populations in Kipuka Alala are also declining, but

METHODS

To monitor Elepaio, the male territory song is played over a portable recorder with an attached amplified speaker in areas where birds were located the previous year. If a bird responds, the location is marked using a hand-held GPS unit. The birds are followed for as long as possible to determine the approximate territory using the tracking function on the GPS unit. Observations regarding sex, mates, presence of bands and health are made using 8x40 binoculars.

RESULTS

In March 2003, 21 personnel-hours were spent trying to locate new Elepaio (Figure 4-3). None of twelve attempts to call males using territory songs were successful. In Area A, an additional two personnel-hours were spent trying to locate the male with the band combination, WH/AL, RD/WH. Although NRS had recently heard Elepaio calling from this area, the banded male and his mate were not located.

In May 2003, seven personnel-hours were expended locating the unbanded pair in Area C (Figure 4-2). A pair (one male and female) was observed within Area C as well as an additional male. It was unclear if the additional male also had a mate. The area was revisited later in May and the birds were not seen or heard.

In June, approximately eight personnel-hours were spent conducting rodent control and searching for the birds in Area A. Again the banded male and his mate were not located.

DISCUSSION

Staff hunting within the Kipuka Alala Fence Units prevented access to Training Area 23 and it was difficult to monitor Elepaio this breeding season. The banded male, WH/AL, RD/WH, and his mate were not found. The pair may have been in a slightly different area, so that they were missed on survey days. NRS did hear Elepaio calling near Area A in February 2003; therefore it is possible the pair is still near the area.

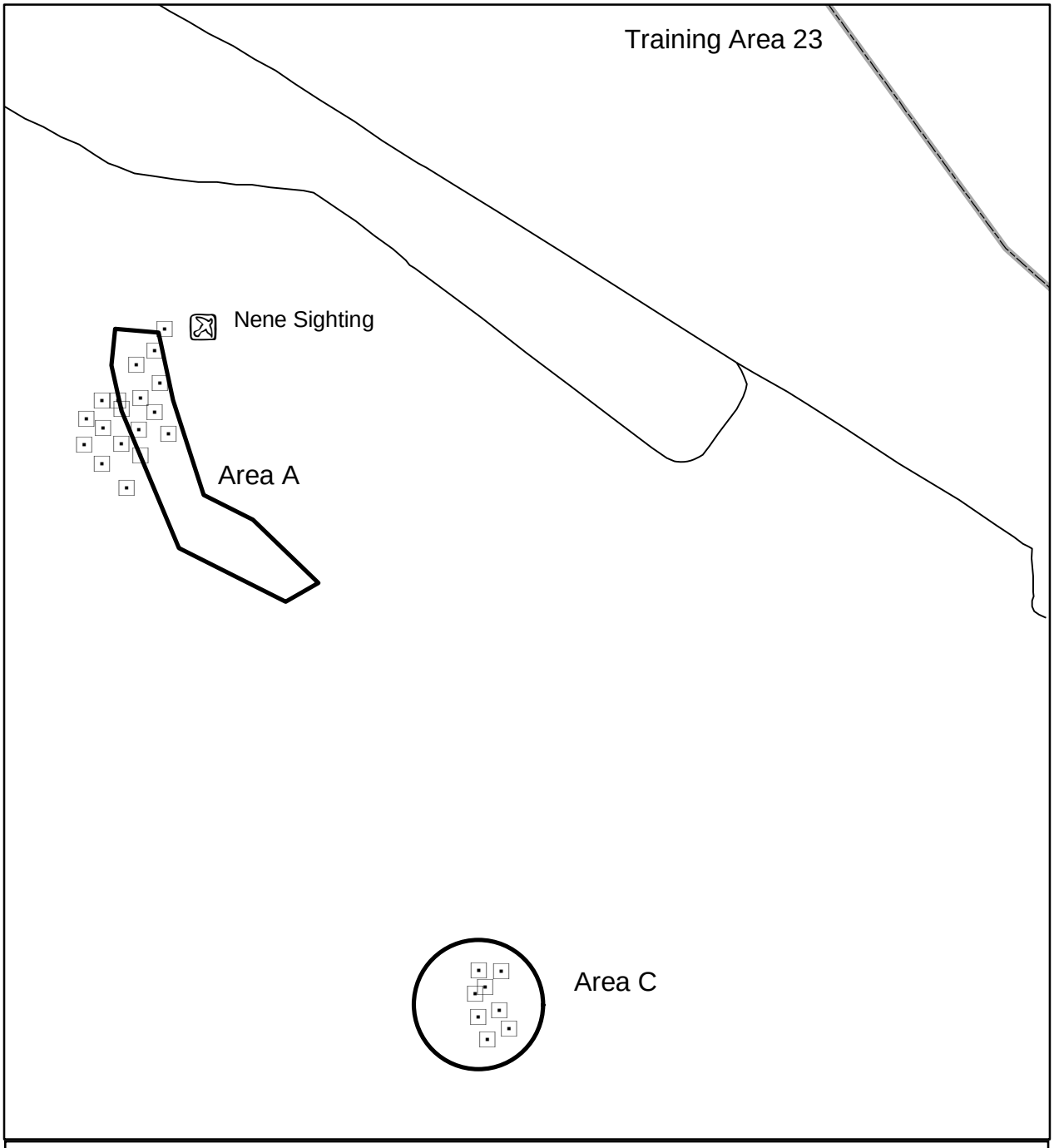


Figure 4-2

Bird Monitoring in TA 23

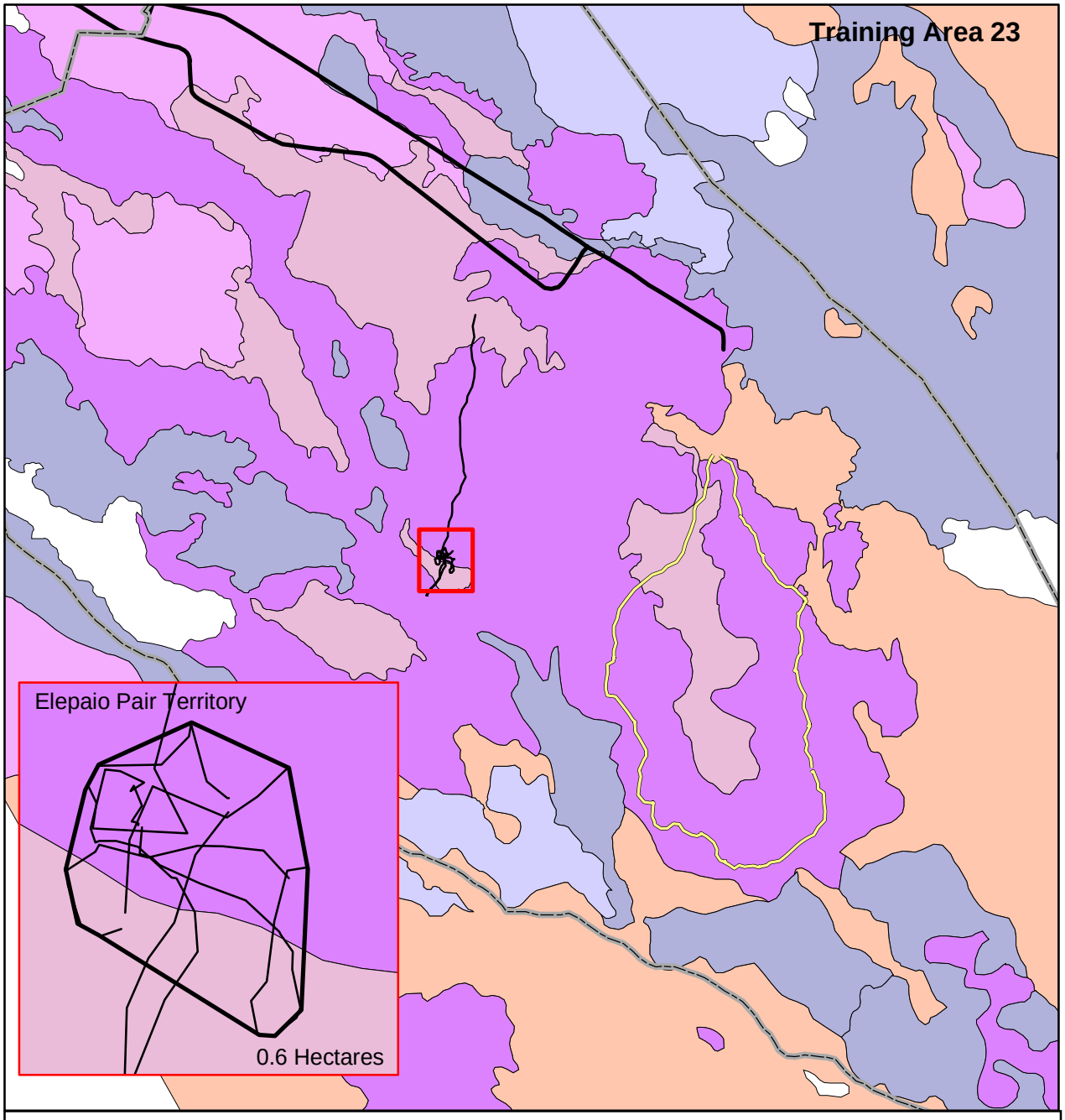
Elepaio Territories
Bait Stations
Roads and Trails
Kipuka Alala Fence Unit

1:13,010
0 240 480
Meters

N

Datum NAD 83
Projection UTM

July 2003
Lena Schnell



March 2003 Survey
May 2003 Survey
Fence Unit
Roads
1 - Barren Lava
2 - Sparse Metrosideros Treeland
3 - Open Metrosideros Treeland sparse shrub understory
14 - Myoporum - Sophora Mixed Shrubland
15 - Myoporum - Sophora Shrubland forb understory
16 - Myoporum - Sophora Shrubland grass understory

Figure 4-3
Elepaio Monitoring 2003

1:26,685

0 420 840

Meters

N

Datum NAD 83
Projection UTM

July 2003
Lena Schnell

It was encouraging to see the unbanded pair in the same general area as last year. Another male was in the area and the two males were challenging each other during the May monitoring. The pair was followed for approximately one hour while they foraged. It was not determined if the female had a nest.

It is unclear if other bird populations are also declining in Kipuka Alala. The percent occurrences of birds from the annual PTA forest bird censuses suggest that other bird populations have been relatively stable since 2000 when monitoring began. The Elepaio population has declined in other portions of PTA as well. Scott (1986) found Elepaio in Training Area 22 during the Hawaii Forest Bird Surveys, but surveys in 2001 and 2002 did not detect any Elepaio in the same areas. It is unclear why the Elepaio Populations at PTA have be declining. Some possible factors contributing to their decline may be habitat degradation, population fragmentation and isolation, nest depredation causing low nesting success, and changing environmental conditions, such as prolonged conditions.

MANAGEMENT RECOMMENDATIONS

Without identifying color bands, it is difficult to tell one Elepaio from another. Coordinating with Oahu NRS to band additional Elepaio would be helpful in identifying the birds. Predator control in areas with nesting Elepaio should continue.

4.4 INTRODUCED PREDATOR CONTROL

4.4a Predator Control for Birds

Introduced predators have been extensively studied in Hawaii because of their effect on native bird populations (Atkinson 1977, Sarr *et al.* 1997, Amarasekare *et al.*1993). At PTA, introduced predators include cats (*Felis catus*), mongooses (*Herpestes auropunctatus*), black rats (*Rattus rattus*) and mice (*Mus domesticus*). Black rats probably pose the greatest threat to native birds because of their arboreal habits.

METHODS

Two rodent control areas were baited around Elepaio territories in Kipuka Alala for the 2003-breeding season (Figure 4-2). Bait stations were placed at 50-meter intervals along transect lines. Area A has a total of 16 stations and Area C had a total of eight stations. Peanut butter flavored bait blocks impregnated with Diphacinone rodenticide was used inside the bait stations. Three to eight poison bait blocks were placed inside each station. Stations were checked on a regular basis through the breeding and fledging seasons.

DISCUSSION

Because access to Training Area 23 was limited due to USDA ground hunting activity, it was difficult to locate Elepaio this breeding season. After the pair in Area C was found occupying a slightly different area, the bait boxes were moved accordingly to better protect this pair. Eight pounds of bait were used in this territory. An additional six pounds were used in Area A.

MANAGEMENT RECOMMENDATIONS

Since Elepaio numbers are low, predator control should continue. It is recommended that attempts be made to locate territories prior to breeding season. Effort can then be concentrated in

the areas the birds are using during the current season. The USDA is currently pursuing approval for the hand broadcasting of Diphacinone. Should approval be granted, its use at PTA will be evaluated.

4.4b Rodent Control for Plants

Rodents are believed to impact native plant species by consuming fruits, seeds and seedlings (Sugihara 1997). Rodents can have a devastating effect upon endangered and rare plants such as *Schiedea hawaiiensis* by eating foliage and meristems (Steve Weller pers. obs.). The fleshy, juicy fruits of many native plants are a potential source of moisture and nutrition for rodents (Clark 1982, Sugihara 1997).

To protect some of the critically endangered species that bear large fleshy fruits or favorable foliage, rodents were controlled around the plants using poison bait blocks. It was difficult to determine effectiveness of the baiting because few, if any, impacts have been directly linked to rodents such as seed or seedling depredation. However, the rarity of these species and low natural recruitment justifies control without a clear demonstration of negative impacts by rodents.

Neraudia ovata

Bait stations with Diphacinone (rodenticide) have been placed in all exclosures for *N. ovata*. During the contract period the bait stations in Site 01 were monitored twice. A total of eight pounds were distributed over eight bait stations. At Site 02, bait stations were monitored once and a total of four pounds was distributed between two bait stations.

Schiedea hawaiiensis

Rodent control has been continuous for this species. During the reporting period no new browse was seen on the adult plant or reintroduced seedlings. Therefore the baiting appears to be effective. Rodent control for this species is extremely important since rodents have an affinity for this particular genus and other species have also been browsed in greenhouses (Weller, pers. com.).

Solanum incompletum

Bait stations were placed at all plants within Site 01. A total of 2.6 pounds was distributed among three bait boxes.

Zanthoxylum hawaiiense

In June 2003, to protect an abundance of seeds at Site 18, four pounds of bait were distributed among four bait stations.

MANAGEMENT RECOMMENDATIONS

Baiting should continue for endangered or critically rare plant species that are suspected of being impacted by rodents. Bait stations should be placed at the recently discovered S. *incompletum* population (Site 02). The baiting program should be expanded to include more locations, area and species.

4.5 ALIEN ANT CONTROL

There are no native ant species in Hawaii (Wilson and Taylor, 1967). Several ant species have been documented at PTA including *Cardiocondyla venustula, Hypoponera opaciceps, Linepithema humile* (Argentine ant), *Monomorium latinode*, *Pheidole megacephala* (Big-headed ant), *Tapinoma melanocephalum* (Tiny Yellow House ant), and *Technomyrmex albipes* (Oboyski 1998, Oboyski *et al.* 2002). These species are predators of other arthropods and some such as *L. humile* and *P. megacephala* have been implicated in declines of native Hawaiian arthropods (Oboyski *et al.*2002, Reimer *et al.*1990). *L. humile* can colonize high elevation areas and has been shown to reduce populations of important native pollinators such as *Hylaeus* a ground nesting native bee (Cole *et al.*1992).

In 2001, an isolated population of *L. humile* was documented at PTA in Training Area 23 around the Administration Site (Oboyski *et al.*2002). It is assumed that this population was established during construction of these building in the early 1990s. Because this population is isolated, relatively small, and located within a native dominated habitat with rare and endangered plant species, NRS is attempting to control or eradicate this population.

METHODS

Surveys to delineate the population extent were conducted from November 2002 to June 2003. To test for ant presence or absence, baits were placed along transects at 20 meter intervals. NRS used a baiting method modified by Oboyski *et al.* (2002) from Wetterer *et al.* (1998). Baits consisted of oil-packed tuna, and honey blended in a conventional blender and placed in small paper cups. Baits were checked 3-4 hours after placement to allow for maximum ant recruitment.

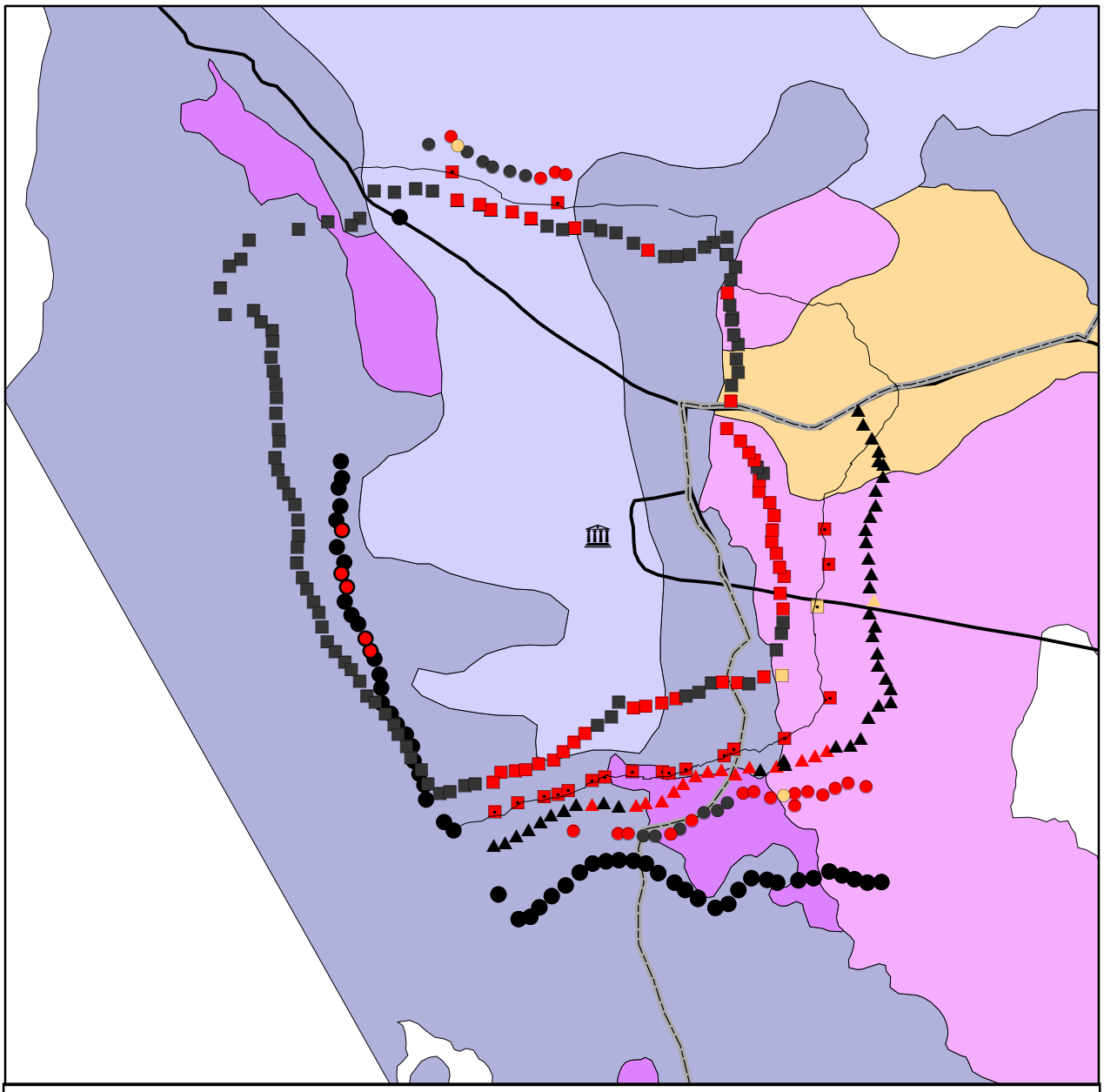
The coordinates for each bait cup were recoded using GPS. Bait cups with ants present were flagged in red and recorded. The GPS coordinates were downloaded into ArcView to determine the extent of ants present. For successive surveys, new monitoring sites were established 50 meters from the old monitoring sites using ArcView. These new sites were uploaded into the GPS unit as waypoints. Areas between new monitoring sites were also sampled.

RESULTS

A total of six surveys were conducted (Figure 4-4). Out of 567 bait cups, two ant species were recorded at 127 (22%) bait cups. *L humile* was recorded at 117 (20%) bait cups and *T. melanocephalum* was recorded at ten (2%) bait cups. The ants encompassed approximately 62 hectares (153 acres) and were found in Ohia (*Metrosideros polymorpha*) forest with native understories and Mamane/Naio (*Sophora crysophylla/ Myoporum sandwicensis*) forests with native shrubs. Assuming the ants were first established at the Administration Site, the population has expanded to the north 640 meters, to the west 396 meters, to the south 508 meters and to the east 343 meters.

DISCUSSION

The population of *L. humile* in Training Area 23 covers a relatively small area compared to infestations above PTA base camp and Haleakala National Park, Maui (Banko *et al.* 2001 and Krushelnycky *et al.*1998). Assuming the population was established in 1990 when the Administration Area was relocated to its current site, the average rate of spread along the northern axis has been approximately 50 meters per year (Department of the Army, 1990). This rate is comparable to rates observed in Haleakala National Park (Haines *et al.*2002).



11 Feb 03
- L. humile
- T. melanocephalum
- None

12 March 03
- L. humile
- T. melanocephalum

20 March 03
- L. humile
- T. melanocephalum
- None

25 March 03
- L. humile
- T. melanocephalum
- None

5 June 03
- L. humile
- None

- Kipuka Alala fence Unit
- Roads
- 2 - Sparse Metrosideros Treeland
- 3 - Open Metrosideros Treeland sparse shrub understory
- 11 - Myoporum Shrubland
- 14 - Myoporum - Sophora Mixed Shrubland
- 15 - Myoporum - Sophora Shrubland forb understory
- 16 - Myoporum - Sophora Shrubland grass understory

Figure 4-4

Argentine Ant Infestation 2003

1:20,750

0 210 420

Meters

N

Datum NAD 83 July 2003
Projection UTM Lena Schnell

The ants were located in four different vegetation types (Shaw and Castillo 1997). Two of the vegetation types were Ohia dominated forests with varying densities of native shrubs in the understory. The substrate was aa lava and the vegetation was patchy. The ants appeared to be associated with islands of vegetation situated amongst the lava flow and were rarely recorded from barren areas. The other two vegetation types the ants were found in were Mamane/Naio dominant forests with dense native shrubs. The substrate was soil and the vegetation was relatively continuous. Ants appeared to have moved the greatest distance in the Ohia forest within the aa substrate. Because the vegetation is patchy in these areas, it is possible the ants have to move farther to colonize the islands of vegetation.

Haleakala National Park, Maui, has been trying to control the spread of Argentine ants through aerial broadcasting of granular insecticide baits (Krushelnycky and Reimer.1998). They have used baits along the perimeter of the populations and have documented a slowing but not complete halt of ant population expansion (Haines *et al.*2002). At PTA, because of the relatively small area infested by the ants, it may be possible to aerial broadcast granular insecticide over the entire affected area. This may substantially reduce ant numbers with the hopes of eradicating the population all together.

MANAGEMENT RECOMMENDATIONS

Granular insecticide bait should be broadcast by helicopter over the entire infested area during the summer months when nutritional needs of the ant colonies are highest. A second treatment should follow, two to three weeks later to kill any remaining ants and/or ants that may have emerged from eggs and/or pupa.

CHAPTER 5: RARE PLANT PROPAGATION

5.1 PCSU CONTRACT REQUIREMENTS

REQUIREMENT 5.b.15

Propagating Priority Species (PS) 1 and 2, maintaining database of propagation methods, maintaining seeds in storage and conducting periodic germination tests. Work in conjunction with other agencies to determine seed viability and establish genetic safety nets for PS 1 and 2. Based on the propagation methods, prepare a report that includes methods, results and management recommendations. The report shall also include status of seed viability determinations and assessments.

DISCUSSION

Work has continued on developing propagation protocol for PS 1 and 2, as well as some of the lower priority species. Records of germination trials and propagation methods include the source of the seed or vegetative material, the date collected and the collector, the date and number of seeds planted, the propagation media, treatments, and germination percentage. A log is kept showing the number of seeds germinating over time. Notes and recommendations are also included.

Seeds from the field and the Rare Plant Propagation Facility (RPPF) are collected when available and placed in storage at PTA for future outplanting purposes. Seeds in storage are also used to test seed viability over time. Seeds of some species have been sent to H. L. Lyon Arboretum for seed storage studies and seed banking. Seeds of *Solanum incompletum* have been sent to Professors Carol and Jerry Baskin at the University of Kentucky for germination studies. Spores of *Asplenium fragile* var. *insulare* have been sent to Dr. Valerie Pence at the Cincinnati Zoo and Botanical Garden for spore storage studies.

NRS is working with the Big Island Rare Plant Group (BIRP) to coordinate and prioritize recovery efforts by various agencies and landowners for the island's rarest plants. Currently four taxa found at PTA have been placed on the Genetic Safety Net List for the Big Island. They are *Neraudia ovata*, *Schiedea hawaiiensis*, *Solanum incompletum*, and *Tetramolopium* species 1.

REQUIREMENT 5.b.16

Managing the operation of the plant nursery and adaptation compound, working generally with plant taxa that cannot be grown at lower elevations where commercial propagation facilities are available. An annual report shall be prepared which describes sub alpine dryland propagation and outplanting methods and results.

DISCUSSION

RPPF maintenance continues to be labor-intensive, with over 1,000 propagules being readied for outplanting in Fall 2003. The shaded area of the facility has been enlarged to accommodate the increased number of seedlings. Plants are fertilized and monitored for insects and pathogens regularly. A heating system is being considered to protect some of the more temperature sensitive species, especially *Hedyotis coriacea* and *Neraudia ovata* from the lower temperatures possible during the winter months.

REQUIREMENT 5.b.17

Developing and implementing an outplanting plan. The plan shall contain outplanting methods and monitoring protocols. It shall also include drafts of documents needed for permits and approvals for outplanting of listed species. Thereafter, outplanting shall commence and sites shall be monitored and maintained, as appropriate. Annual reports shall summarize accomplishments and recommend future management actions.

DISCUSSION

PTA's U.S. Army Biologist drafted the Rare Plant Outplanting Plan during the last reporting period. It utilizes some of the recommendations from the 1999 Draft Recovery and Outplanting Plan prepared by NRS. Small-scale outplanting projects for 11 of PTA's listed and rare species and for some common native species have been undertaken. Seedlings are being readied for larger scale outplanting projects in Fall 2003.

REQUIREMENT 5.b.18

Maintaining and managing an interpretive garden to educate visitors on the management and causes of degradation of natural resources within the Pohakuloa dryland ecosystem. The garden will encompass approximately one-quarter acre.

DISCUSSION

Maintenance of the Interpretive Garden has continued during this reporting period, with more plants being added to the area.

REQUIREMENT 5.b.19

Designing and testing protocols for utilization of native dryland plants in revegetation projects. The approximate area for testing will be 76 meters squared (250 ft. x 250 ft.). A report shall be prepared describing the rationale for the design, method and results. Findings shall be evaluated and recommendations made for management actions.

DISCUSSION

Cooperative efforts with Integrated Training Area Management (ITAM) staff have included providing space for ITAM nursery stock in the RPPF and some assistance in their maintenance. No projects are currently in place in the test plot. Revegetation projects by ITAM staff take place *in situ*.

5.2 INTRODUCTION TO RARE PLANT PROPAGATION

Every plant species has one or more mechanisms for delaying germination until the seed has been dispersed (Deno 1993). Understanding and overcoming these delay mechanisms to propagate PTA's rare plants poses a challenge to NRS. To successfully propagate a species, a thorough understanding of its seed dormancy characteristics, its mating system, and its possible reliance on insects or animals for dissemination of pollen and/or seeds is critical. This information is not available for most of PTA's rare plants. In addition to this lack of biological and horticultural information, small population size may reduce seed set, seed viability, germination percentage, and overall seedling vigor (Ellstrand and Elam 1993). The situation is further exacerbated by the intraspecific diversity

often exhibited by Hawaiian plants (Wagner *et. al*. 1990) and the variable environmental conditions that can affect plant fecundity (Baskin and Baskin 2001).

The methods, results, and recommendations presented here should be regarded as preliminary findings. Due to the large number of variables noted above, it would be unwise to extrapolate these initial results to all populations of these species or even to particular harvests. Many more trials may be necessary to determine a germination protocol for each species. The small sample size for the trials conducted thus far precluded any kind of statistical analysis. Results are reported as simple germination percentages. Propagation by cuttings has been attempted when seed germination has proven problematic. Because seeds are unique genetic entities that may exhibit enhanced ecological adaptability and may be more resistant to environmental stresses than vegetative propagules (Schmidt 2000) efforts have been concentrated on seed germination trials.

Propagation efforts and future restoration activities will benefit greatly from a more thorough understanding of the life history characteristics, the reproductive biology and the ecology of these vulnerable species. It is hoped the initial findings reported here will serve as a guide for the direction of future inquiries.

5.3 PROPAGATING PRIORITY SPECIES 1

A Priority Species (PS) list was developed by NRS to prioritize management actions. The taxa in PS 1 have fewer than 500 individuals and/or nine or fewer populations remaining statewide (Evans *et al*. 2002b).

5.3a *Hedyotis coriacea*

Seed production and collection of *Hedyotis coriacea* during this reporting period was much higher than in the previous period. Seeds were collected from 34 individuals at seven of the ten *H. coriacea* sites in the fall of 2002. Seedlings are extremely small and difficult to handle. Growth is very slow. Lack of regeneration in the field continues to be a concern.

METHODS

More than 900 seeds from Sites 2, 3, 4, 5, 7, 9, 10 and the Interpretive Garden were surface-sown in mid-March, 2003 on a 1:1 perlite/vermiculite mixture.

RESULTS

Time to first germination: 18 days
Germination percentage: 70-80%
Percentage survival after 4 months: 27%
Time from seeding to outplanting: Not yet determined

MANAGEMENT RECOMMENDATIONS

Seeding in early spring seems to produce better germination results than mid winter seeding. Germination time was approximately 50% shorter and percentage survival after four months was three times higher than in mid winter trials. Future germination efforts may be able to determine if these results were actually a function of temperature or other environmental conditions present during seed production.

5.3b *Neraudia ovata*

N. ovata is typically dioecious, although Evans *et al*. (2002b) have reported that two individuals at PTA have possessed either male or female flowers at different times of the year. This kind of mating system reduces the effective population size and further compounds other possible risks for a small population. Shortage of sufficient pollen may impact seed set, viability, germination and seedling vigor (Baskin and Baskin 2001). Germination percentage has been very low and germination extends over a period of many months. Seedling vigor is described as poor with, seedlings being very susceptible to stem wilt soon after germination. Propagation by cuttings has been successful.

METHODS

Five hundred eighty-six seeds from both greenhouse and field stock were sown in early February 2003 from collections made between July 1998 and January 2003. Seeds were soaked in water or gibberellic acid (GA-3) at a concentration of 125 ppm for 48 hours.

RESULTS

After three months one seed had germinated. No further germination from these trials has occurred since then. Seeds sown in January 2002 have continued to germinate sporadically during this reporting period. The greatest number of seedlings (28) have emerged 11 to15 months after seeding. Germination percentage for the January 2002 trial is at 23%.

MANAGEMENT RECOMMENDATIONS

Plants maintained in the greenhouse for seed collection or outplanting will need protection during the winter months when temperatures may drop below 30°F (-1°C). Continue with seed germination trials.

5.3c *Solanum incompletum*

In January 2002, greenhouse-grown seeds were sent to Professors Carol and Jerry Baskin at the University of Kentucky, leading researchers in seed ecology, dormancy and germination. Because of its responsiveness to GA-3, the Baskins speculate that *S. incompletum* possesses a type of physiological dormancy that requires a specific temperature regime for germination. They are presently conducting germination trials under various alternating diurnal temperature regimes. Germination results after 72 weeks show 57% germination at 15°C (day)/6°C (night), 25.5% at 20°C/10°C, and 30% at 25°C/15°C, with most activity occurring during the first 25 weeks. Because the ungerminated seeds appear to be still viable, Professor Carol Baskin has initiated another experiment to test if drying would promote loss of dormancy for the seeds that have not germinated during the extended period of imbibition (Baskin pers. com.).

Simultaneously propagation efforts have continued at the RPPF utilizing GA-3 during the colder winter months. Seedlings are generally hardy and can be transplanted to potting media at the cotyledon stage. Seedling survival is good. One hundred eight seedlings are currently in the RPPF, most of which will be ready for outplanting in Fall 2003. The three transplants in the Interpretive Garden were injured during the cold spell in January 2003, but have recovered.

METHODS

Greenhouse and field grown seeds (922 total) were treated with GA-3 at 375 ppm or a vitamin B-1 solution for one to three days. Media was either a 1:1 ratio of perlite and vermiculite or moistened paper towels.

RESULTS

Time to first germination: 7 weeks, continuing sporadically.
Germination percentage: Ranged from 0-24% after 6 months
Time from seeding to outplanting: Not yet determined. Shortest possible time estimated at 8-10 months.

MANAGEMENT RECOMMENDATIONS

Utilize GA-3 at 375 ppm as a germination stimulant until further studies determine specific dormancy breaking requirements. Gather more phenology data concerning times of seed maturity and germination in the field. Monitor for insect damage to seeds in the field.

5.3d *Schiedea hawaiiensis*

S. hawaiiensis is the most rare species at PTA, with only one known founder in the field. Both the field and greenhouse specimens have produced viable seed this year. Some seeds require an after-ripening period, a time of physiological maturation that occurs after harvest or abscission. For *S. hawaiiensis*, an after-ripening period of six months is recommended before planting (Weller pers. com.). Seedling survival is good and they are easily transplanted to potting mix.

METHODS

Greenhouse and field grown seeds (528) were surface sown on perlite/vermiculite (1:1) after a 24-hour water soak.

RESULTS

Time to first germination: 34 days
Germination percentage: Greenhouse seed-47%; Field seed-26%
Time from seeding to outplanting: 6-8 months

MANAGEMENT RECOMMENDATIONS

Continue germinating both greenhouse and field grown seed when available in order to monitor for possible differences in seedling vigor both in the RPPF and as outplants.

5.3e *Tetramolopium arenarium* ssp. *arenarium*

Propagation efforts utilized seed from some of the new Kipuka Kalawamauna sites discovered during the last reporting period, as well as seed collected by CEMML personnel in 1991-92. Of the four trials using seed from this earlier period, only one group germinated, but at an astonishing 74%.

METHODS

A total of 1,100 seeds were sown in vermiculite/perlite (1:1). A two-hour warm water soak produced the highest germination percentage.

RESULTS

Time to first germination: 8 days
Germination percentage: 30-74%
Time from seeding to outplanting: approximately 6 months

MANAGEMENT RECOMMENDATIONS

Because *T. arenarium* does not exhibit any unusual dormancy or germination requirements, efforts should be focused on seed collection to maximize genetic diversity of propagules. Seed should be collected and germination trials conducted from the various clusters within the population. Some seed should be stored and tested periodically to ascertain the long-term storage effects on viability in order to determine future seed collection and seed storage protocol.

5.3f *Tetramolopium* sp. 1

Seed was collected from 12 individuals at both the Kipuka Kalawamauna and Kipuka Alala sites in Fall 2002.

METHODS

Germination protocol used was similar to other *Tetramolopium* species. Seeds (600) were soaked in warm water for two hours and planted in a perlite/vermiculite (1:1) mixture.

RESULTS

Time to first germination: 7-8 days
Germination percentage: 40-48%
Time from sowing to outplanting: approximately 6 months

MANAGEMENT RECOMMENDATIONS

Collect seed from the field maintaining as much genetic diversity as possible. Begin outplanting trials in Fall 2003.

5.4 PROPAGATING PRIORITY SPECIES 2

The taxa in PS 2 have 500-1,000 individuals and /or six to ten populations remaining statewide.

5.4a *Asplenium fragile* var. *insulare*

Propagation of *A. fragile* is being done at the H. L. Lyon Arboretum Micropropagation Facilities. Spore germination has been good, with some gametophytes to be delivered to PTA in August 2003. *A. fragile* spores were also sent to Dr. Valerie Pence at the Center for Conservation and Research of Endangered Wildlife at the Cincinnati Zoo and Botanical Garden for spore storage studies that could aid in conservation efforts. Spores again germinated readily both in the control group and in another group first air-dried and then exposed to liquid nitrogen overnight. Some spores are being stored in liquid nitrogen for at least two to three more years before further testing will be done.

MANAGEMENT RECOMMENDATIONS

Develop protocol for acclimating propagules received from H. L. Lyon Arboretum to the PTA environment.

5.4b *Silene lanceolata*

Halward and Shaw (1996) report varying germination responses among the different populations of *S. lanceolata* tested (both field collected and greenhouse grown seed). In general, they recommend an after-ripening period of at least 40-60 days. Germination trials at the RPPF have been conducted with greenhouse and field grown seed collected between 1998-2002 in Kipuka Kalawamauna and Kipuka Alala. Germination percentages from the 1998 seed lots were roughly the same as from the seed lots collected more recently.

METHODS

Seeds were soaked in water for 24 hours and planted in a mixture of perlite and vermiculite (1:1).

RESULTS

Time to first germination: 10 days
Germination percentage: 54%
Time from seeding to outplanting: 8 months

MANAGEMENT RECOMMENDATIONS

Germination trials should be conducted with seed from both the Kipuka Alala and Kipuka Kalawamauna populations to try to determine if there might be specific germination patterns peculiar to the individual populations. This information may be useful in developing the outplanting/management plan.

5.4c *Zanthoxylum hawaiiense*

Z. hawaiiense, like some other Hawaiian *Zanthoxylum* species, is very slow to germinate with an extended germination period of many months (Moriyasu pers. com.). This extended germination period is not uncommon among some Hawaiian dryland species and may be the result of genetic and/or environmental influences (Baskin and Baskin 2001). The germination trial begun in this reporting period has not yielded any seedlings to date. Three of the 21 seeds (14%) planted during the last reporting period have germinated. Approximate time from seeding to outplanting is estimated to be at least two years.

Seed collection in the field should include as many individuals as possible. Continue germination trials.

5.5 PROPAGATING OTHER SPECIES

Germination trials have also been conducted for *Festuca hawaiiensis* and *Portulaca sclerocarpa* (PS 3), *Eragrostis deflexa* (PS 4) and *Chamaesyce olowaluana*, *Haplostachys haplostachya, Silene hawaiiensis*, *Spermolepis hawaiiensis,* and *Stenogyne angustifolia* (PS 5). Other taxa not included on the Priority Species List are experimented with as time and seed availability permits. Data collected may be helpful in future habitat restoration activities. Germination trials have been conducted for the following species:

Caesalpinia kavaiensis	***Plectranthus parviflorus***
Carex wahuensis	***Ranunculus hawaiiensis***
Coprosma ernodeoides	***Rumex giganteus***
Dianella sandwicensis	***Rumex skottsbergii***
Dodonaea viscosa	***Santalum paniculatum***
Exocarpos menziesii	***Sida fallax***
Isodendrion hosakae	***Sophora chrysophylla***
Myoporum sandwicense	***Vigna o-wahuensis***

5.6 MAINTAINING SEEDS IN STORAGE

A seed storage program had been previously initiated for both listed and common species at PTA. Seeds continue to be collected from the field and catalogued by species, date, collector, location and founder. They are stored in sealed polyethylene bags in a refrigerator at 5º C and 23% relative humidity. Seed germination trials are conducted to determine germination protocol and to test seed viability over time. When a germination protocol for the listed species has been determined and if seed is available in quantities greater than what is necessary for outplanting needs, then some seeds are sent to H. L. Lyon Arboretum on Oahu. At H. L. Lyon Arboretum seed storage protocol for each species will be determined. Depending on the species and quantity of seed available, some seed will be put into a genetic safety net storage program and some will be stored for future experimentation and outplanting purposes at PTA. Seeds that are available in ample number and have been found suitable for long term storage will be sent to the USDA's National Seed Storage Laboratory at Fort Collins, CO.

5.7 MANAGING THE RARE PLANT PROPAGATION FACILITY

The RPPF has been cleared of stock from past projects and new seedlings are in residence. Currently there are approximately 1,600 seedlings in the facility, the majority of which will be outplanted in Fall 2003. Routine maintenance is provided to ensure plant vigor. To minimize the use of chemical

insecticides, which may be harmful to sensitive plant tissue, an integrated pest management program is utilized. This system includes keeping the facility clear of weeds and decaying matter, regular and thorough inspections to detect pest/pathogen outbreaks at inception, isolation of infected individuals during treatment, and use of mechanical and other non-chemical controls when possible. Pesticides used are rotated to minimize the possibility of built up resistance in the target pests.

5.8 Developing and Implementing an Outplanting Plan

As part of preliminary small-scale outplanting trials, 235 seedlings, representing 23 species, have been outplanted at seven different sites this reporting period. Of the 23 species planted, seven are federally listed as endangered (*H. coriacea, P. sclerocarpa, S. lanceolata, S. incompletum, S. hawaiiensis, S. angustifolia,* and *Z. hawaiiense*) and four are Species of Concern (*Alphitonia ponderosa, Chamaesyce olowaluana, Eragrostis deflexa,* and *S. hawaiiensis*). This group makes up 73% of the total outplanted. The remaining 27% are more common natives.

The purpose has been to gather information and experience that will be helpful in future larger scale projects and to utilize the seedlings that have resulted from germination trials. All sites are at PTA except for the Puu Huluhulu site that was planted in cooperation with the State's DLNR. Average survival for all sites is 80%. Survival of the rare species subgroup is also 80%. Plant mortality has been the result of freezing temperatures in January, ungulate damage, poor site selection and alien bird damage.

Sites were chosen that provided appropriate habitat for the species being planted and that were accessible for ease of maintenance. Site preparation included building emergency fencing when necessary, clearing the area of alien plants, and setting out rodent bait stations around the perimeter of the site at least two weeks prior to outplanting. Plants were watered at the time of outplanting, one week later, two weeks after that, and then every four to six weeks depending on natural precipitation. Seed is already being collected from some of the *Schiedea hawaiiensis* outplants, and it is expected that seed will be collected from outplanted individuals of *Spermolepis hawaiiensis* in August 2003.

Management Recommendations

Now that aerial hunting has been approved, fence units should be cleared of ungulates as soon as possible. Begin outplanting in early September to give outplants time to get established before the low winter temperatures. *Haplostachys haplostachya, Hedyotis coriacea, Neraudia ovata, Portulaca sclerocarpa, Solanum incompletum,* and *Stenogyne angustifolia* seem most susceptible to low temperatures. Elevation may be a consideration in choosing outplanting sites for these species. *Hedyotis coriacea* may require more watering than the other species initially and should be monitored closely.

Projects for the next reporting period will reintroduce geographically discrete populations of several species within the fence units at PTA. Seedlings being readied in the RPPF include approximately 200 individuals each of *Tetramolopium arenarium, Tetramolopium* sp.1, and *Silene lanceolata*; approximately 150 individuals of both *Hedyotis coriacea* and *Solanum incompletum*; approximately 75 individuals of *Schiedea hawaiiensis*; and 40 individuals of *Neraudia ovata*.

Efforts should also be made to reintroduce populations to areas outside of PTA to create a genetic safety net against loss due to fire or other stochastic events. Cooperation with government and private agencies can provide protected and suitable areas for our rare species. *Neraudia ovata* seedlings have been provided to Hawaii Volcanoes National Park and DLNR's Puu Waawaa exclosure during this reporting period.

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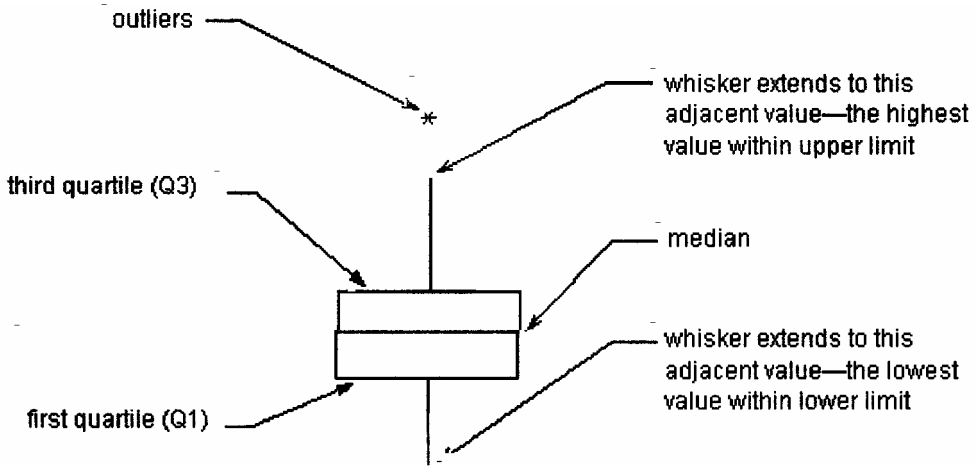
APPENDIX 1. BOX PLOT INTERPRETATION

Reprinted from the Help Menu in the statistical software program MINITAB, Release 13 (Adobe Systems Inc. 2000).

Boxplots, also called box-and-whisker plots, are particularly useful for showing the distributional characteristics of data. By default, a boxplot consists of a box, whiskers, and outliers.



A line is drawn across the box at the median. If a red dot is present, it represents the mean. By default, the bottom of the box is at the first quartile (Q1), and the top is at the third quartile (Q3) value. The whiskers are the lines that extend from the top and bottom of the box to the adjacent values. The adjacent values are the lowest and highest observations that are still inside the region defined by the following limits:

Lower Limit: Q1 - 1.5 (Q3 - Q1)

Upper Limit: Q3 + 1.5 (Q3 - Q1)

Outliers are points outside of the lower and upper limits and are plotted with asterisks (*).

Introduced Animal Monitoring and Control