Dryland Forest Restoration Forum
November 14, 1997, 9 a.m., Pu`u Wa`a Wa`a, Kona

I. Introduction & Welcome (Andrea Beck).

The purpose of this forum is to strengthen and extend the network of people working to restore Hawai`i's dryland forest ecosystems. In the morning there will be brief presentations on five restoration projects, and in the afternoon there will be topical discussions focusing on finding solutions to common problems.

There are also other projects pending or happening which were unable to send representatives today. Keoni Fairbanks and Paul Higashino of the Kaho`olawe Restoration Commission are in Fort Lauderdale today attending a national restoration conference. Although they deeply regret missing this gathering, they will have a lot to report when they return, and a draft restoration plan for Kaho`olawe is being circulated for public comment. Higashino noted that Kaho`olawe is a challenging environment in which everything is an unknown. If the ordnance is cleared to a depth of four feet, they still can only plant six inches deep. Compared to that, a`a and fountain grass almost seem easy.

Art Medeiros of the USGS Biological Resource Division was also unable to attend today. This is the third day of a three day window for a helicopter to apply herbicide on kikuyu grass in their ten acre exclosure on Maui. The project is located in western Auwahi ahupua`a on Ulupalakua Ranch at about 4,000 feet in elevation. It has remnants of shrubland which they are trying to restore. Once the grass has been knocked back, there are plans to scatter seed in one part of the exclosure and to let regeneration occur naturally in another part of the exclosure. There are hopes to reestablish a shrub layer which will encourage natural regeneration by creating suitable microhabitats. Among the seeds they will scatter will be a`ali`i, mailelauli`i, olopua, ule and pilo.

The Queen Emma Foundation was also unable to send a representative to speak today. They have eight exclosures in Kawaihae, and their consultant Benton Keali`i Pang has written a two page summary of their work thus far (see attached).

II. Ka`upulehu Preserve, Hawai`i (David Lorence).

A. Introduction.
Destruction of tropical rain forests has received much media attention. Yet tropical dry forests are one of the world's most threatened and endangered vegetation types and are very diverse communities. Over 90% of Hawai`i's dry forests have been destroyed by human activities, alien

plants, grazing animals and burning.

B. Background

The Ka`upulehu Preserve is a 5.8 acre (2.3 ha.) parcel of kipuka dry forest with lama as the dominant species. It is located on a 1,500 - 3,000 year old a`a lava flow at the 2,050 - 2,100 feet elevation.

The Preserve was established in 1951-1952 as a Territorial Forestry Preserve and it was fenced at that time to exclude ungulates. The National Tropical Botanical Garden (NTBG) has been leasing the parcel from Kamehameha Schools Bishop Estate (KSBE) since the early 1970s.

Fountain grass (*Pennisetum setaceum*) had covered 95% of the ground and posed a severe fire threat. Recruitment of native species had been very low or absent because fountain grass and rats (*Rattus exulans*) were consuming the seeds of many native species before they could grow.

C. Project Goals

The Hawai`i Forest Industry Association, with a grant from the US Fish and Wildlife Service (USFWS), collaborated with a Dryland Forest Working Group which selected the Preserve as a pilot project to do the following: 1) conduct a baseline survey and inventory of flora and vegetation including seedlings; 2) do yearly post-treatment follow up surveys; 3) eradicate fountain grass by weed-whacking and manual spraying with Fusillade, a grass specific herbicide; 4) control rats using diphacinone bait blocks; 5) outplant native trees and shrubs to jump start regeneration; and 6) establish a fire break on two unprotected sides of the Preserve.

D. Achievements to Date

1) Baseline Survey and Follow Up Surveys

928 native trees and shrubs have been numbered, tagged and measured. 53 10 x 10 meter plots have been sampled within the Preserve and 26 control plots have been sampled outside of the Preserve for comparison. The numbers of individuals and percent cover were recorded in each plot. The pre-treatment survey recorded 67 vascular plant species of which 37 were native and 30 were naturalized. Survey results have been written up for publication in an ecological journal.

2) Eradicate Fountain Grass

The Preserve was weed-whacked in November - December 1995, and there were five rounds of Fusillade spraying from January 1996 to March 1997 including one spot spraying which resulted in the elimination of about 90-95% of the fountain grass. Roundup was sprayed on half of the Preserve in the first round of spraying and it seemed comparable to Fusillade, but had killed small native plants and was discontinued. 16 5 x 5 meter plots were hand weeded.

3) Rodent Control

24 bait stations were donated by KSBE and were rebaited every 1 - 2 weeks. In 13 months, 350 pounds of bait had been used, and based on consumption, it is estimated that 800 rats had been killed. So far, there have been some minor problems with ants taking the bait and mongoose or cats breaking into the bait stations, however there appears to be no more rat predation on native seeds.

4) Outplanting

A drip irrigation system was installed using 2 gal/hr emitters and an automatic timer using water that was donated by Hualalai Ranch. NTBG on Kaua`i raised 196 seedlings of 8 species from seed collected in the Preserve. These were outplanted in four different areas by volunteers. As of November 1997, the overall survival of the outplants was 80%. 61 of 77 (79%) lama seedlings survived while 33 of 40 (83%) kauila, 24 of 27 (89%) a`ali`i, 16 of 20 mamane (80%), 13 of 18 (72%) koki`o, 5 of 9 (56%) iliahi, 2 of 4 (50%) uhi uhi and 0 of 1 (0%) `aiea seedlings survived. In addition, survival rates were highest (92%) in the planting area which had a forest canopy with relatively deep soils. The next highest (89%) was in an area with some canopy and relatively deep soils. Survival rates were lower (76%) in the planting area with full sun and sparse, rocky and shallow soils and lowest (64%) in the area with full sun and very sparse, rocky and shallow soils.

5) Establish a Fire Break

A 20 foot wide fire break was sprayed with Roundup in mid-1997 on the mauka and Kailua sides of the Preserve. The Kailua side was weed-whacked before it was sprayed.

E. Project Costs

Total project costs for the entire parcel over a two year period was $53,297. This includes $27,819 that was received through a grant and $25,500 that was received through in-kind services and materials. The total cost per acre was $9,189. $1,900 per acre was spent for alien plant control ($10,843 plus $260 in-kind), $5,600 was spent weedeating, $5,200 was spent on herbicide application, $830 was spent on the fire break, $4,250 was spent on raising and outplanting the seedlings, and $11,567 plus $23,135 in-kind was spent on administrative costs.

F. Obstacles Encountered

Roughness of terrain made weed-whacking and spraying difficult and risky. It also made baiting and finding the rat stations difficult and time consuming. Spraying of herbicides was weather dependent and the irrigation system had problems with fluctuating pressure and the automatic controller.

G. Lessons Learned

Ungulate exclusion is a critical first step to restoring the dryland forest, but after forty years weeds and fire are still a threat. The second step is to clear the fountain grass, which relaxes competition, enables natives to grow and regenerate, and reduces the threat of fire. But, these two steps are not enough. There is a potential for invasion by new alien weeds which may establish and spread quickly as well as the return of fountain grass. Long term monitoring is needed to determine what ultimately will happen to vegetation composition, and long term management will probably be necessary. For example, a post-treatment survey after one year found 81 species (38 native) including 14 new species (3 native and 11 alien).

High rainfall in 1996-1997 helped regeneration. A dedicated water tank is needed for the site and manual water control is best to water seedlings on an as needed basis.

Introduced insects such as ants, scales, aphids and mealy bugs are plaguing the outplants and seedlings. There will be future efforts to plant native seeds rather than seedlings to see if it is more cost effective.

Manual clearing (weed-whacking and/or hand weeding) and manual spraying are effective, but too expensive for large scale operations. A more cost effective means of weed control like helicopter spraying needs to looked at for large scale operations.

Finally, interagency collaboration, combining resources and expertise, and volunteers have been helpful and essential for the success of the project.

H. Question, Answer and Discussion

Q: What nursery materials were used to grow the seedlings?
A: Sterile medium dipped for insects before shipping.

Q: How often were the outplants watered?
A: Twice per week for 1 -2 hours. Now the plants are being weaned off irrigation. The `aiea and wili wili will die with too much water.

Q: Is shading critical for outplant survival?
A: Survival rates were highest in areas with shading, however the plants still had a 64% - 76% survival rate in areas with full sun. Soil conditions also had a significant impact on outplant survival.

Q: Have there been any problems with ants plugging the emitters used in the irrigation system?
A: Ants are present, but they have not been a big problem.

III. Pu`u Wa`a Wa`a, Hawai`i (Lyman Perry).

A. Background.

Pu`u Wa`a Wa`a is located on the northern flank of Hualalai volcano, bounded by the 1859 and Ka`upulehu lava flows. The entire ahupua`a is owned by the State and about 21,000 acres is leased by Pu`u Wa`a Wa`a Ranch. Despite over a hundred years of intensive ranching, numerous wildfires and the spread of alien plant species, Pu`u Wa`a Wa`a today supports roughly 182 species of native plants of which 22 are officially listed as endangered.

Pu`u Wa`a Wa`a Ranch was started in 1893. Animals raised on the ranch included goats, sheep, cattle and turkeys. The lease expires in the year 2000 and currently there are discussions going on between the Division of Forestry and Wildlife (DOFAW), The Nature Conservancy (TNC), Tropical Reforestation and Ecosystem Education (TREE) and other interested parties regarding the future management of the area.

B. Project Goals

Currently DOFAW manages fifteen rare plant exclosures within the Pu`u Wa`a Wa`a ahupua`a. The goal is to protect and enhance rare plant populations through construction of ungulate proof fences, collection of seed and outplanting of species that are imperiled throughout their range. Ultimately, we would like to be able to create conditions that will allow these species to regenerate of their own accord.

The long term management goal is to reestablish native forest cover in approximately one-half of its former range. This is an ambitious goal which will take many years and tremendous investments of labor and money. DOFAW also plans to initiate a community based approach to forest planning and restoration through collaborative decision making processes that involve stakeholders in forums designed to encourage creative problem solving. Partnerships will be formed between government agencies, private conservation organizations, ranchers, hunters, educational groups, researchers and the interested public. In this way, we hope to include most of the interested public in the management of this area.

C. Achievements to Date

Activities include firebreak maintenance, chemical and mechanical weed control, small mammal control, seed collection and outplanting of native species. Seed regeneration has been at the Volcano Rare Plant Facility. The outplants are fertilized with a 180 day release 18-18-18 and watered at time of planting. Most of the outplanting sites or plant enclosures are small, less than two acres, and protect both existing populations of rare dryland plants and provide areas protected from ungulates for outplanting of rare species known from the area. Rare species that have been

protected within the exclosures include: *Hibiscus brackenridgei*, *Pleomele hawaiiensis* (hala pepe), *Hibiscadelphus hualalaiensis*, *Kokia drynariodes* (kokio), *Colubrina oppositifolia* (kauila), *Caesalpinia kavaiensis* (uhi uhi), *Sicyos macrophylla*, *Delissea undulata* and *Nothocestrum breviflorum* (`aiea).

D. Project Costs

Funding has been largely supported by Federal Section 6 monies for protection and enhancement of endangered and threatened plant species populations. Costs for building ungulate proof fencing materials are quite expensive. In addition to fencing materials, labor costs are high since each fence post hole needs to be drilled because the substrate is extremely hard. Costs for one mile of fence material in 1997 dollars is roughly $4,500 while construction (labor) costs are roughly $4.50 per foot. In fiscal year 1996-1997, weed control, small mammal control, fence maintenance, outplanting and propagation for ten plant enclosures cost $38,562 of which $25,000 was Federal Section 6 monies.

E. Obstacles Encountered and Lessons Learned

Threats to native species include fountain grass, banana poka, german ivy, kikuyu grass, silk oak, wildfire, and browsing by cattle sheep, goats, and pigs. Fences have been effective in deterring ungulate damage, but with exclusion of ungulates from these areas comes growth of weed species which preclude native species' regeneration. A good deal of time is spent controlling weeds around plantings, and in order to prompt better growth of native species, we will concentrate on trying to create shade by planting fast growing native species such as wiliwili, mamane, naio, and koa. Additionally, native vine species such as *Canavalia hawaiiensis*, *Cocculus trilobus* and *Stenogyne rugosa* will be planted to a form ground cover that will prevent alien grass reestablishment.

Outplanting has been found to be more successful if the plants are not too big at the time of planting. The outplants have not been irrigated, but a water tank may be helpful for re-applying herbicide.

F. Question, Answer and Discussion

D: A suggestion was made to use a fertilizer with less nitrogen.

Q: Have there been any data collected to back up the claim that shade is important to seedling growth?

A: No

D: Wendy Fulks from TNC found that shading has had no effect in two species that she has outplanted. Transpiration may be a more important factor in outplanting survival. Bruce Koebele from Leeward Community College has found shading to be important in the first week or two.

IV. Pohakuloa Training Area (PTA), Hawai`i (Lena Schnell and Steve Evans).

A. Background.

PTA is located in the saddle region between Mauna Kea and Mauna Loa. It is the largest training area in the Pacific with a total of 109,000 acres of which 51,000 acres are designated as impact areas and are restricted.

The intensity of usage presents a unique strain on the natural resources at PTA which has some of the largest intact dryland forest remaining in the state. It has 11 endangered plants, the endangered Hawaiian hoary bat and occasionally, endangered birds such as the palila, i`o and nene.

B. Project Goals

The main threat at PTA is ungulate browsing and grazing. An ungulate control program has been established to remove goats, sheep and pigs from native ecosystems with high concentrations of endangered plants. Components of the program include: census taking, public hunting, fencing and ungulate movement studies.

C. Achievements to Date

1) Public Hunting

Public hunting has been the only method used to remove animals. Mammal hunting is year round and is concentrated in the Bobcat and Kapele areas. The pressure has been beneficial on the westside because of threatened and endangered plants. Goats comprise over half of all the animals taken. Hunters are mostly removing the male goats and sheep which has not been effective in preventing population growth.

2) Ungulate Census

A census of ungulates was taken to get an idea of the abundance and distribution of ungulates. Three counts have been completed, but not enough data points have been gathered to get a population estimate yet. The bulk of the animals that are counted are located on the western side of PTA where most ungulate management actions are concentrated. The east side of PTA occurs on a lava flow with mouflan sheep and has a different habitat than the west side. Habitat has become an important factor in ungulate control. Documentation will be collected on the effectiveness of management actions such as fencing and public hunting.

3) Fencing

For certain plants more aggressive management actions have been necessary. Emergency fencing has been erected for critically endangered plants which has been effective in protecting individual plants, but there has been no natural regeneration. Three large fence exclosures of 2,500, 500 and 300 acres are scheduled to be erected in December 1997. These will encompass

17 miles of habitat.

4) Ungulate Tracking

Hunters have been concerned about the disruption fencing causes on the animals' seasonal movement patterns. 10 animals (6 sheep and 4 goats) have been captured and tracked with radio collars. Preliminary data over the last eight months have shown no movement to other hunting areas or a seasonal migration.

5) Weed Control

Until recently, weed control has only been done along road sides by outside contractors. There are now in-house weed technicians working on Russian thistle in heavy weed and burn areas. Quarantine areas have also been established to prevent vegetative and seed spread from military operations which may come from attachment to clothing, gear or machinery. There are plans to vegetate firing areas with a mat-forming grass. Future efforts are planned to control weeds along and in the road, especially fountain grass. Roads have been found to be a very long band of disturbance which lead into the less disturbed and more sensitive areas.

Fountain grass control has been over 95% effective after 10 months using a 1 - 2% Glyphosphate mix. Areas that have been sprayed in this manner have been recolonized by other weed species and have had little native regeneration. Hexazinone (Velpar) has been found to be slightly more effective than Roundup, but it is more persistent, both had cover of less than 10% after two years.

Russian thistle control was done using trials of 2-4-D and Roundup. Multiple treatments were applied until the seed bank had been exhausted. These areas have also been recolonized by other weed species and there has been little native regeneration.

D. Project Costs

In 1997, $120,000 was spent on ungulate census taking and tracking which included two censuses and eight months of intensive tracking by three biologists. Tracking has been costly, especially putting collars on the animals, the use of helicopters and labor.

Emergency fencing has been found to be inexpensive, usually quick to achieve and done with volunteer labor. Large scale fencing, on the other hand, has been more expensive because of the rough terrain and has cost $585,000 for 17 miles of fence.

Weed control costs using outside contractors were: $20,000 for 2 miles of road and 5 acres off road; $68,000 for 12 acres with a project botanist; $217,000 for 46 acres; and $130,000 for 11 miles of road. In-house control costs were: $5,500 for a weed technician; $530 for a 200 gallon

tank placed in back of a truck; and $1,400 for a motor and spray pump.

E. Obstacle Encountered
Public reaction to proposed management actions has pushed back large scale fencing for an entire year. If the public had been involved sooner, the delay may have been avoided.

G. Lessons Learned
Public relations is important especially when dealing with controversial issues. Data supporting the planned management action need to be presented in a clear and concise manner to decision makers recognizing that they do not all have a biological background. Also, when dealing with multiple agencies and the public on a project, things may take longer to accomplish.

In order for quarantine zones to be effective, barricades must be impenetrable. Timing is also important. Training is planned six months to one year in advance and things tend to move slowly. Communication with individuals at all levels must be done. A lot of time can be spent in briefings and diplomacy and non-reactionary styles are mandatory. Expectations are drastically altered, and success in the short term can be determined by the will of the CO which changes every 2 - 3 years.

H. Question, Answer, Discussion
Q: Where are the impact areas located and what is being done on them?
A: They are in the center of PTA and are restricted to everyone. There are some kipukas in the barren lava flows and some ungulates present in the impact areas, however no surveys will be conducted.

Q: Is there hunting in the exclosure areas?
A: There will be some hunting in the exclosures and gates will be put up. There are also plans to do an animal drive.

Q: How many goats are in PTA?
A: There appears to be three distinct herds consisting of 150 to 70 head.

V. Ka`ana, Moloka`i (Ed Misaki and Kali Arce).

A. Background
Ka`ana is the site of the "Ka Hula Piko" (the center of the hula). It is said that the Hawaiian Goddess Laka took the hula from (after years of training) Ka`ana to the rest of the Hawaiian islands. Kumu Hula John Kaimikaua and his Hula Halau Kukunaokala has asked the help of the Moloka`i community to revegetate Ka`ana in the native vegetation that would have been there in

the time of Laka. The project is located on the top of Maunaloa (West Molokai Mountains) at an elevation of about 1,200 feet. The land is owned by Moloka`i Ranch and has been heavily grazed for most of this century. Moloka`i Ranch is strongly supporting this project. Other partners involved in helping Kumu and the halau reach their goal are: the Natural Resource Conservation Service which includes the Conservation District and the Plant Materials Center; UH Cooperative Extension Service (CES); Moanalua Gardens; Department of Education; and The Nature Conservancy.

B. Project Goals.

The goals of the project are: to revegetate Ka`ana with native vegetation; to preserve the landscape that contains the "Ka hula piko" site, so the culture can be practiced and sustained; to involve the Moloka`i community; to instill pride, appreciation and responsibility in the stewardship of the native landscape; and to perpetuate cultural sites and practices.

C. Achievements to Date

In the first year, the focus was on organizing simple planting efforts to learn what basic conditions must be met to sustain the revegetation efforts at Ka`ana. The sixth grade class at Kaunakakai school was the first attempt to get students to care for transplanted seedlings of wiliwili and a`ali`i and do the actual outplanting at Ka`ana. Maunaloa Elementary School was the next school. In all, 111 youth and 15 teachers and staff participated in transplanting and outplanting activities. During these sessions, a total of 73 wiliwili and 85 a`ali`i were germinated and transplanted by the end of December 1997.

Site preparations included fencing the property and Moloka`i Ranch installing a chainlink fence eight feet tall and almost one mile long covering 15 acres. Later the ranch cut a total of four parallel contour lines, 20 feet apart, totaling 1600 linear feet. UH Extension installed a drip irrigation (sub-irrigation method) for the contour lines. Markers were placed 20 feet apart in each row for wiliwili to be planted and the a`ali`i was planted in-between. A complete fertilizer of 10-20-20 was broadcasted on the contour lines, and a handful of a 2:1 mix of 10-30-10 and phosphorus (0-45-0) was placed in the planting hole before the trees were put into the ground.

D. Project Costs

The majority of the costs have been covered by in-kind services and materials. All the partners involved have donated their resources and personnel for this first year.

E. Obstacles Encountered

Finding seed material from the Ka`ana area is difficult as there are not many native plants left. This is a volunteer effort which makes keeping the project manageable and sustainable difficult. There was also no budget and no green house. The irrigation system had problems with inconsistent

pressure and flow rates. The site itself offered potential problems for the outplantings such as: wind damage, soil compaction from previous cattle grazing, questionable soil fertility and competition with exotic weeds such as glycine, rattle pod and lantana.

F. Lessons Learned

In order to improve the project, the following is needed: long term planning; a continuous planting of seeds in order to have seedlings at all times; finding an appropriate nursery site; and an improved curriculum for classroom education. It is also realized that a project that depends on a lot of volunteering and partnership should be planned with a slow progression in mind. Go slowly, learn, make adjustments. It will be awhile before we can know what a successful project will look like.

VI. Kanepu`u, Lana`i (Wendy Fulks).

A. Background

The 590 acre Kanepu`u Preserve was established when Dole Food Company gave TNC a perpetual conservation easement in 1991. The Preserve was created to protect and enhance the olopua and lama lowland dry forest community which once covered large portions of the lowlands on Maui, Moloka`i, Kahoolawe and Lana`i. Kanepu`u contains the best of what remains of this community type.

In addition to the landowner, we work closely with the state which through the Natural Area Partnership Program pays 2/3 of the management costs. A community group, Hui Malama Pono o Lana`i is also involved in the project and has been active in the protection of Kanepu`u forest since the 1980s, in addition, individual members of the hui have been active since the 1960s and 1970s.

Seven distinct management units were fenced in 1992 at a cost of $180,000. The largest unit is 369 acres. Each unit contains patches of forest remnants differing in size and quality. The forest canopy is about 80% olopua and 10% lama. There are currently seven rare plant species in the preserve these include Bonamia, Santalum (iliahi), gardenia and others. The only native birds on the site are pueo and kolea.

The primary threats are axis deer and other ungulates, christmas berry and other weeds, fire and erosion.

B. Project Goals

The goal of the restoration work at Kanepu`u is to promote a self-sustaining, diverse dryland forest containing a complement of common and rare plants that perpetuates this unique natural community and its component species. Specifically, we are working on expanding and enhancing native forest patches, stabilizing windward forest edges and eroded sites, and promoting the

recovery of rare plants.

C. Achievements to Date

Major accomplishments include: constructing nine miles of 6'3" tall fence; enlisting the assistance of volunteer hunters to remove more than 500 deer since 1992; removal of weeds in some areas, concentrating on canopy-dominant aliens such as christmas berry, guava and koa haole in the most intact patches; initiation of 26 rat baiting stations that are re-baited monthly around rare plants and high quality forest patches; installation of a weather station to track rainfall, relative humidity, temperature and wind speed; initiation of detailed vegetation monitoring.

The growth of olopua and lama planted in the sun versus in the shade has also been looked at. For both species, there was no significant difference between planting in the sun and shade.

Ways to plant seedlings where a minimum of weed control would be needed has been investigated. A trial has been established where native seedlings were planted in an area dominated by dallis grass, an area dominated by lantana and an area cleared of weeds. Planting within dallis grass appears to be viable and the seedlings in these areas are growing better than the ones in the lantana. The only weed control used has been to push the grass back by hand, which takes about ten minutes, to let more sun in.

A nursery has been established, and as of September there were 1,300 seedlings in the nursery. Seedlings in the nursery include: 791 lama, 13 keahi, 100 ohe makai, 29 naio, 6 iliahi, 354 *Gardenia brighamii* and 24 *Xylosma*. The naio has been grown from cuttings, and there have been problems propagating olopua.

Erosion control trials have been implemented. Tubes of Geojute fabric measuring 4 x 50 feet were constructed and filled with roughly 2/3 soil from unstable dune areas, and 1/3 chipped christmas berry, koa haole and lantana. Seeds of a`ali`i were sowed in part of one tube and they are beginning to germinate.

In addition, we are seeing natural regeneration in many places, we believe as a result of deer control.

D. Project Costs

There are presently two full time field technicians on Lana`i, and between me, our Biologist, Program Director and an Administrative Assistant, there is about 8/10 of another full time equivalent. $56,000 was spent in fiscal year 1992, $75,000 in fiscal year 1993, $98,000 in fiscal year 1994, $111,992 in fiscal year 1995, $158, 791 in fiscal year 1996, and $158,157 in fiscal year 1997. A total of $658,433 over six years, or $110,000 per year has been spent on the project. There is $190,000 budgeted for fiscal year 1998.

E. Obstacles Encountered

Natural seed production is low during dry years which can cause set-backs. Related to this, we have had problems propagating olopua. One problem has been seed viability. It should also be noted that there has been very little natural regeneration of olopua when compared to lama, kolea and other less common canopy components such as alahee. We really have no idea what the forest used to look like. We call it "olopua/lama" dominated forest, but in 25 or 100 years there may be different dominants.

There has been a lack of understanding of basic plant lifecycles and needs. For example, we do not know what is going on with the olopua seeds, we do not know exactly when certain species will flower or fruit which makes it difficult to plan and implement on a timetable.

Ungulate control is an ongoing and large component of restoration. It does not go away and requires continued effort, sometimes at unexpected levels.

Water for irrigation can also be an obstacle. Water can be piped or trucked to locations throughout the preserve. We currently have two 1,500 gallon tanks that are filled with trucks.

F. Lessons Learned.

At the start there were unrealistic staffing plans. We assumed one person could do threat control, start restoration and also manage another preserve on another island. Now, we are more reasonably staffed.

Not enough attention was given to propagation and seed stock development. We started out assuming others would grow plants for us and ended up with a lot of seeds in contaminated soil, without water and other care that resulted in high mortality. We were also not able to learn from propagation trial and error since we were not involved, and we ended up with our own nursery which requires additional staff to maintain.

Deer are difficult to eradicate even when you have a fence. Fences in this climate deteriorate faster than you might think. We are already faced with the challenge of replacing virtually all nine miles of fence completed in 1992. We did not plan for such a large-scale effort, and this work will slow restoration progress because we do not have the funds to hire additional staff or a contractor.

The next steps are to re-write a restoration plan that will better outline what we want to see, to include a wider participation outside TNC in the planning effort, and to study seed bank germination techniques for various species.

VII. Topical Discussion to Identify Major Challenges and Ways to Solve Them

The group identified the following as major topics to discuss: A) propagation, outplanting techniques, and data collection and analysis; B) history of ecosystems, microclimate, natural regeneration, restoration of fauna, soils and soil biology, and life cycles from germination to maturity; C) large scale applications; D) eliminating threats: controlling weeds, pathogens, rats, fire and erosion; E) outreach, social and cultural issues; F) monitoring success; G) reforestation; H) funding and long term budgeting.

A. Propagation, Outplanting Techniques and Data Collection and Analysis

There is a need to record and publish knowledge on growing plants. Information could be provided from Heidi Bornhorst's book, Greg Koob's potential newsletter on horticulture of Hawaiian plants, email or the Internet thorough the Center for Plant Conservation, the NTBG database, and a central record of archives.

Good protocols should be followed when propagating plants. Good records of species, seed sources and planting location need to be kept. When propagating species you should start with the closest source within the historic range, which may vary from project to project as well as with the project's goals. A large scale seed production facility that could act as a seed nursery rather than a seed collector and provide long term seed storage would be helpful. Some infrastructure is already in place like the Plant Center on Moloka`i. There is a demand for seed at Kaho`olawe and for government replanting.

Planting in sensitive locations could be a problem. The issue of hybridization should be considered because of the potential for loss in genetic diversity in local populations and the potential risk of re-diversifying the gene pool by bringing in outside stock. There has been a lack of success in different conditions, little is known about the genetics of existing plants, and it is not known if diversity will be helpful. However, the gene pool may not be an important factor when reforesting pasture land. The worse case is that the species may be genetically distinct because of isolation and it may lose that distinction.

It may be possible to grow plants by banking genetic material. The Center for Plant Conservation and USFWS are doing some work in this area, but plants cannot yet be grown from banked material. The USFWS is funding the national seed storage bank in Ft. Collins, Colorado to test Hawaiian seeds for cyro preservation. If some components of an ecosystem are lost, a substitute may be needed. For instance, the USFWS plans to translocate seed of *Pritchardia ramota*, a rare palm from Nihoa to Laysan Island. Better coordination of the collection and propagation of seeds is needed. This should also go hand in hand with outplanting to proper sites, strategy and timing.

When outplanting the proper age, root structure and field handling is important. The easiest method is to use the smallest plant. The size of the planting hole has been found to be significant, the depth being more important than the diameter. Holes should be three times the depth of the container. This allows roots to go deeper, reduces drought stress and reduces competition. Cutting back on and leaching out nitrogen before outplanting helps to reduce insect predation. Fish emulsion helps plants in their juvenile stage, but can attract pigs, and too much phosphorus can prevent mycorrhizal growth. Good drainage is needed for native plants, but cinder should not be added. Mulching can reduce evaporative water loss and nematodes, but may increase slugs. Kaena Point and Haleakala have had success using a flat stone mulch. Large scale plantings should utilize the existing soil seed bank. For instance, a bulldozer can be used to scarify for koa or mamane growth. Moving seedlings that were naturally regenerated can be costly. Hakalau has dug up seedlings, placed them in a green house and replanted them, and for `ohi`a this can save six months. Whether to revegetate an area using seeds or seedlings would be useful information.

When collecting and analyzing data, care needs to be taken when drawing conclusions. Variables change from year to year. Tracking rainfall is important, however it does not measure fog, and monthly and annual averages can hide extreme events. Kanepu`u takes hourly averages at their weather station. There are also weather stations in place at PTA, Mike Tomich's near Ka`upulehu and the O`ahu Nike site. Correlating weather data with growth, seed production and fertilizer and herbicide application can be difficult. It is difficult to understand how crucial rainfall is to plants and the timing of planting can be critical. At Kalopi 1/2 of the trees were irrigated and 1/2 were not irrigated and planted in good weather conditions. This resulted in losses anywhere from 2 to 75%. The perfect weather conditions for replanting are hard to determine and vary depending on the species.

B. History of Ecosystems, Microclimate, Natural Regeneration, Restoration, Soils and Life Cycles
Sources for information are needed on past flora and fauna. Good sources are *Indigenous Trees of the Hawaiian Islands* by Rock; identifying species from charcoal, either in soil or archaeological sites, is a good way of getting at prehistoric distributions; historical specimen data at the Bishop Museum; *The Hawaiian Agriculturist and Forester* by territorial foresters Judd and Lyon; Lyon Arboretum; chants and oral traditions; gulch/kipuka species and conditions; archaeological records from birds and other fossils; UH DNA work on certain rare plants; and early botanical works and works by extant botanists.

Soils are a complex system. Little is known about whether soil microbes are different in pasture and forest soils. Transferring a 1/2 cup of soil from the forest into the planting area can be important. In Kaho`olawe inoculation made a difference in the survival of the outplants without irrigation. There are also questions regarding proper protocol when inoculating and the possibility of transferring pathogens. Local sources of inoculates have been found to be better than commercial

sources. Restoration projects should have an experimentation component that includes soil analysis. Kanepu`u is experimenting with transferring forest soil on the site and in the nursery. Soil samples should be taken when collecting seeds and water samples may helpful as well.

C. Large Scale Applications

Scaling up may be easier if starting with more intact areas. There is a need to move away from irrigation, nurseries and backpack spraying on a large scale. Aerial spraying of herbicides may be more applicable for large areas that are zoned agricultural, but may not be appropriate in areas with sensitive watersheds or a lot of native plants. PTA would not allow aerial spraying of ginger because it was located in the Ko`olau watershed.

An effort should be made to rely on the existing seed bank on larger areas. Game birds may be a good source to disburse native seeds. Medeiros showed an 80% increase in germination in some areas by placing native seeds in the bird feed.

Broadcasting rat bait would be beneficial for large areas, however it has been difficult getting the chemicals registered. Baiting rat stations is not practical on a large scale and something is needed that is long lasting. Pitfall traps could be used using a seven gallon bucket of water.

D. Eliminating Threats: Controlling Weeds, Pathogens, Rats, Fire and Erosion.

The most efficient chemicals for controlling weeds needs to be determined. Rodeo and Garlon may not be suitable in some watersheds. Costs of herbicides are high. Roundup is less expensive and faster acting than Fusillade, but can also harm native plants. Dead grass can also be good biomass for enriching the soil's organic matter. Pre-emergents last about six months and help keep the grass from re-seeding. A spray is used to wipe out the black twig borer also effects the native twig borers which cultivates fungus in the holes that it bores.

Grazing regimes and fire can act as tools to maintain natives. Some native plants like a`ali`i, kolea, and mamane grow better after fire. An anti-feedant can be sprayed on individual plants where there are grazing animals present. The length of the grazing period is also important and animals should be moved before they can eat the trees. In Volcano, trampling by grazing animals slowed koa growth, but grass removal was beneficial. Trees need to be old enough before introducing grazing animals.

Rats eat seedlings, growing tips and fruits. They can quickly move into and reinvade an area. PTA started looking at rat predation on iliahi seeds in December and found placing Ropel on fruits discouraged rat feeding. There were dramatic results on seed and fruits when mice and rats were controlled on Kaena Point. Ka`upulehu started out using six cakes per bait station and now puts in twelve cakes per station. This reduces the number of trips that is needed to refill the stations,

however ants and animals have been breaking into the bait boxes.

E. Outreach, Social and Cultural Issues.

There is a broad audience interested in replanting Hawaiian plants. A plan needs to be developed on educating people. The people need to be given the reasons why reforestation is important. At Ka`ana there are a lot of cultural ties with the land and many volunteers provide in-kind help.

Erecting fencing on prime hunting lands at PTA has caused conflicts with many hunting groups. Restoration and hunting do not necessarily have to be mutually exclusive and efforts at finding resources for both game management and restoration should be made. Land usage needs to be looked at and how to manage the forest for ungulates with the hunting community.

VIII. Next Steps

The following actions were suggested as useful ways to continue education among those involved in dryland forest restoration. However, with the exception of item C, no commitments were made on the items listed below.

A. Create and disseminate a bibliography of propagation successes and failures.

B. Create and disseminate a newsletter that tells who is doing what, where and how.

C. Set up an email list server that could work with faxes. HFIA will be distributing the name, address, phone, fax and email of all the participants with the proceedings.

D. Interview people in the field.

E. Meet again. There may be a possibility to have a meeting in conjunction with the Conservation Conference. Meeting once per year and with larger groups could be useful.

F. Distribute and contribute to journals like *Restoration Notes* and *Restoration Ecology*.