



National Tropical Botanical Garden

# NTBG: Rooted in the Past, Growing in the Future

*David A. Burney and Lida Pigott Burney*





## It's all about thinking BIG in Time and Space!

### Why Think BIG?

#### Because the challenge is BIG

- Hawaii is the extinction capital of the US

#### Conventional approach has not been BIG enough

- In situ and ex situ conservation failures

#### Genetic and ecological requirements are BIG

- Genetic bottlenecks
- Loss of ecological functions

#### BIG opportunity to further engage the public

- Public has good intentions, but what to do?
- Mitigation strategies need to be real

# Hawaii: Extinction Capital of the United States

- Extinctions: Of 540 US extinct plants and animals, 250 were in Hawaii (46%)
- Federally listed: Of 699 US plants, 263 are in Hawaii (38%)
- At risk of extinction or already extinct: 590 of 1209 species of Hawaiian plants (49%)



*In situ* conservation: **strategies for conserving rare species by managing them where they currently occur**





*Ex situ* conservation: *strategies for conserving rare species outside their natural environment (zoos, botanical gardens, seed banks)*



# Is there a third possibility?

## *INTER SITU CONSERVATION:*

*“...the establishment of species by reintroduction to locations outside the current range but within the past range of the species. In some cases, closest living relatives or ecological surrogates may be substituted for globally extinct species that are regarded as essential in order to maintain a process believed critical to the function of the target ecosystem. Inter situ conservation bridges the gap between conservation efforts applied to species in a pre-existing wild condition in their current range (in situ) and efforts based on intensively human-controlled environments such as botanical gardens and zoos, genetic banks, and propagation facilities (ex situ).”*

(Burney and Burney, *Frontiers in Ecology*, in press)



# Ile aux Aigrettes Nature Preserve: *inter situ* restoration

MAURITIUS



Mauritian Wildlife Foundation (painting by Dr. Julian Hume)

"All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident."  
-- Arthur Schopenhauer (1788-1860)

(As applied to inter situ conservation)

1. "...it's crazy...it won't work...it's not that simple...more or less Pie in the Sky..."
2. "...it's unnatural...it's probably illegal...it distracts people from serious conservation...it doesn't look good..."
3. "what's the big deal...everybody knew this all along...this is what we've all been doing for years...of course it will work, so what?..."





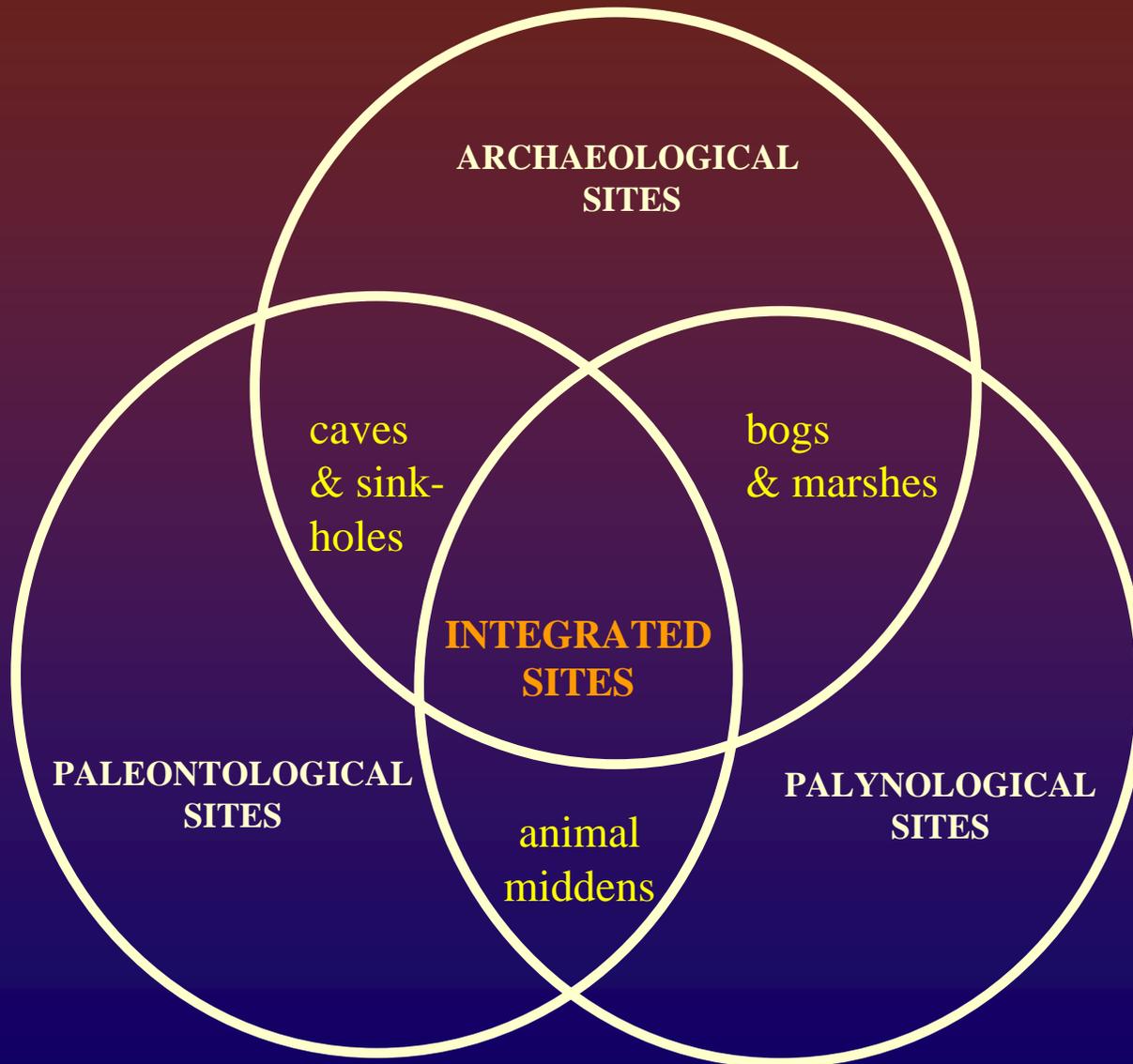


*An Integrated Site...*

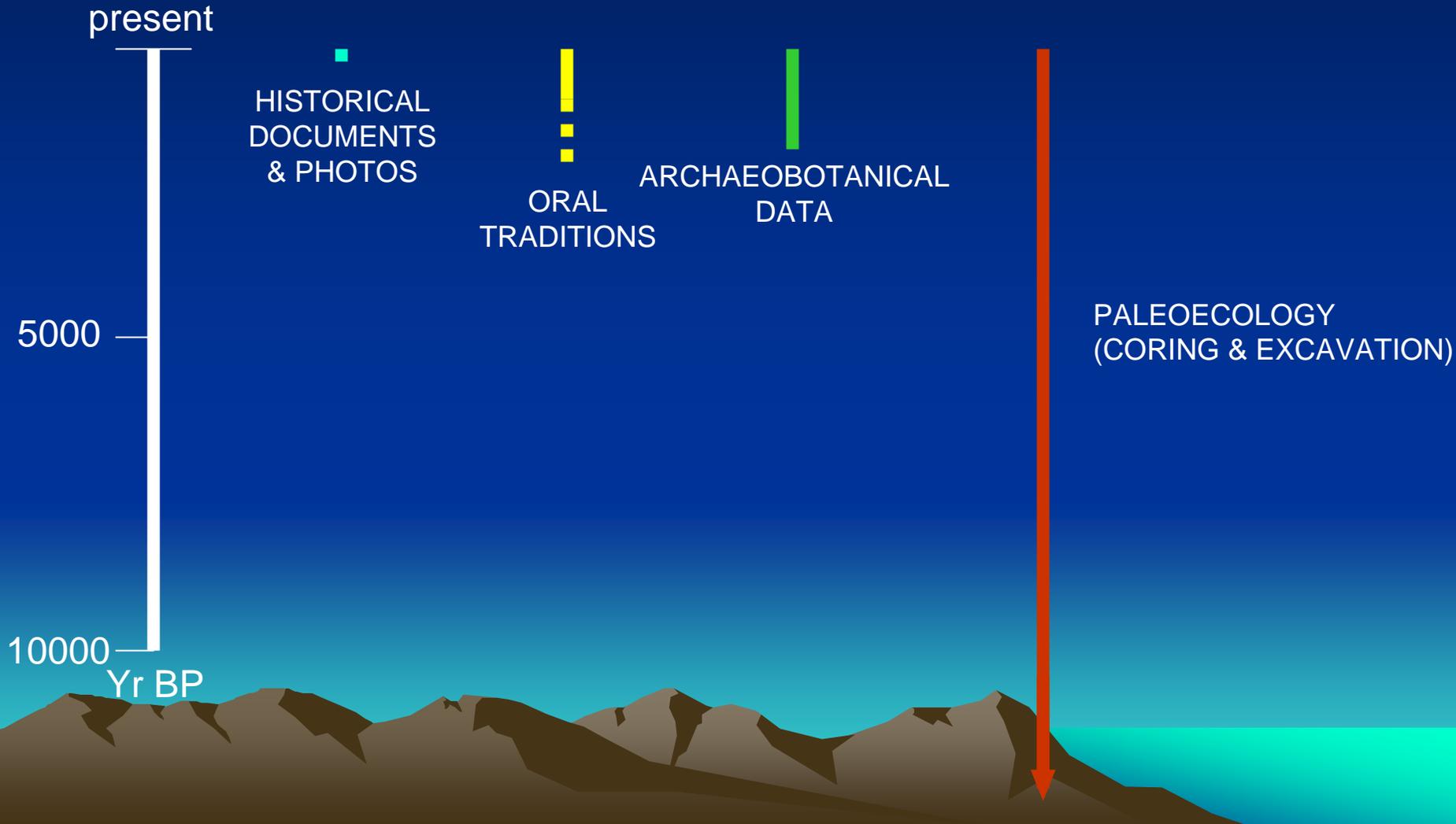
Makauwahi Cave, Maha`ulepu, Kauai

**E komo mai !**

# INTEGRATED SITE ANALYSIS



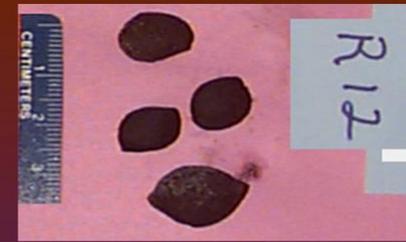
# Temporal perspectives on restoration projects



# There are many useful kinds of fossil evidence



BIRD BONES



SEEDS

## Macrofossils...



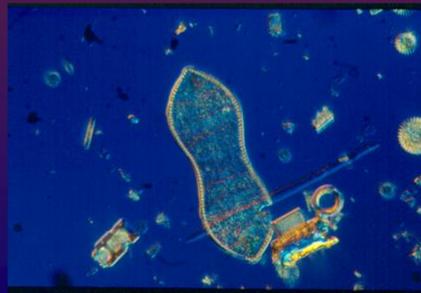
LAND SNAIL SHELLS



POLLEN



CHARCOAL PARTICLES



DIATOMS

## Palynomorphs...



BONE FISHHOOK



STONE MIRROR

## Artifacts...

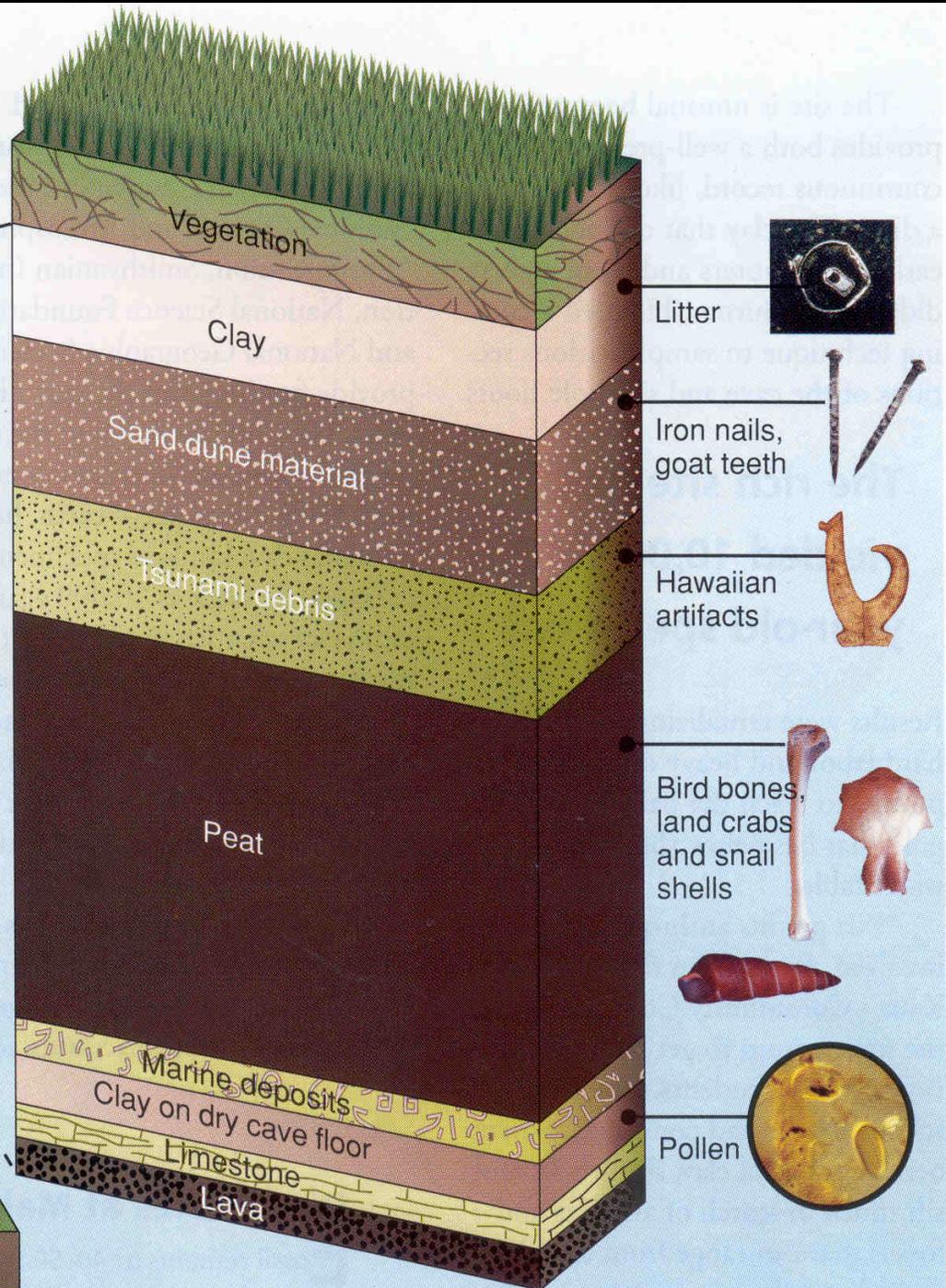
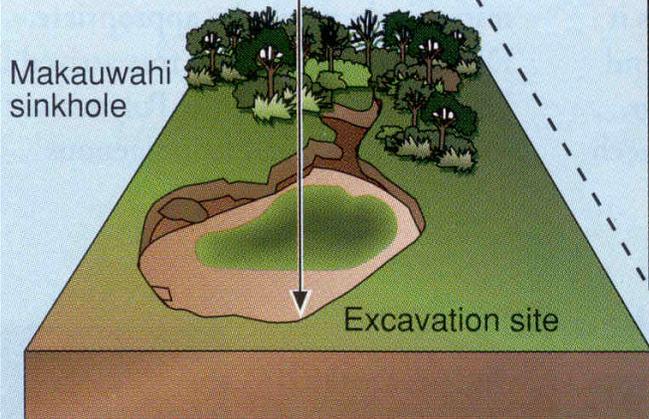
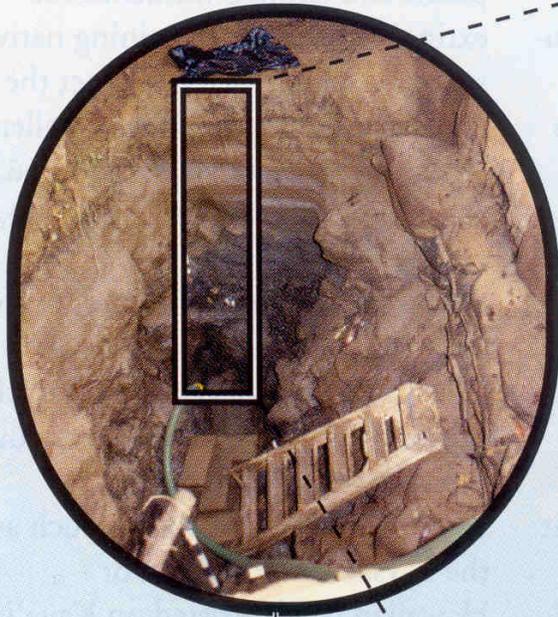


CANOE FRAGMENTS



# A Kaua'i Diary

Layers of earth in the Makauwahi sinkhole digs record life on the islands for the past 10,000 years



# How theory affects practice:

- Many now-rare taxa were once more widespread in the islands
- Hawaiian biota evolved with some mesoherbivory
- Nutrient flux from marine to terrestrial environment was much higher
- Fire occurred before humans in some habitats
- Biological invasions have had strong effects for a millennium or more.
- Extinction rates were extremely low before human arrival



**5,000 year old fossil kou seed capsules from Makauwahi Cave show definitively that, contrary to previous notions, *Cordia subcordata* is a native plant – Burney et al., 2001, *Ecological Monographs***





Some plants now restricted to higher mauka areas were  
Once widespread in the lowlands, like *Zanthoxylum kauaense*

1996...



**1997...**



**2004...**



2006...



# Makauwahi Cave Reserve

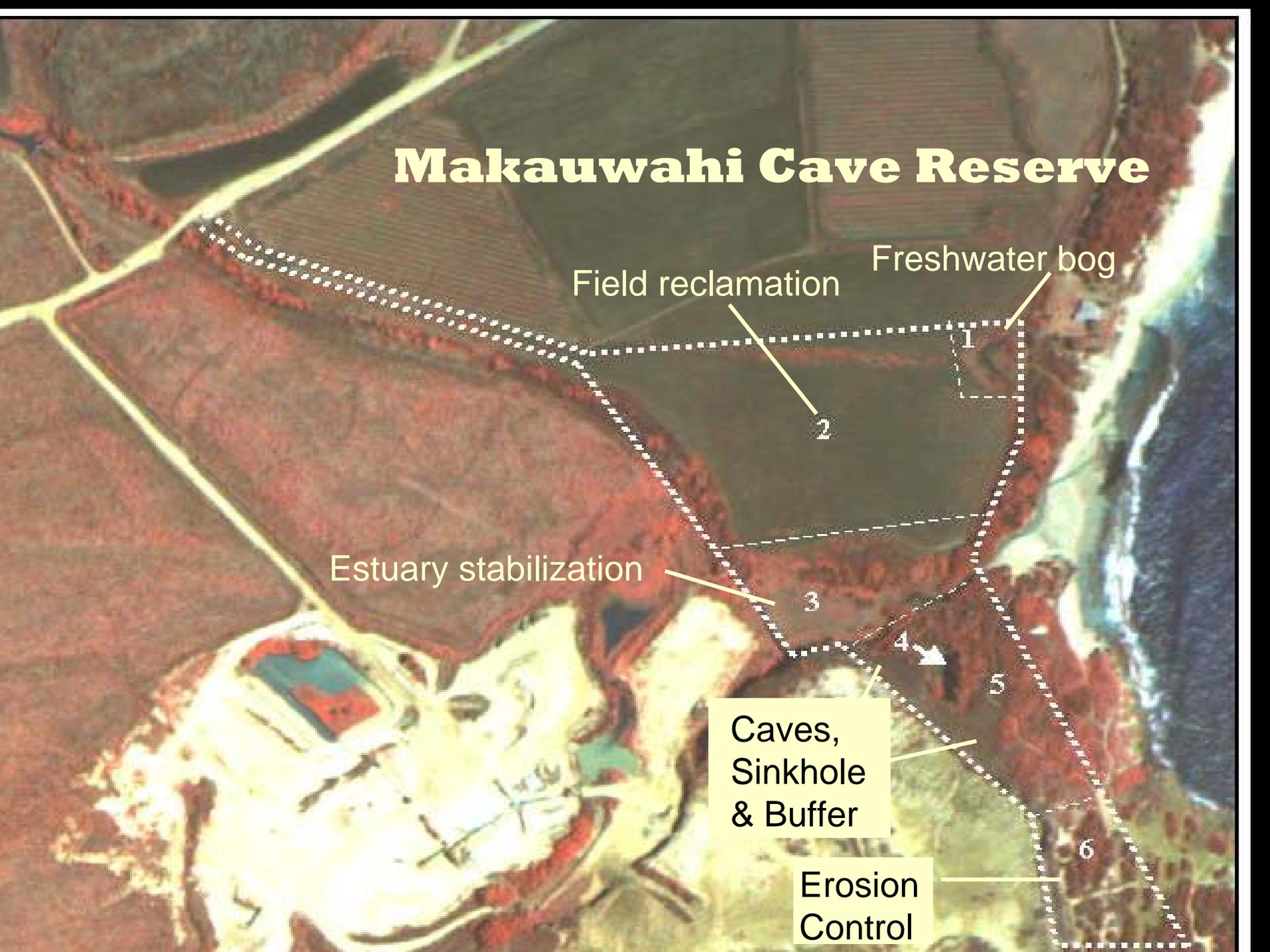
Field reclamation

Freshwater bog

Estuary stabilization

Caves,  
Sinkhole  
& Buffer

Erosion  
Control





## TECHNIQUES:

- Shredding
- Gang-disking
- Harrowing
- Rotary tillage
- Drip-irrigation
- Hoeing
- Hand-weeding



# INTER-CROPPING Food Plants and Natives:

- Demonstrates compatibility of food production
- Subsistence and cash cropping possible
- Competes with weeds
- Some examples tried:

- Okra
- Squash
- Melons
- Legumes
- Herbs
- Eggplant
- Peppers
- Tomatoes

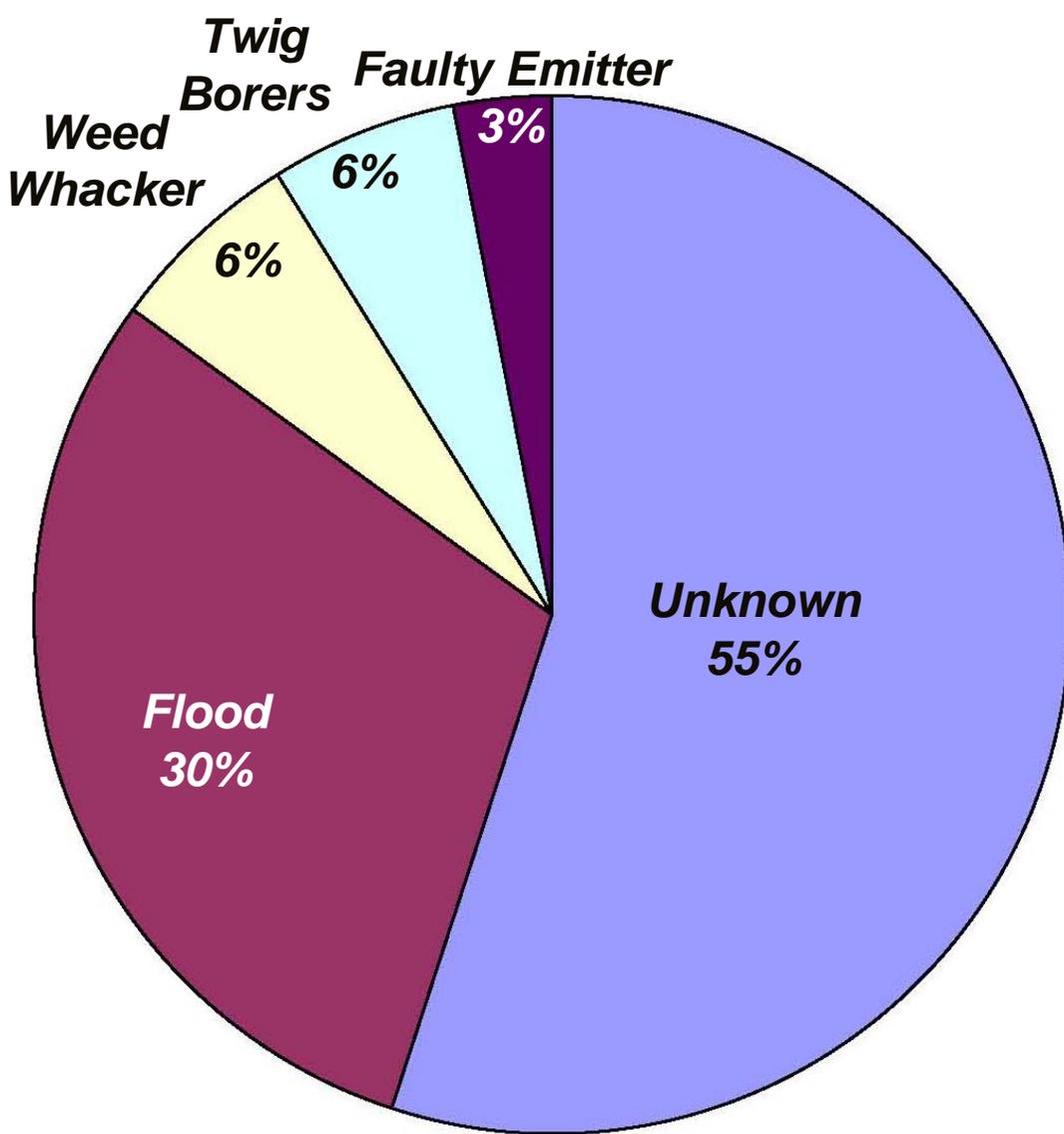


# Management Unit 2 Schedule

## *Cane Field Reclamation*

- ❖ 6 Oct 04: Surveyed field
- ❖ 22 Oct 04: Mowed and disked field
- ❖ 31 Aug 05: Mowed again; disked & harrowed half
- ❖ 18 Sept 05: Set up automated drip-irrigation system
- ❖ 25 Sept 05: Began tillage
- ❖ 1 Oct 05: Planted windbreak (Sudax sterile hybrid)
- ❖ 3 Oct 05: Began planting trees & shrubs
- ❖ 8 Apr 06: Completed 12<sup>th</sup> 1000-ft row (avg. 50 plants/wk)
- ❖ 6 Apr 07: Completed 20<sup>th</sup> row

<b>PLANT</b>	<b>PLANT</b>					
<b>Latin Name</b>	<b>Hawaiian Name</b>	<b>TYPE</b>	<b>#</b>	<b>DATE</b>	<b>UNIT</b>	<b>ROW</b>
Psydrax odorata	Alahe`e	S/T	2	29-Jan-06	2	10
Psychotria hobbdyi	Kōpiko	S	1	29-Jan-06	2	10
Scaevola taccada	Naupaka	S	1	29-Jan-06	2	10
Dodonaea viscosa	`A`ali`i	S	1	29-Jan-06	2	7S
Erythrina sandwicensis	Wiliwili	T	3	29-Jan-06	2	7S
Gossypium tomentosum	Ma`o	S	1	29-Jan-06	2	7S
Hibiscus waimeae subsp. waimeae	Koki`o ke`oke`o	T	2	29-Jan-06	2	7S
Scaevola taccada	Naupaka	S	2	29-Jan-06	2	7S
Sesbania tomentosa	`Ohai	S	1	29-Jan-06	2	7S
Osteomeles anthyllifolia	`Ūlei	S	16	31-Jan-06	2	5
Vitex rotundifolia	Kolokolo	S	19	31-Jan-06	2	5
Plumbago zeylanica	`Ilie`e	S	22	01-Feb-06	2	6
Vitex rotundifolia	Kolokolo	S	3	01-Feb-06	2	6
Plumbago zeylanica	`Ilie`e	S	11	01-Feb-06	2	7
Vitex rotundifolia	Kolokolo	S	16	01-Feb-06	2	7
Munroidendron racemosum	Pōkalakala	T	2	01-Feb-06	2	10
Munroidendron racemosum	Pōkalakala	T	2	08-Feb-06	2	10
Scaevola taccada	Naupaka	S	2	08-Feb-06	2	10
Hibiscus brackenridgei subsp. bracker	Ma`o hau hele	T	3	13-Feb-06	2	11
Pandanus tectorius	Hala	T	2	22-Feb-06	2	11
Sapindus oahuensis	Āulu	T	2	22-Feb-06	2	11
Scaevola taccada	Naupaka	S	3	22-Feb-06	2	11
Sesbania tomentosa	`Ohai	S	1	22-Feb-06	2	11
Sophora chrysophylla	Māmane	S/T	2	22-Feb-06	2	11
Acacia koaia	Koai`a	T	2	23-Feb-06	2	11
Hibiscadelphus distans	Hau kuahiwi	S/T	1	23-Feb-06	2	11



# CAUSES OF MORTALITY

$n = 47$

Survival rates:  
88% overall

# Ecological Restoration Benchmarks

- ❖ 83 native and Polynesian species established
- ❖ 2215 trees & shrubs
- ❖ 12 Genetic Safety Net species
- ❖ 23 Endangered Species
- ❖ 35 total at-risk species
- ❖ 5 acres planted
- ❖ Critical habitat management for `ohai (*Sesbania tomentosa*)
- ❖ Restoration training for high school Junior Restoration Teams
- ❖ Monitoring protocol
- ❖ Cyberinfrastructure
- ❖ Experiments in progress







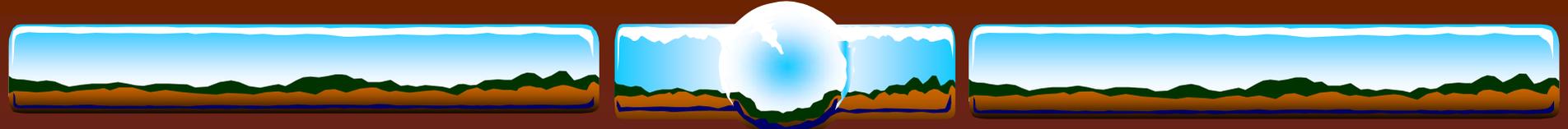






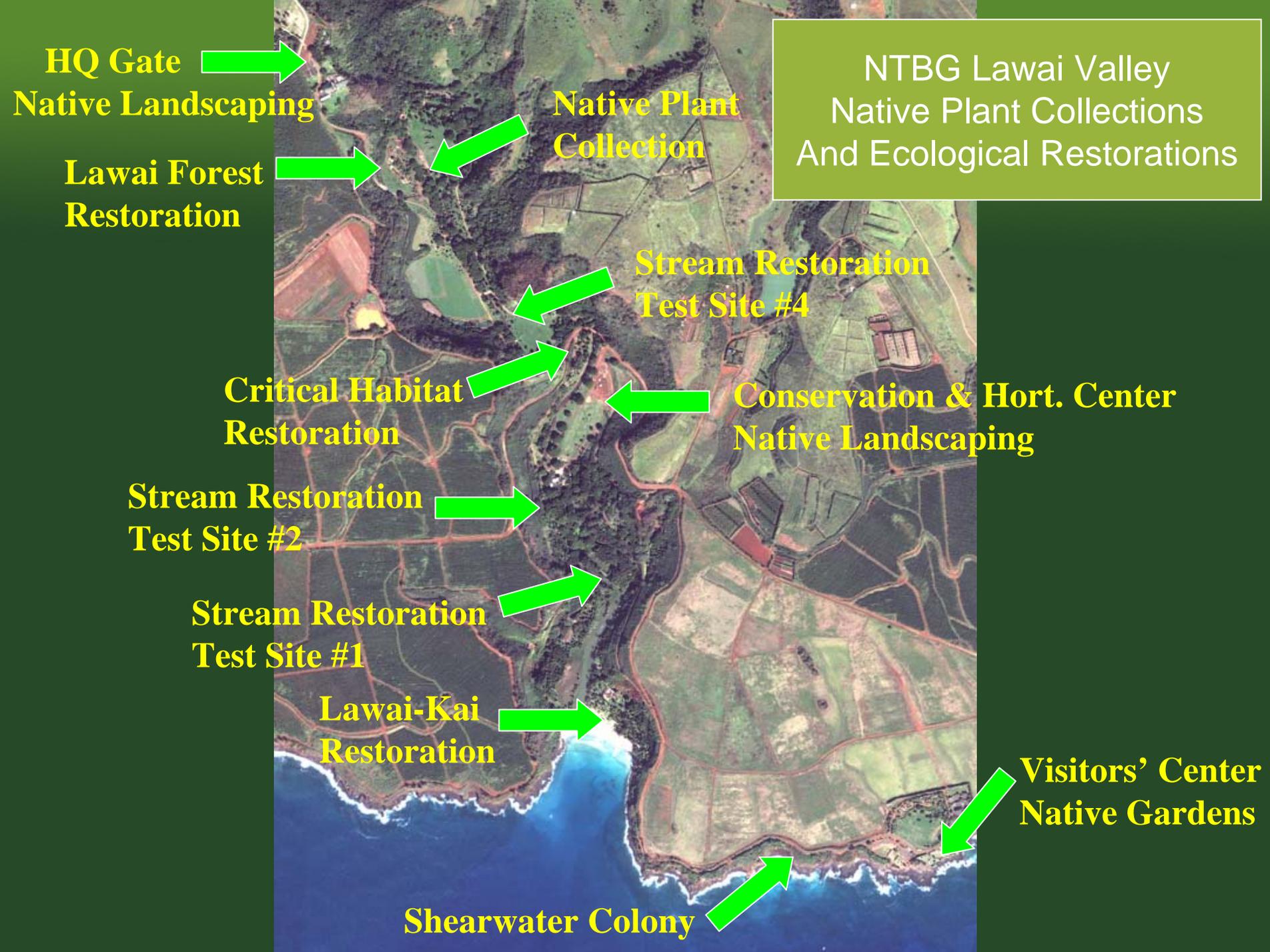






# RESTORATION PROTOCOL

- ❖ 1. Historical background research & restoration planning by management unit
- ❖ 2. Small-scale test plantings in each management unit
- ❖ 3. Full-scale landscape conversion through the gradual replacement of exotics with hardy natives
- ❖ 4. Planting and maintenance of rarer endemics in microhabitats created by native-dominated communities



NTBG Lawai Valley  
Native Plant Collections  
And Ecological Restorations

HQ Gate  
Native Landscaping

Native Plant  
Collection

Lawai Forest  
Restoration

Stream Restoration  
Test Site #4

Critical Habitat  
Restoration

Conservation & Hort. Center  
Native Landscaping

Stream Restoration  
Test Site #2

Stream Restoration  
Test Site #1

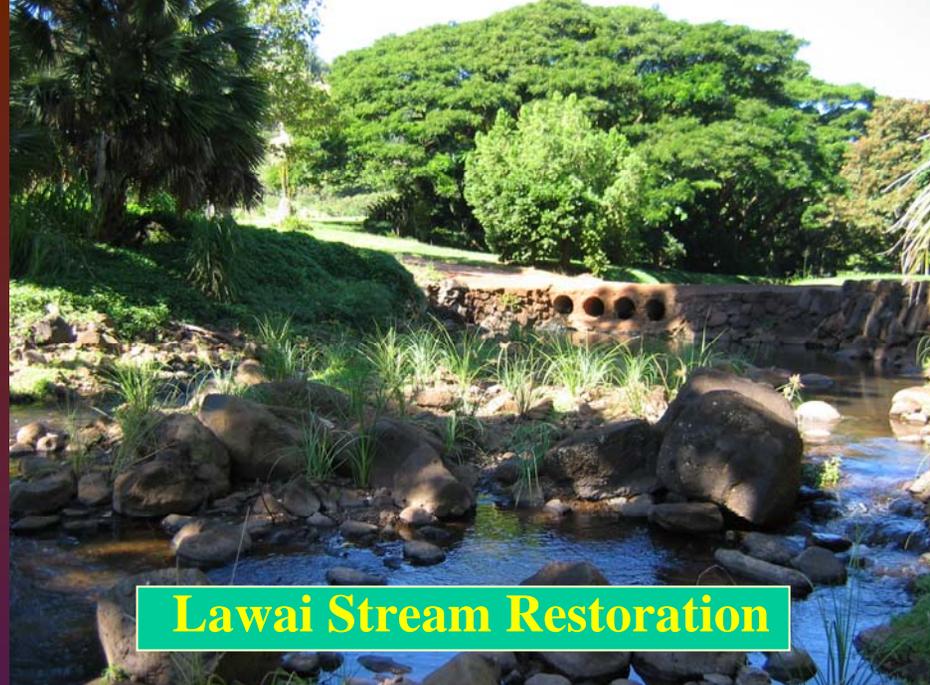
Lawai-Kai  
Restoration

Visitors' Center  
Native Gardens

Shearwater Colony



**Lawai Kai Restoration**



**Lawai Stream Restoration**



**Lawai Forest Restoration**



***Schiedea* Critical Habitat Restoration**



# “Closing the Loop”

- Collecting plant propagules
- Curating materials and information
  - Accessions database
  - Herbarium vouchers
  - Seed bank
  - Tissue culture
- Propagating living collections
- Growing the next generation
  - *Ex situ*
  - *In situ*
  - *Inter situ*



## *NTBG's Progress in Rare Hawaiian Plant Rescue*

	Propagated* Species/Individuals	Outplanted Spp./Indiv.
PEP (GSN)	58 / 3223	17 / 588
Other At-risk	46 / 1041	15 / 929
TOTAL	104 / 4264	32 / 1517

*\* Currently in propagation*

# Collaborating Landowners

- US Fish & Wildlife Service
- State of Hawaii
- Makauwahi Cave Reserve
- Iliahi Project
- Nene Habitat
- Kawaihau Wetland
- Kamalani Playground
- Kukui`ula Development
- Hawaiian Mahogany Inc.
- Kilohana Plantation
- Island School
- Muolea Point Land Trust



Iliahi Project  
*A collaboration with  
Grove Farm Company*

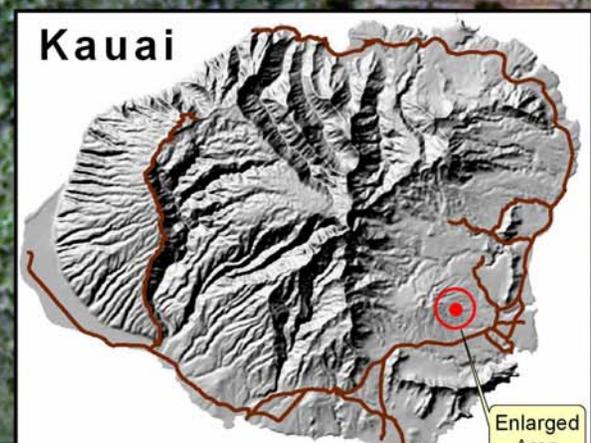
# Grove Farm

## Ecological Restoration

### Iliahi House Site



0 50 100 200 300 400 Feet



November 18, 2006: What a day!





# *Lehua Islet, Niihau*



An NTBG collaboration  
with the US Fish &  
Wildlife Service and  
the State of Hawaii





*Pritchardia* fossil pollen in Lehua Islet paleosol



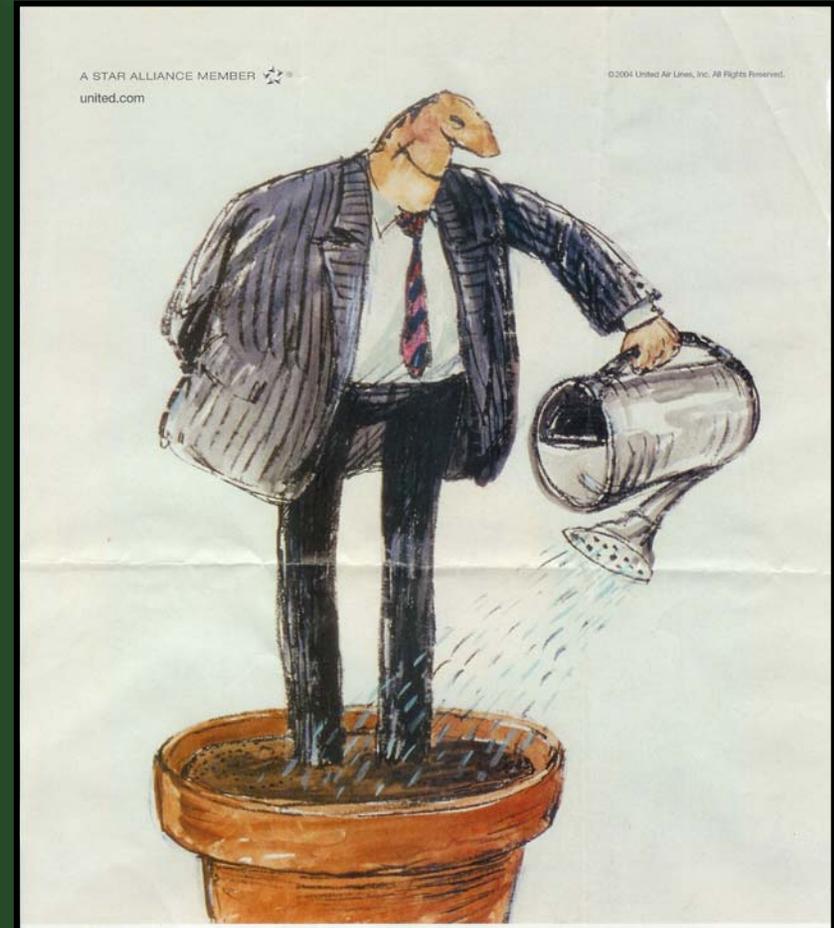
# *Inter Situ Restoration:*

- ❖ Creates a new population within species' former range
- ❖ Provides opportunities for genetic conservation
  - ❖ Increased population size
  - ❖ Genetic representation of many founders
- ❖ Enables competent control of invasives
- ❖ Allows creation of extractive reserve
  - ❖ Abundant nursery stock on demand
  - ❖ Potential cash crops
  - ❖ Practitioner's garden
- ❖ Creates tailor-made wildlife habitat
- ❖ Provides experimental test-beds
- ❖ Facilitates educational demonstrations



# WHAT DO WE NEED TO KNOW, TO DO THIS BETTER?

- How far to go with genetic management?
- How far to go with ecological surrogacy?
- Role of present and future invasions?
- What better options lie ahead?
- Will this strategy buy us enough time to stop a mass extinction?



*"We have a lot of growing to do"*