

Wet Tropics: the paradox of not enough water



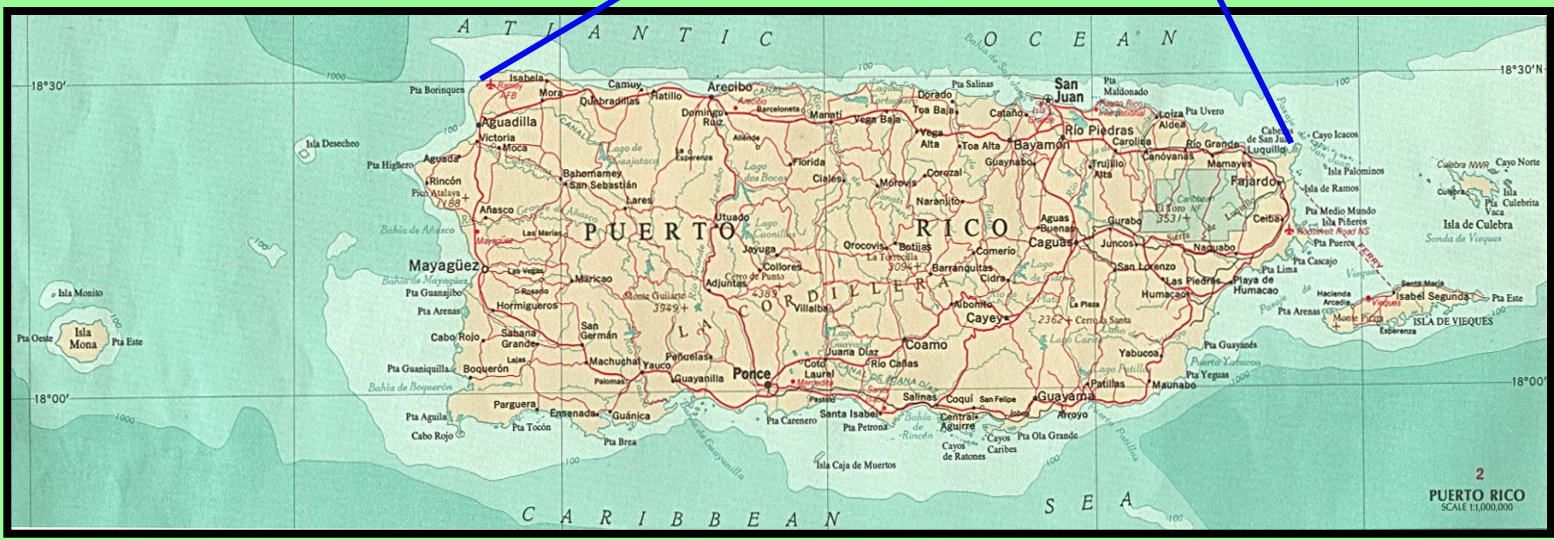
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The Water Center Seminar 12/5/2006



Tabonuco Forest - *Dacryodes excelsa*

- **subtropical rain forests**
- covers lower slopes up to about 600 m.
- larger trees exceed 30 m in height,
- ~ 168 tree species in the tabonuco forest

- Temp range: ~ 24°C in January; 27°C in **September**
- Mean rainfall = ~ 3500-4900 mm per year

Major Disturbance - Hurricanes

- Once/20 yrs
- Hurricane Hugo 1989 –
once/0 yrs event
- Hugo effects estimated 60
years to recover

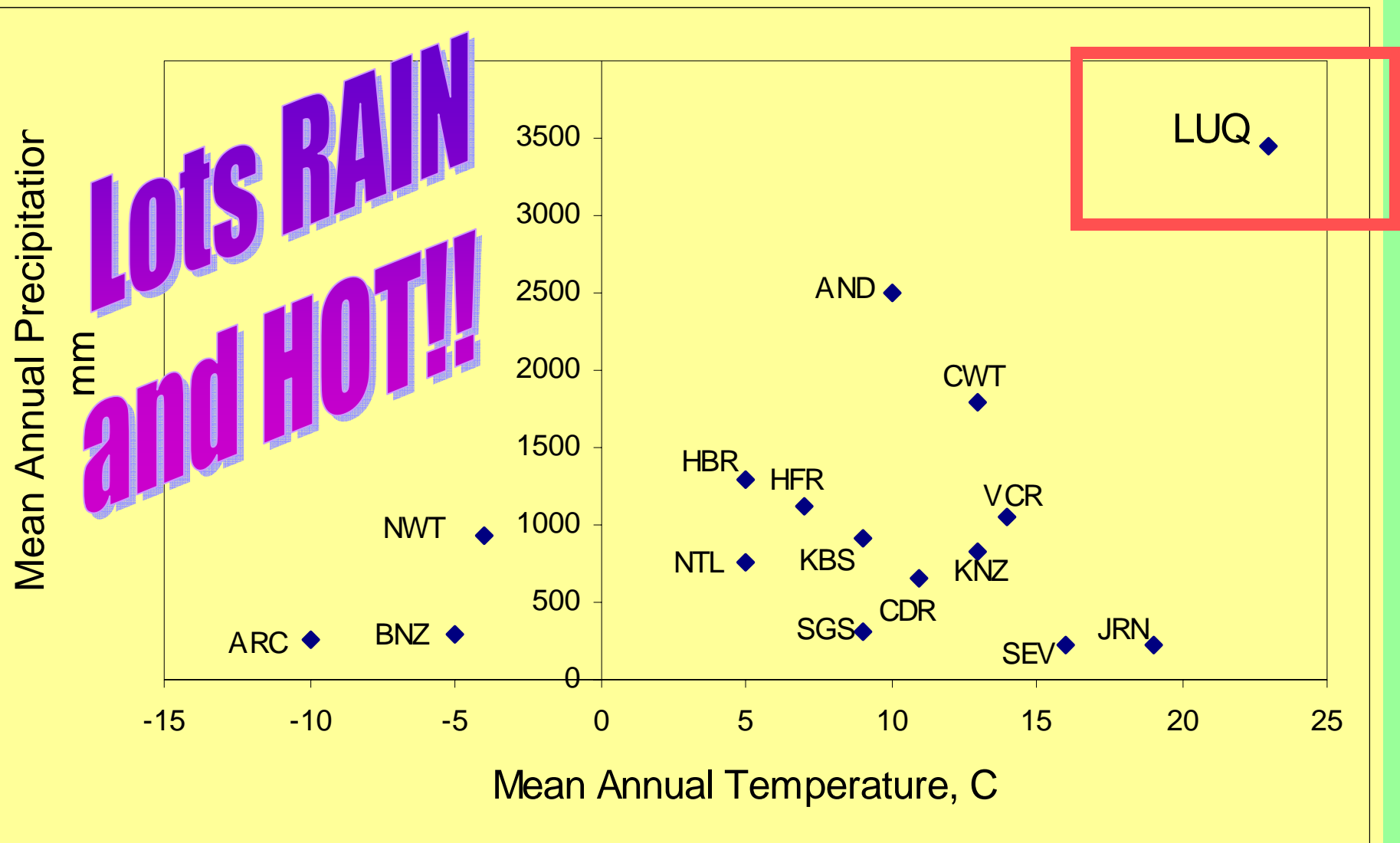
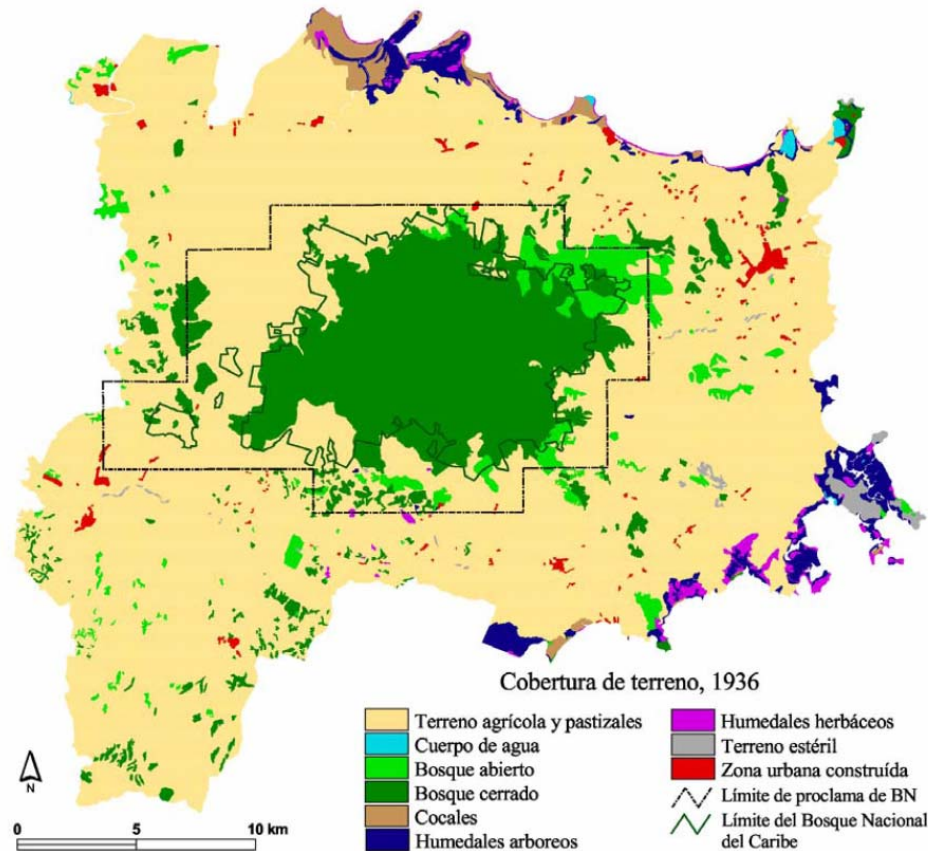


Fig. 2.1.3. Mean annual temperature and precipitation of the Luquillo Experimental Forest relative to other US-LTER sites in the Long-term Intersite Decomposition Experiment. As a result of higher rainfall and temperatures, decomposition in the LEF takes less time than in any of the other US-LTER sites (Gholz et al. 2000).

Eda Melendez Colom and Ariel E. Lugo. 2006. LTER publication

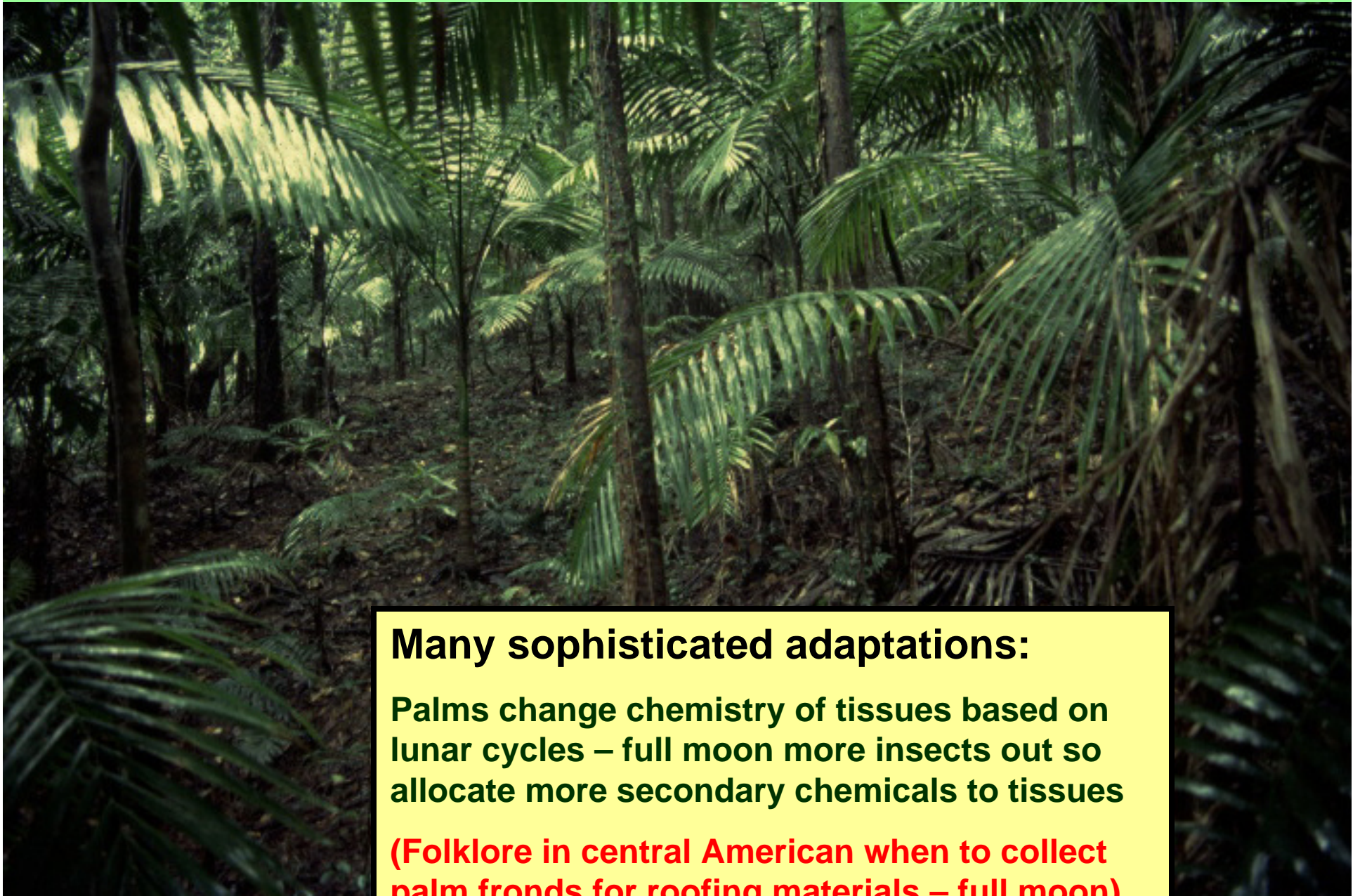
1936

40%
deforested
or 2ndary
forest, <
50% was
continuous
canopy



•Major Alterations of the Forest Landscape by Humans

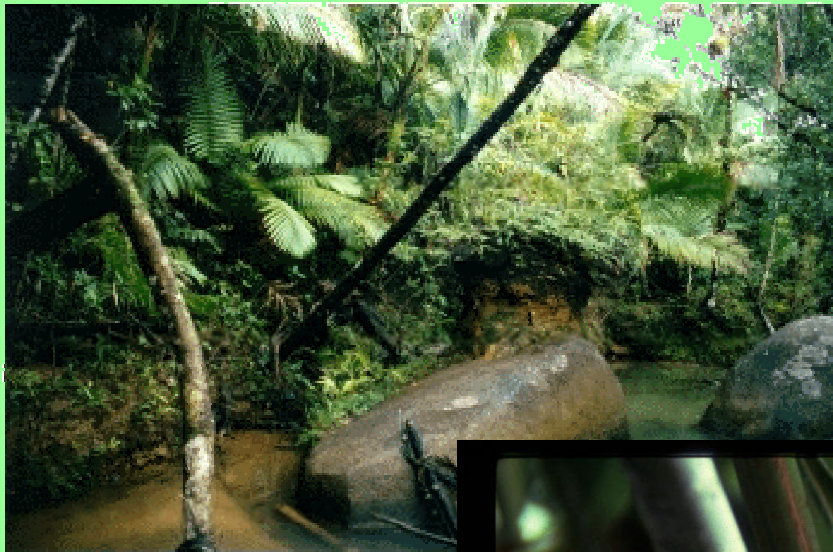
- Disturbance cycles (hurricanes, etc) resulted in high resiliency and dominance by early successional vegetation (difficult to be invasive species)



Many sophisticated adaptations:

Palms change chemistry of tissues based on lunar cycles – full moon more insects out so allocate more secondary chemicals to tissues

(Folklore in central American when to collect palm fronds for roofing materials – full moon)



**Romantically
TROPICS are
WET, WET,
WET**



<http://pr.water.usgs.gov/public/webb/image>



**Natural history
keyed to lots of rain
and periodicities of
storm events**





Plants adapted to get rid of the excess water

- Foliage drip points

Or to obtain oxygen when lots of water

- Aerenchyma on roots



Coqui adapted to high water and success in attracting mates higher and occurs shorter time when lots of rain

(adapted to humans - use toilet and showers at field site as calling site for females)

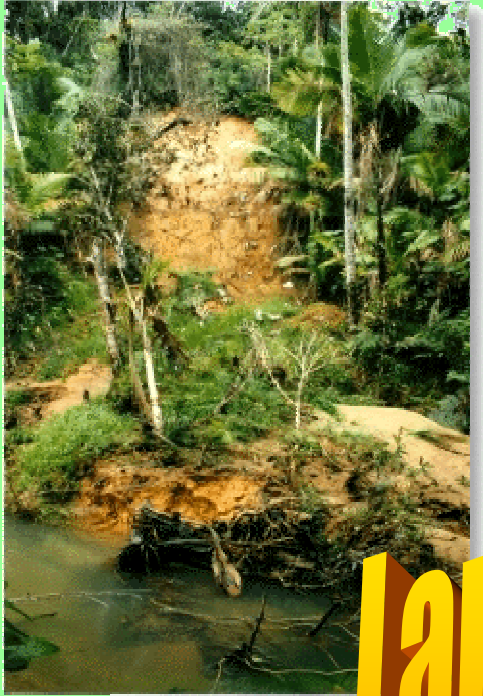


Yes there are rivers but the whole hillslopes are locations of standing water so **traditional definitions of river, riparian, upslope are not relevant** (e.g. find aerenchyma on roots of upslope plants, plants root grafted to support one another on hillslopes)

Water everywhere



**Signature of excess water
visible in this landscape**



**Landslides
everywhere**

**Rocks larger than a car
moving down rivers and
hillslopes**



6 Hurricanes during
Vogts ~ 10 yr study:

Sept 1989 – Hugo;
early-mid Sept 1995 –
Luis & Marilyn;
Jul 1996 – Bertha;
Sept 1996 -Hortense;
Sept 1998 - Georges



THE TRIGGER -ecosystem functions PPP

Hurricane Georges hits Puerto Rico on September 21, 1998. Image by Dennis Charit Jentoft-Nilsen, Craig Mayhew, and Hal Pierce, Laboratory for Mesospheres, NASA Goddard Space Flight Center from data derived from NOAA GOES-8 satellite. Image from "<http://rsd.gsfc.nasa.gov/rsd/images/Georges.html>".

Puerto Rico and hurricanes since 1980s

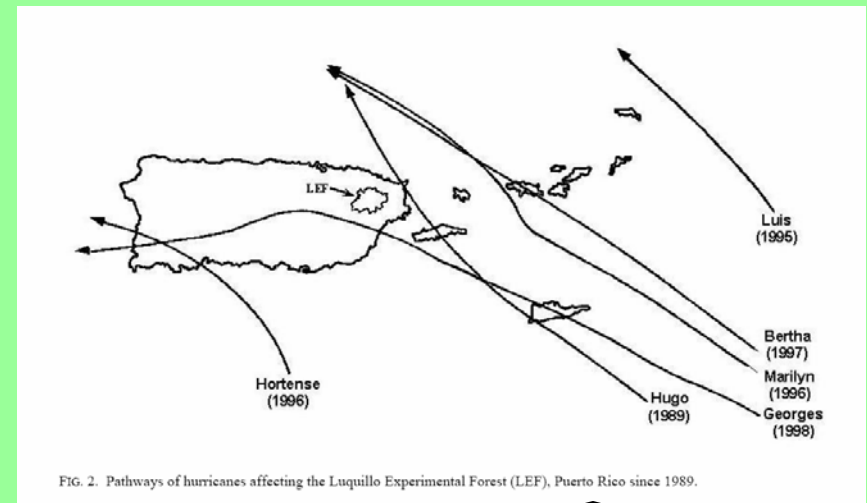
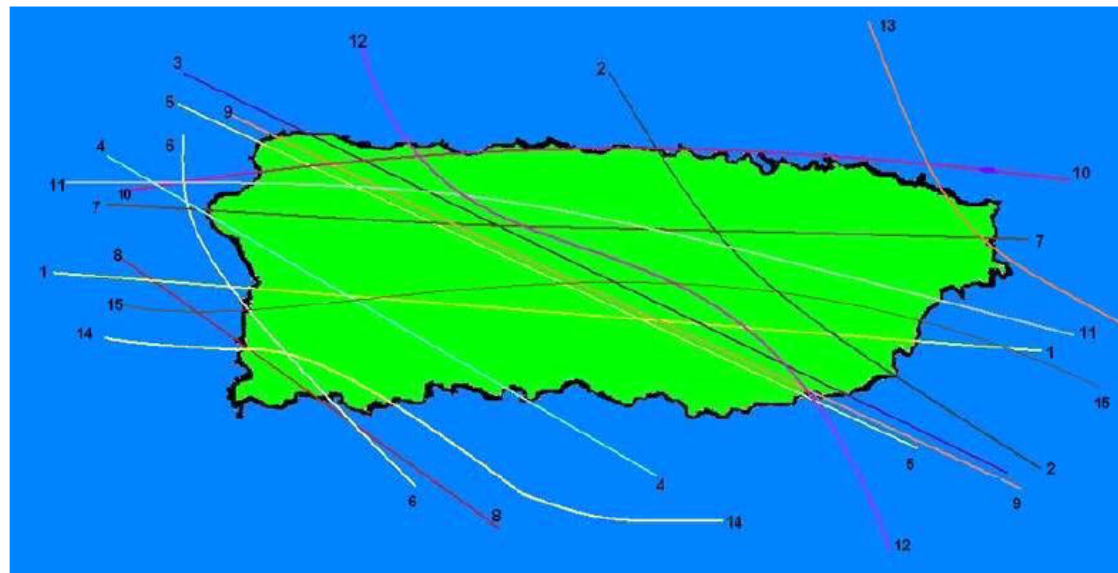
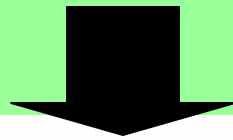


FIG. 2. Pathways of hurricanes affecting the Luquillo Experimental Forest (LEF), Puerto Rico since 1989.



10 years of
our research
in Puerto Rico

At least 21
hurricanes last
25 years

Eda Melendez Colom and Ariel E. Lugo. 2006. LTER publication

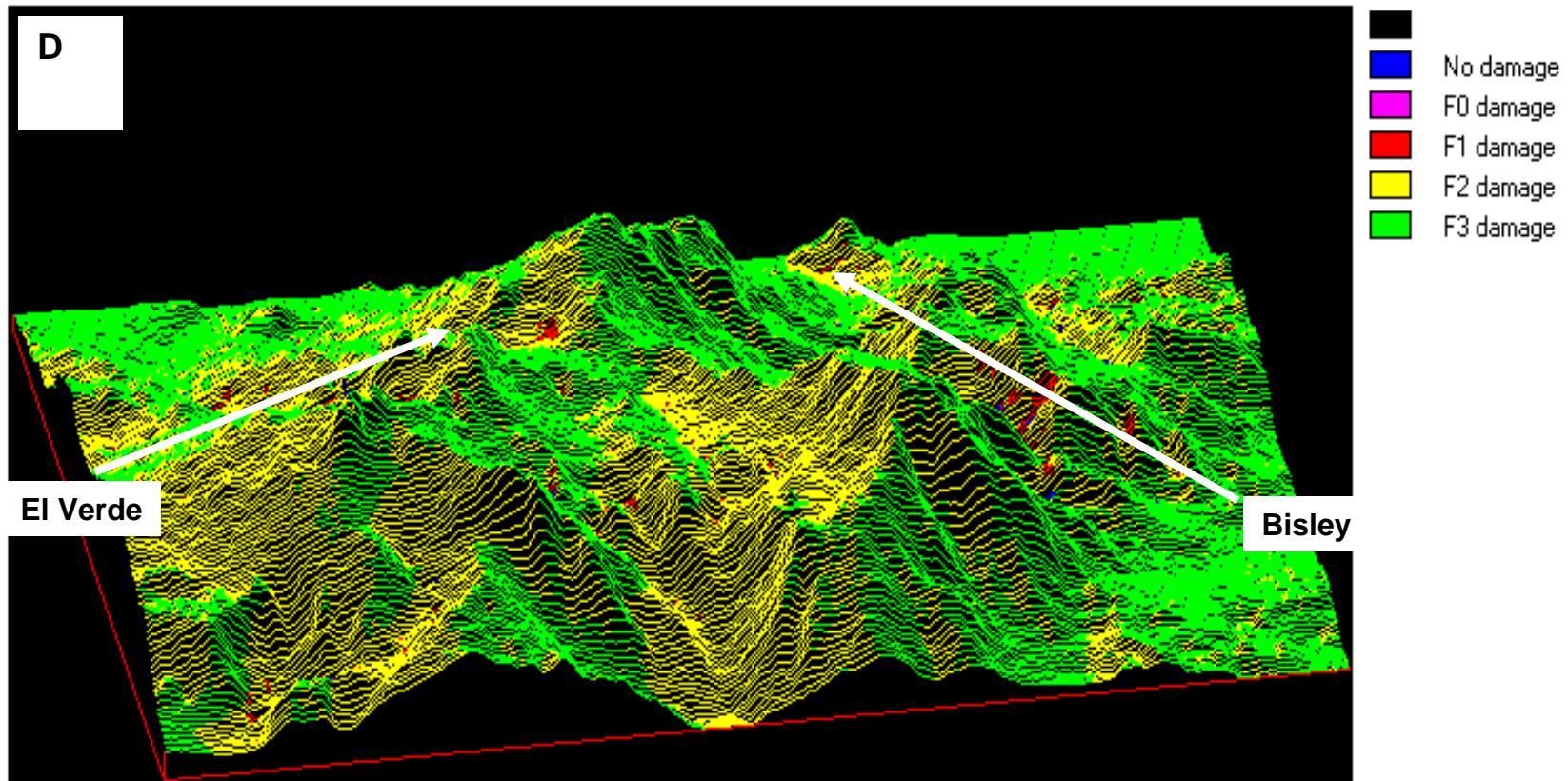


Would think not adapted to hurricanes because of damage but are integral part of ecosystem dynamics

Hurricane Hugo



Luquillo Experimental Forest



1886-1996 Maximum Predicted Damage (view toward north)

D; as estimated by the HURRECON and EXPOSE models, Boose et al. 1994, unpublished) shows that all areas of the LEF sustained severe damage sometime during 1886 to 1996 and that topographic position modifies patchiness of wind damage. Legend shows none to high damage categories, yet most of the surface was highly or very highly damaged over 100 years.

PRLTERProposal2005

Native species adapted to water and hurricanes but introduced, exotic species not adapted and were uprooted (hectares of Mahogany plantations had to be staked back up)



Appears totally devastated but ecosystems adapted to this

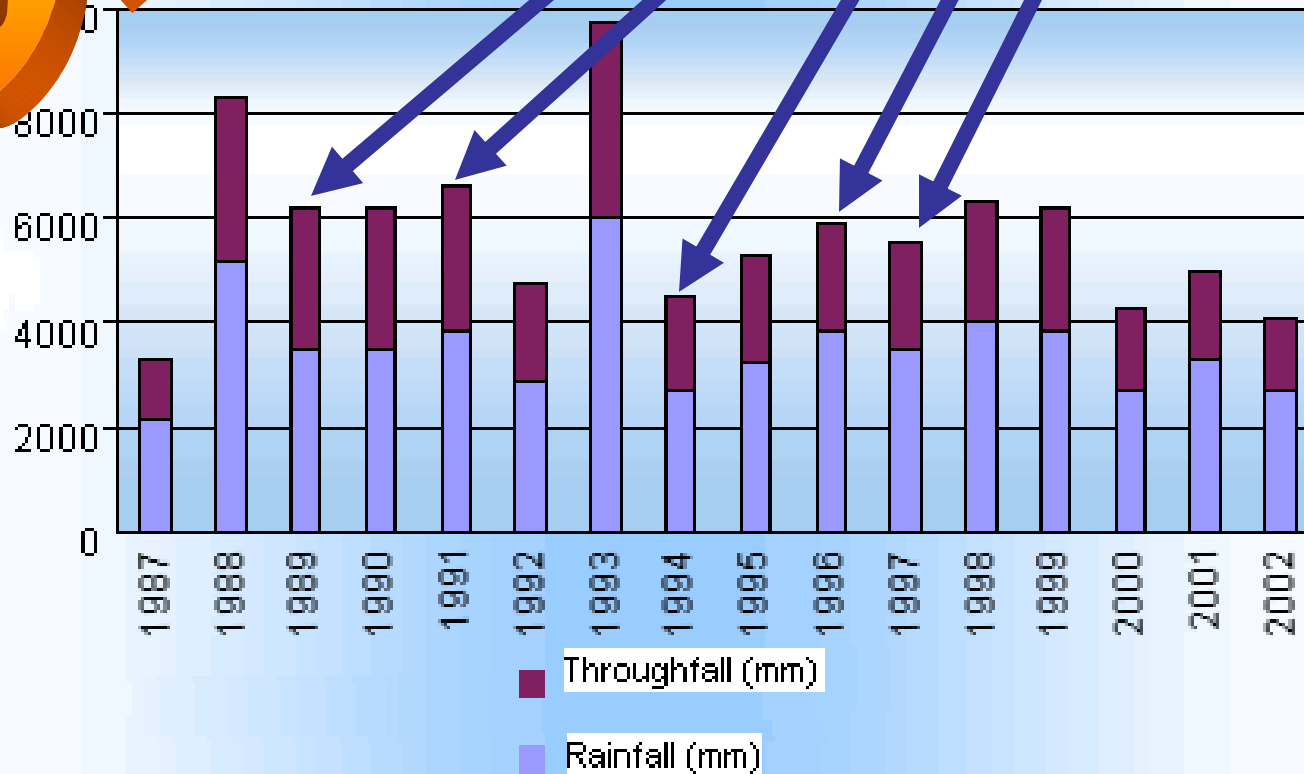
So Ecosystems functioning and resilient

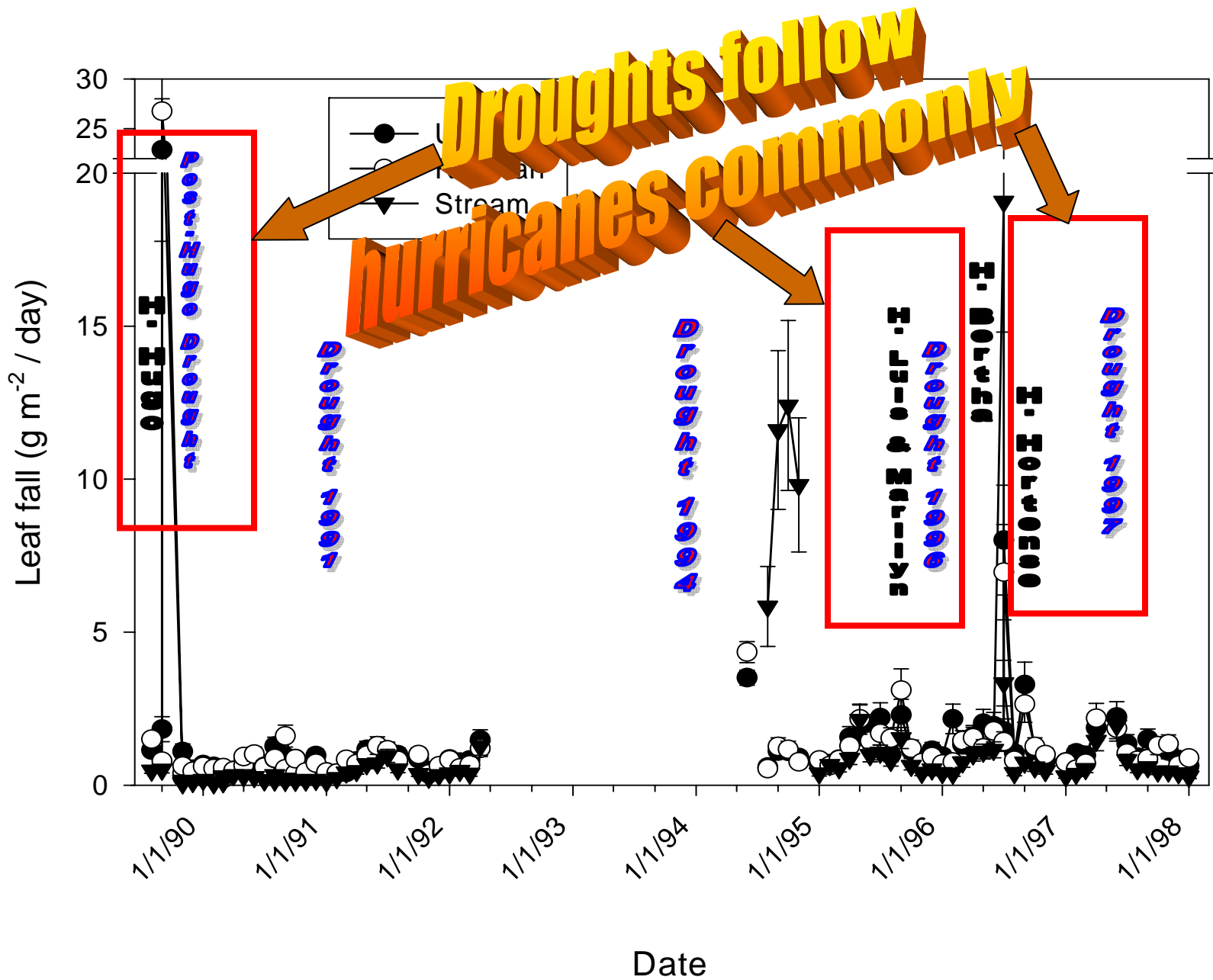


BUT

Drought years –
Oct-Dec 1989, Jan-Apr 1991,
Apr-Jun 1994, Feb-Mar 1996,
Mar-Apr 1997

Bisley Rainfall and Throughfall

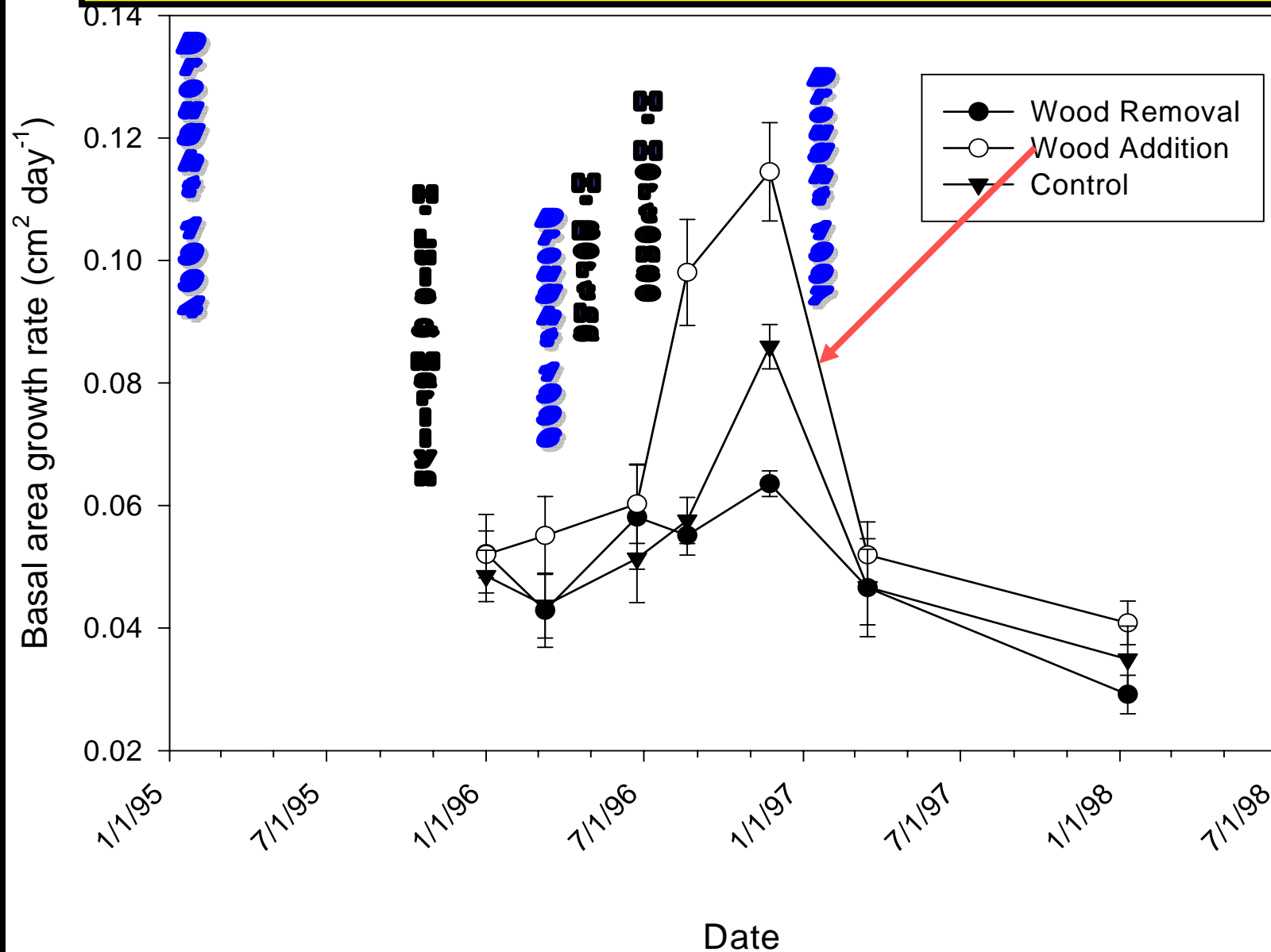






Surface root
mats killed

Tree growth higher when wood added to a site (like after a hurricane), lowest growth when wood removed



Coqui

LOVES HURRICANES
HATES DROUGHTS



Resiliency of Forests
Controlled by Coqui

Cultural icon



Kraus et al. 1998

Coqui Natural History



- Most abundant and widespread frog (20,000/ha)
- Nocturnal terrestrial
- Diurnal retreats
- Male parental care
- Year-round breeding

Role in the Food Web

- 'Sit and wait' predators
- Mostly consume insects on foliage
- Consumes tremendous amount of insects (120,000/ha/night)
- No predator appears to limit populations



**1 m² calling area
for mates at
night**

**Loud (80-90 dBA
at 0.5m) mating
calls.**

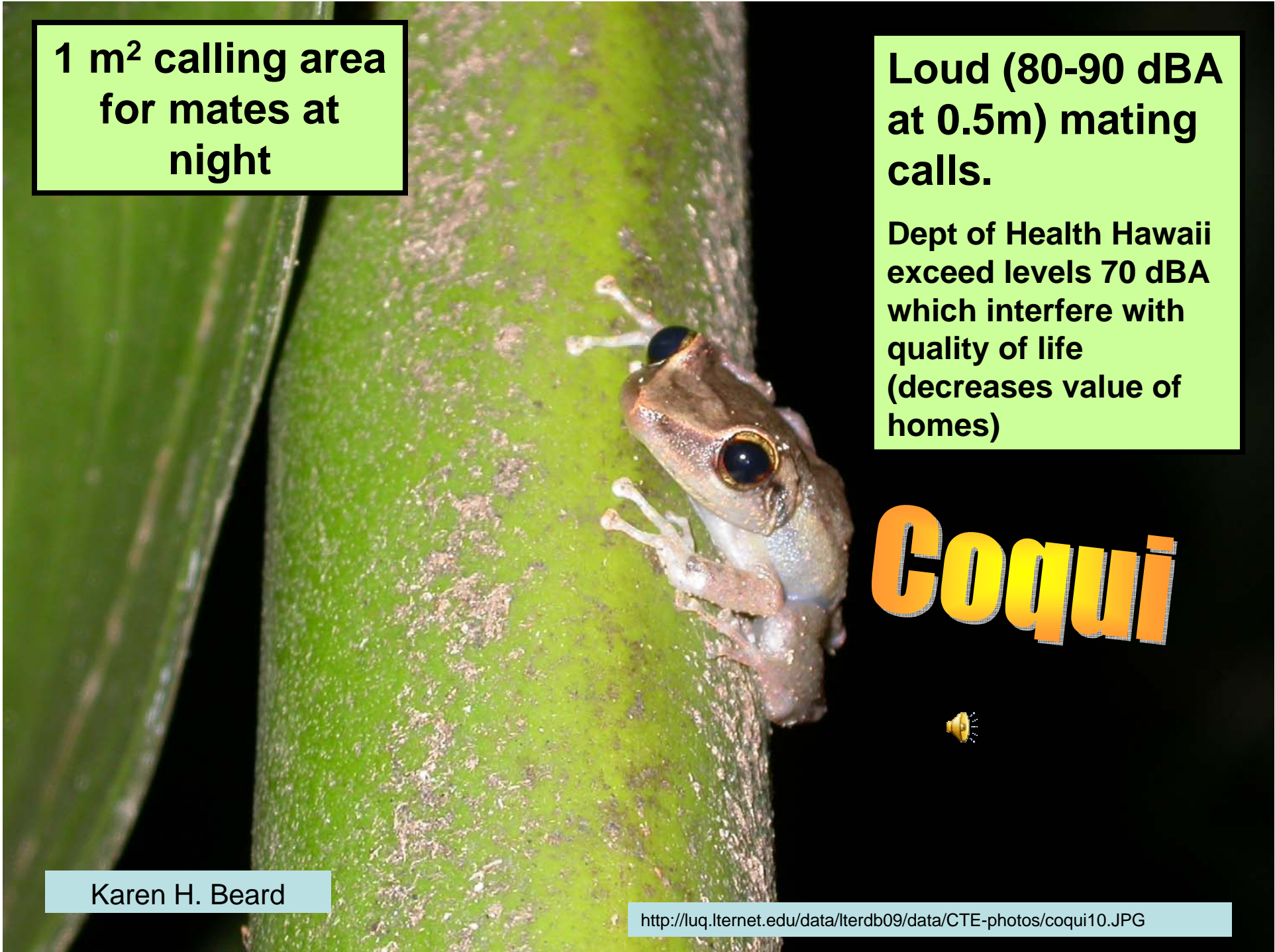
**Dept of Health Hawaii
exceed levels 70 dBA
which interfere with
quality of life
(decreases value of
homes)**

Coqui

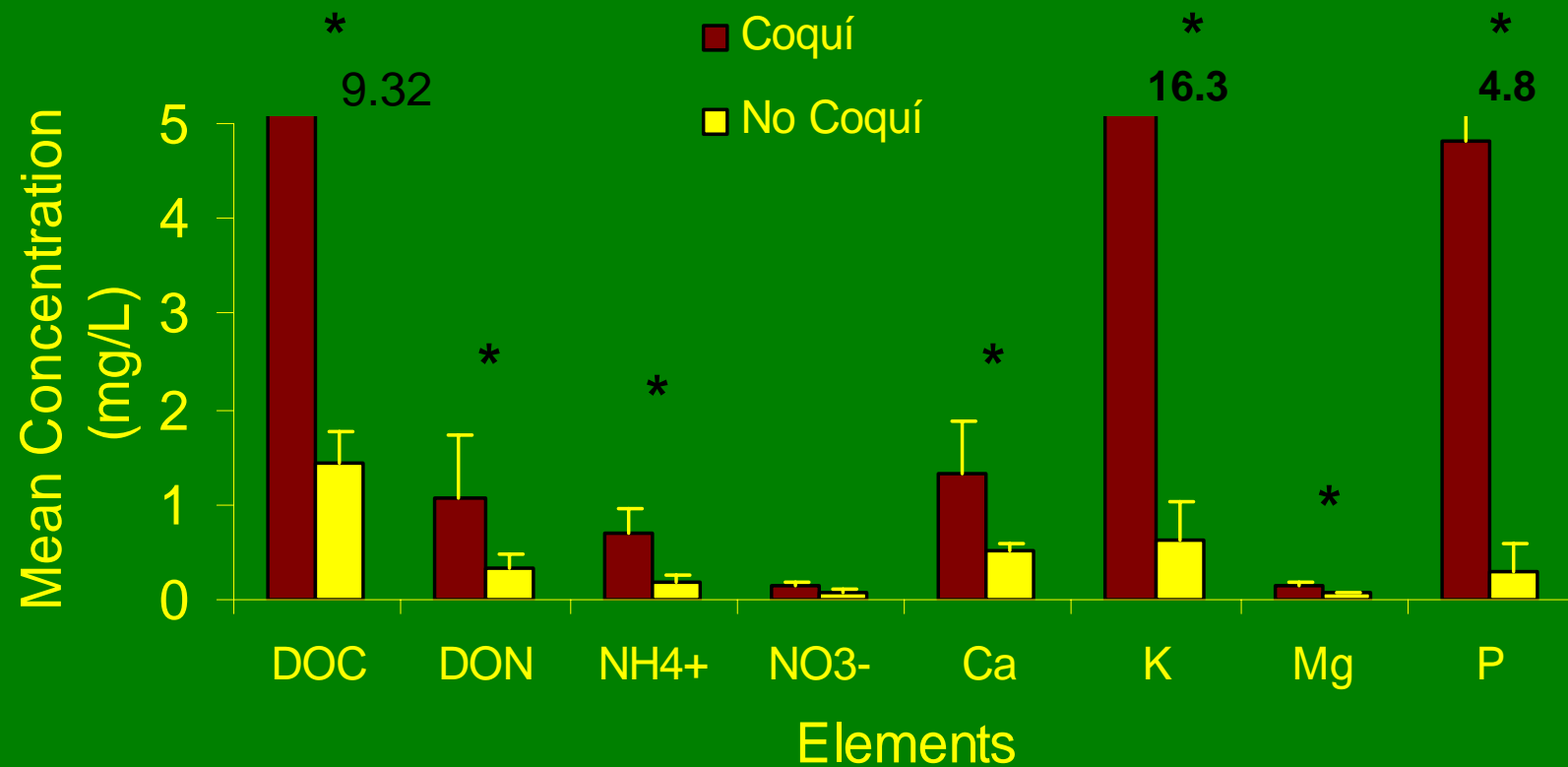


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<http://luq.lternet.edu/data/lterdb09/data/CTE-photos/coqui10.JPG>

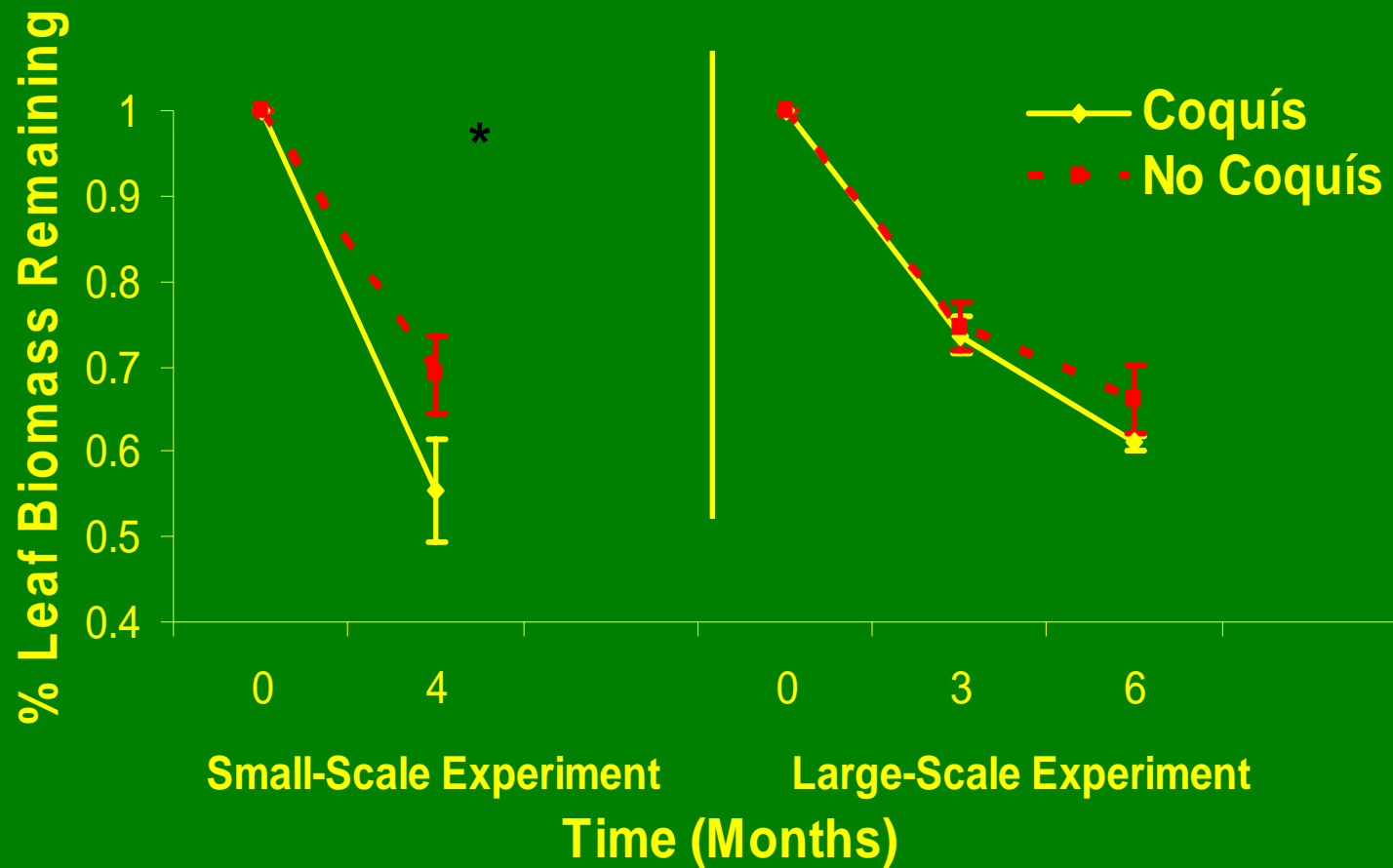


Coquí Associated with Increased Nutrients in Leaf Washes

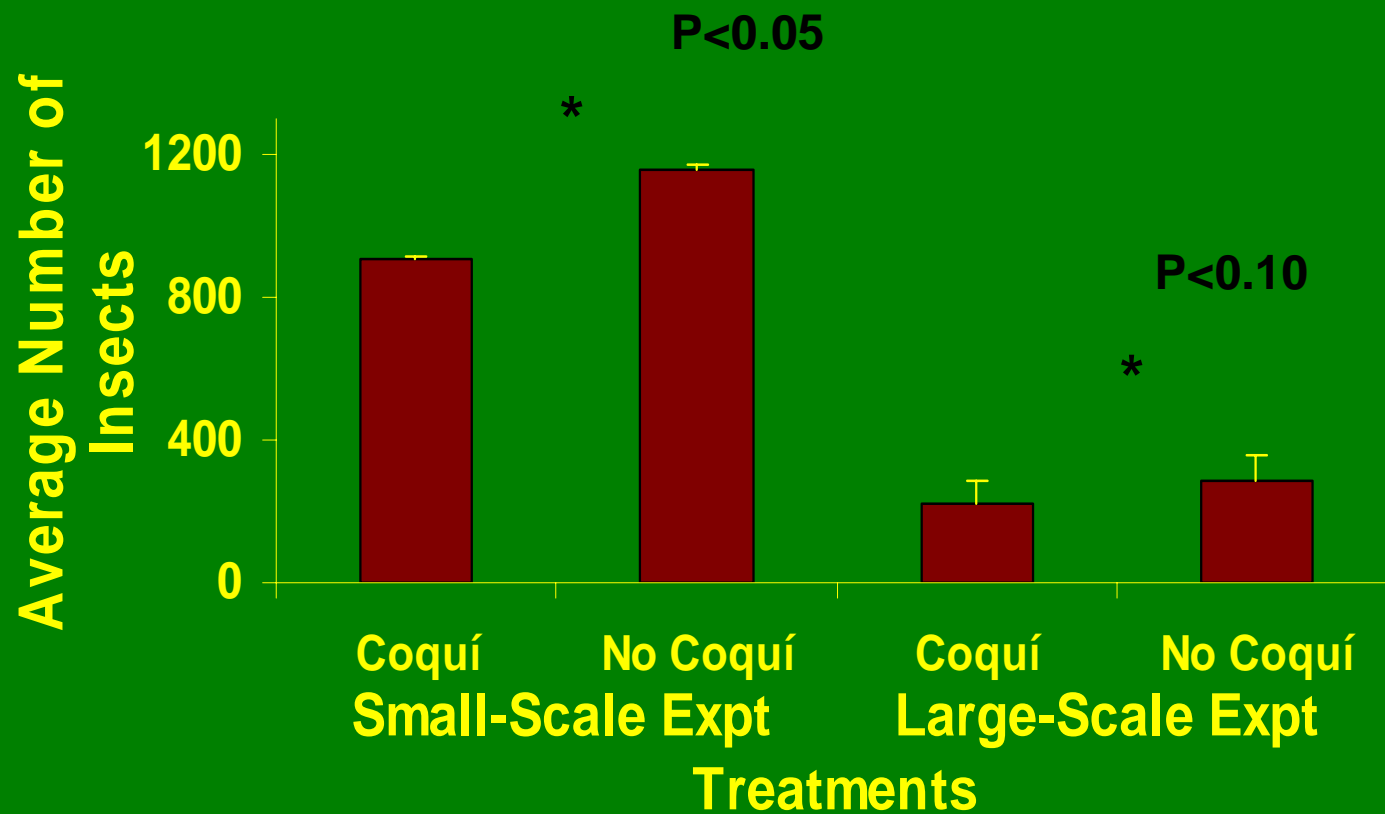


Beard et al. *Oecologia*

Coquís Increase Leaf Litter Decomposition Rates



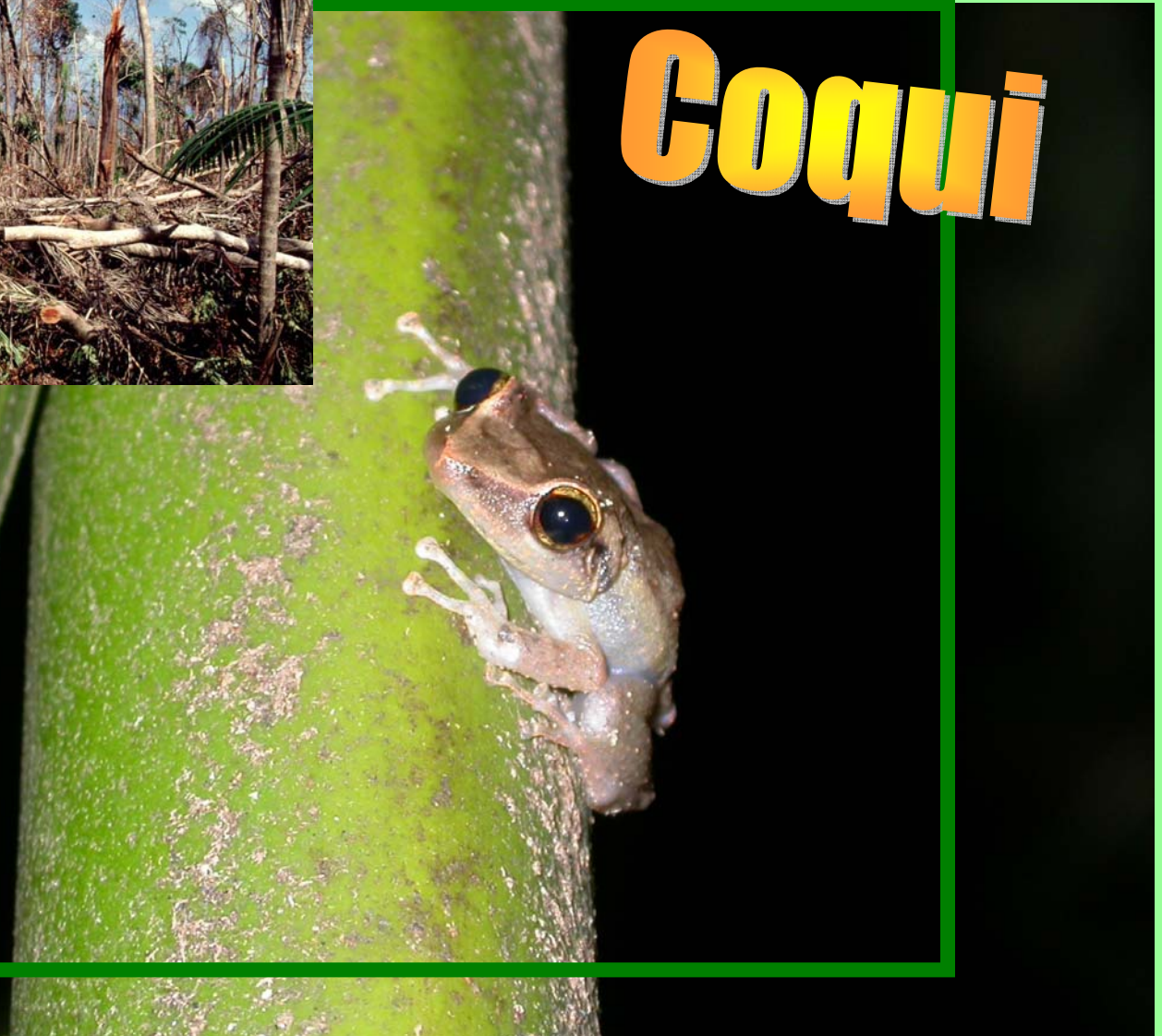
Coquí Reduce Aerial Insects





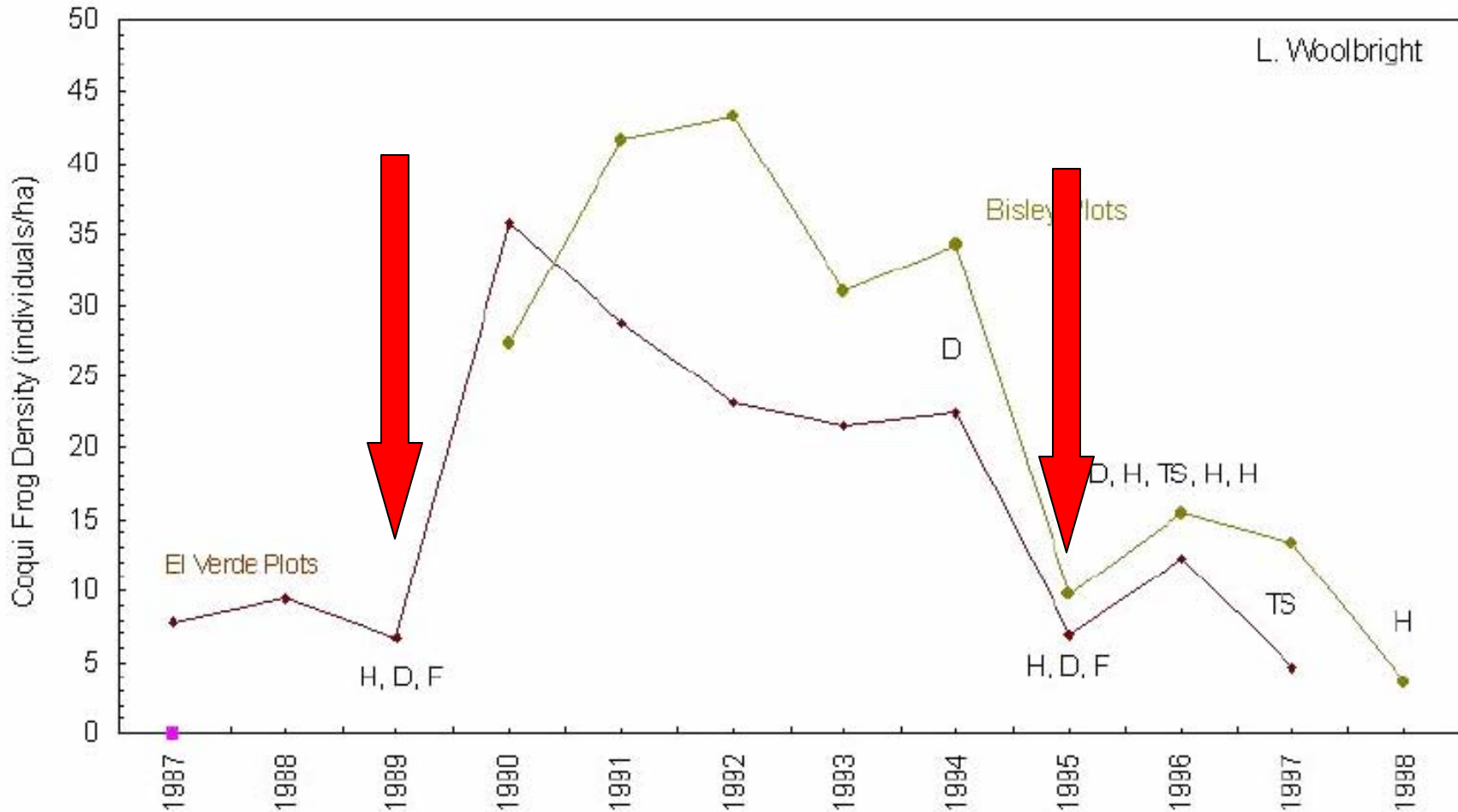
**Amount
habitat
increases
significantly
with
hurricanes**

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<http://luq.lternet.edu/data/lterdb09/data/CTE-photos/coqui10.JPG>

Coqui population density increases significantly with hurricanes

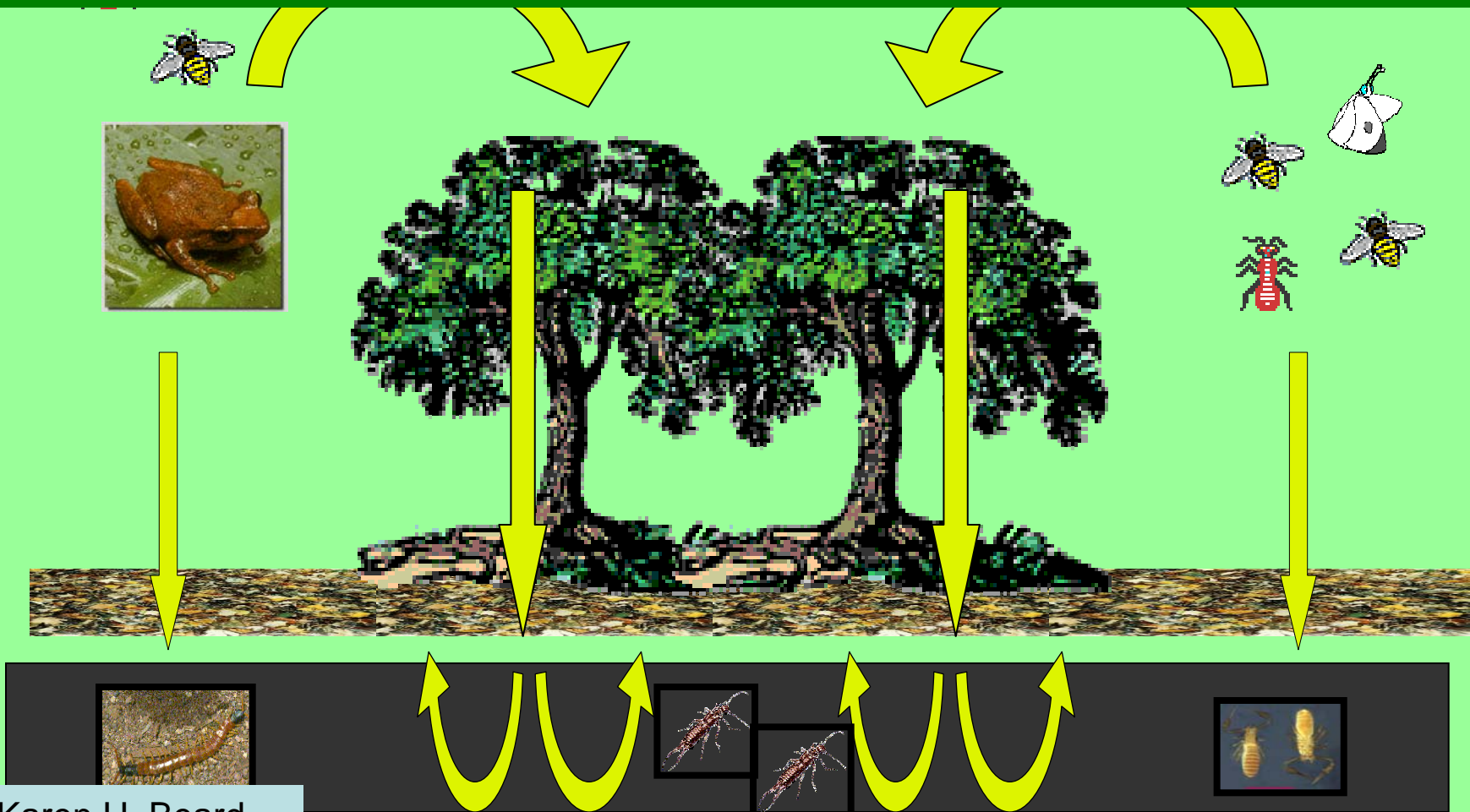


Coqui population density fluctuations

Coquis increase nutrient availability through deposition of excrements

Coquis have top-down control on invertebrate herbivores, which determine the amount of herbivory, and indirectly control production

1994 drought - decreased coquis population---high arthropod herbivory



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'Boiled Frog' Parable – difficulty knowing what is causal factor



HAPPY



COOKED



COOL, SLOW HEAT = Drought

BOILING WATER = Hurricane

**Focusing on HURRICANES
MISSED DROUGHT Impacts**



Instant hot heat

Slowly increase heat



Forest Ecosystem Recovery (for Hurricane Hugo)

Variable	Recovery Time
Total vegetative biomass	> 5 yrs
Tree mortality rates	3 yrs
Leaf litter production	2-5 yrs
Forest floor litter	1-2 yrs
Fine roots (w/ drought)	1 yr (6 yrs)

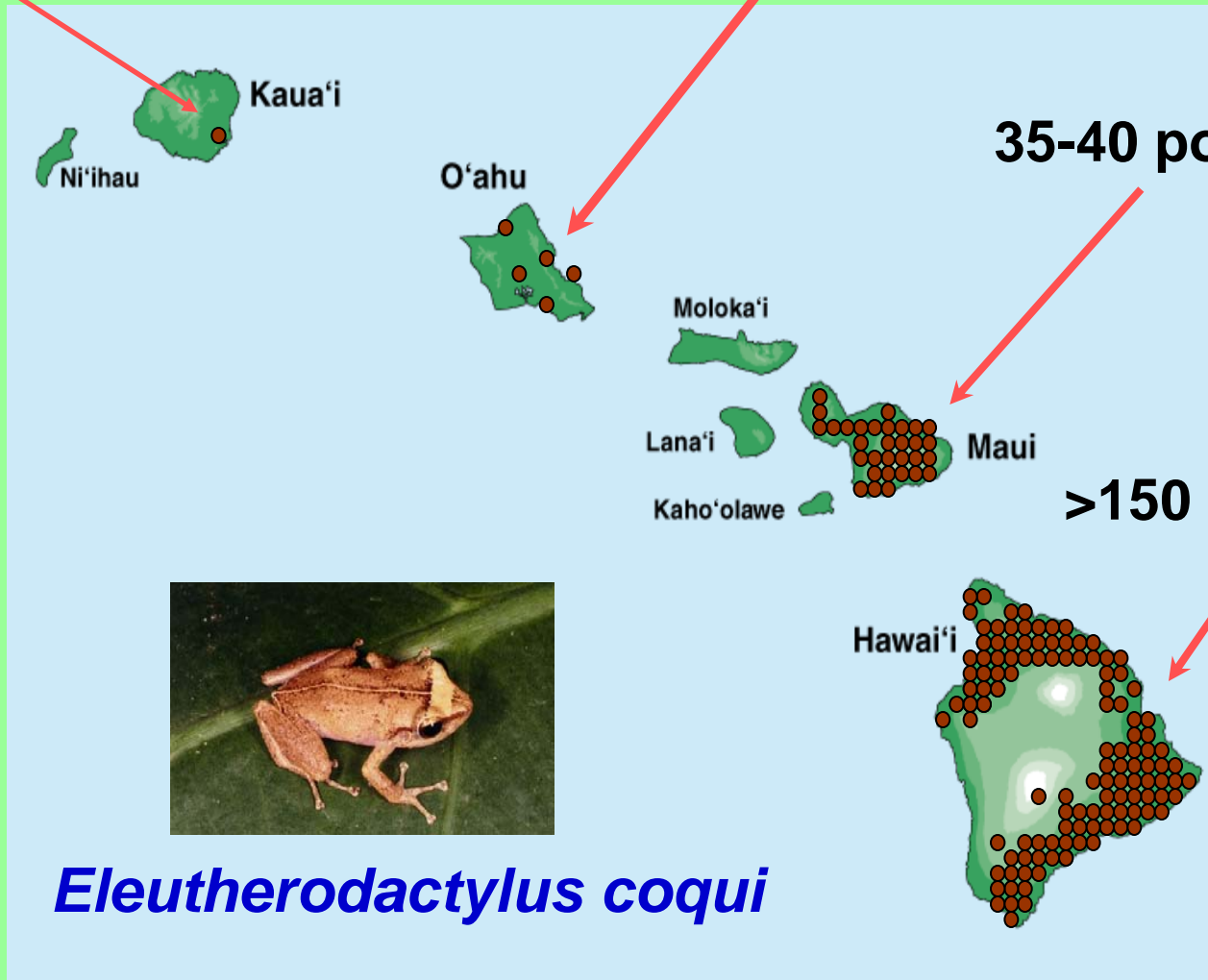
Coqui important in the recovery rate of the vegetation, nutrient cycles
Droughts decrease coqui activity; impact resilience of the ecosystems

1 populations

8 populations

35-40 populations

>150 populations

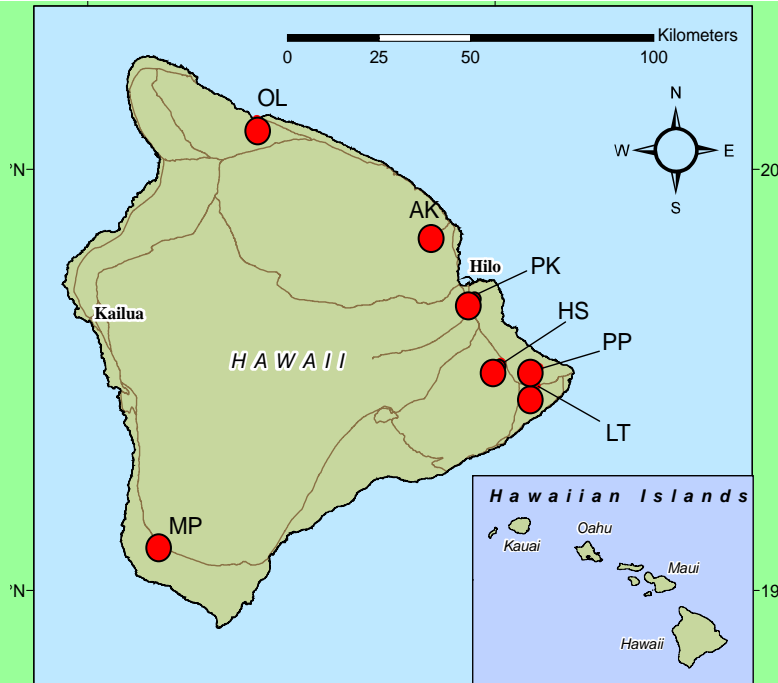


NWRC Field Station, Hilo



Introduced with ornamental plants

Introduced to control insect populations



Schnabel Population Estimates For Adult Frogs

Site	#/100m ²
Akaka Falls (AK)	58
Humane Soc. (HS)	69
Lava Tree (LT)	84
Manuka NAR (MP)	107
Waipio Overlook (OL)	16
Puainako (PK)	44
Paradise Park (PP)	100

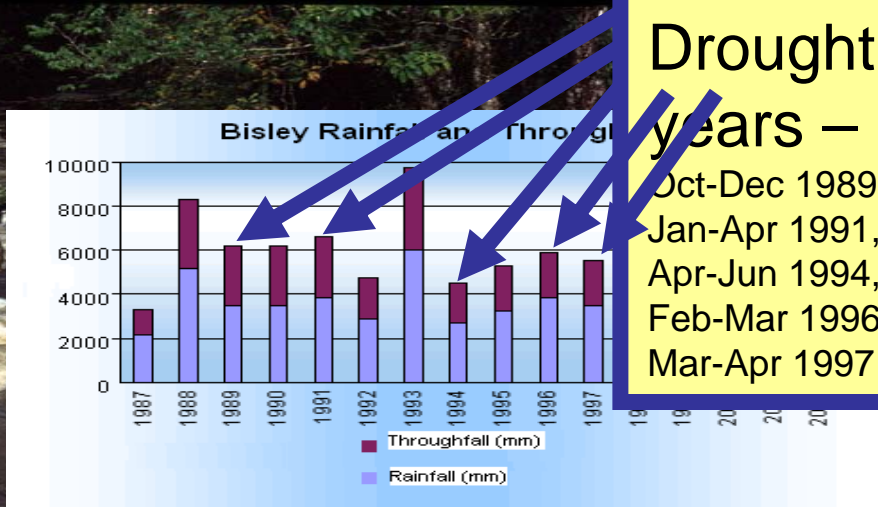
Coquis are presently consuming mostly leaf litter non-native invertebrates.

They have preferred prey items (mostly non-native ants, amphipods) across sites.

Beard and Tuttle (In Progress)



Hurricane Hugo



Drought years –
Oct-Dec 1989,
Jan-Apr 1991,
Apr-Jun 1994,
Feb-Mar 1996,
Mar-Apr 1997



**Wet Tropics:
Hurricanes GOOD
But not enough water**