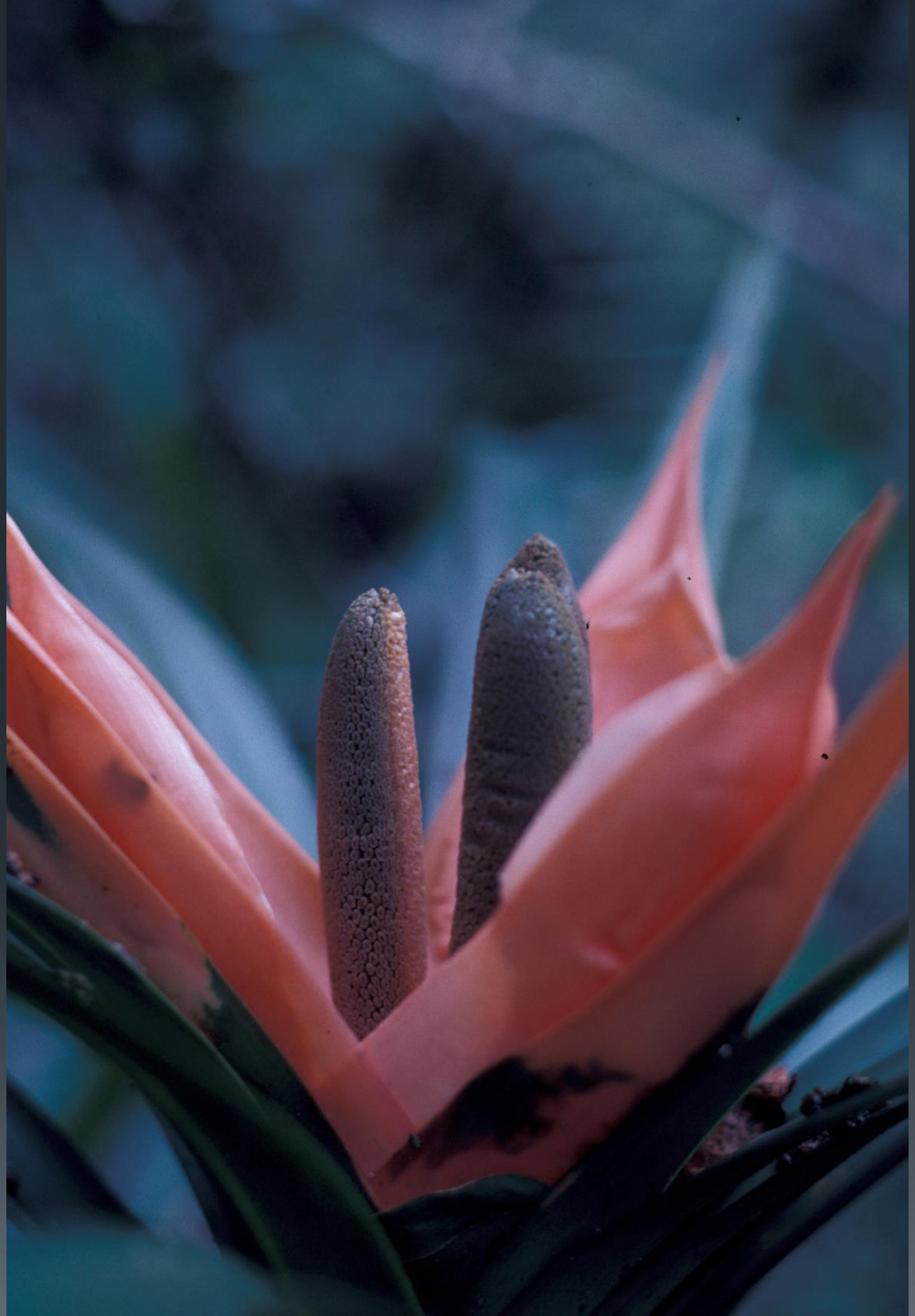
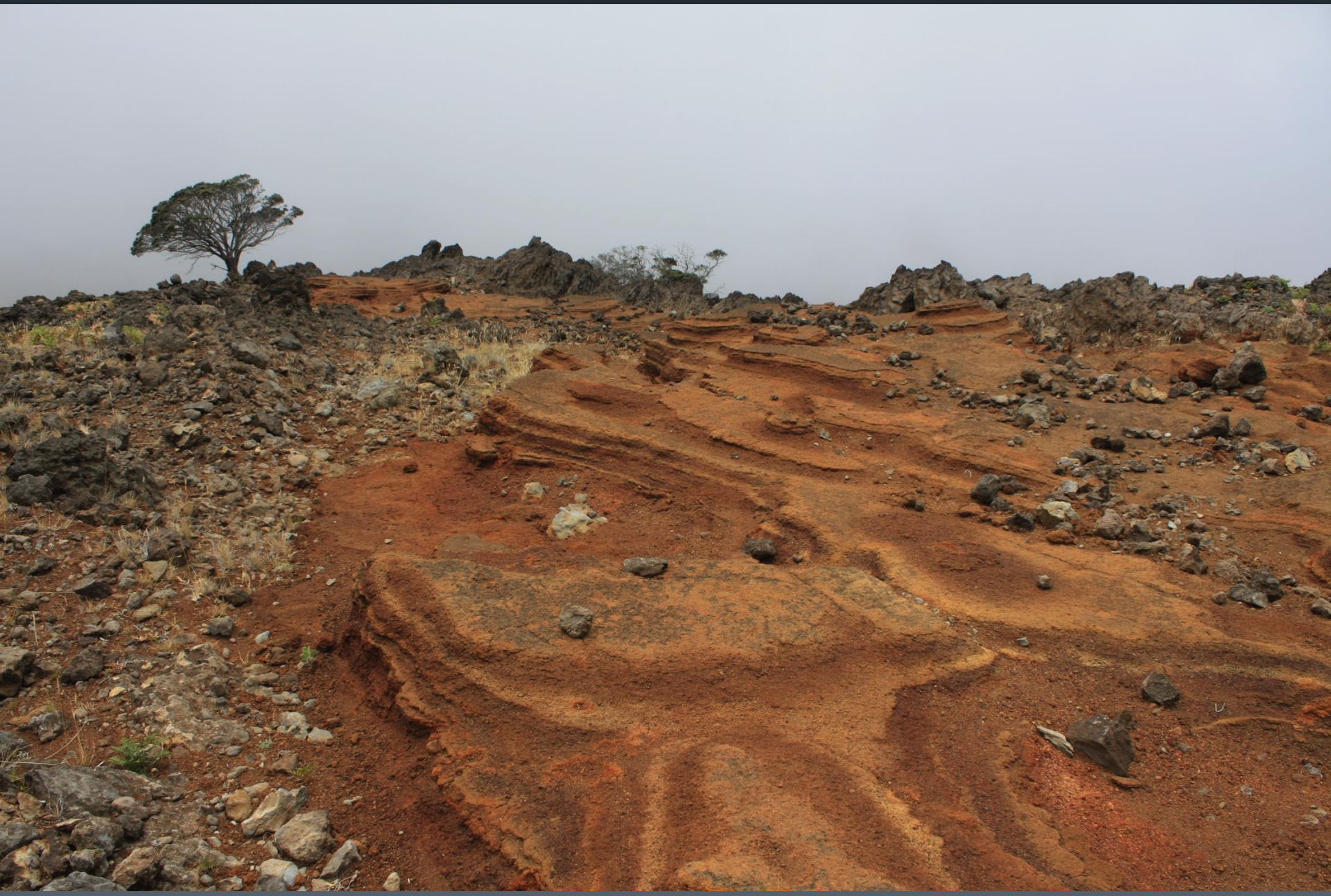
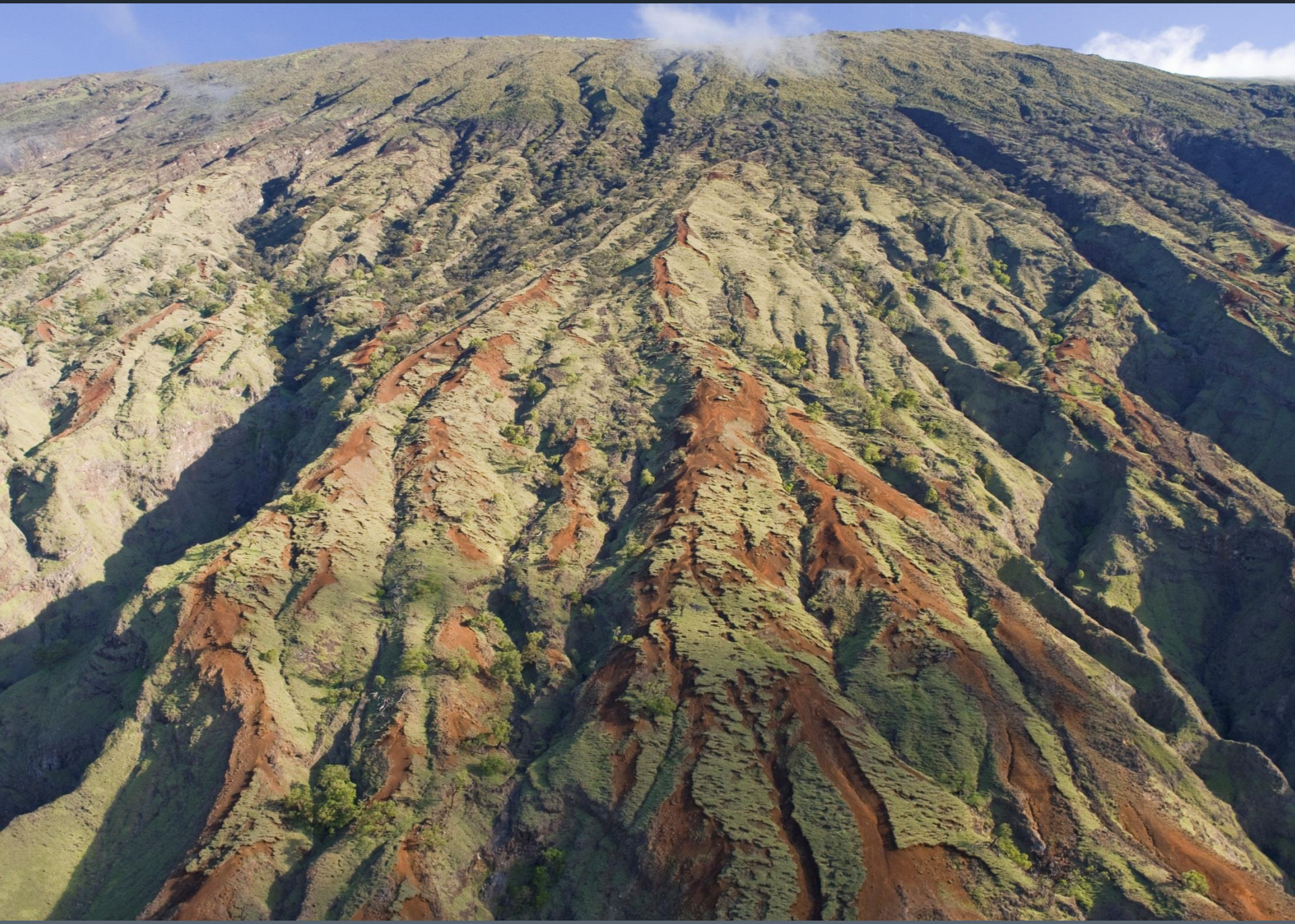
Auwahi
- creating a model for rebuilding Maui's watershed forests and re-instilling a sense of *kuleana* in Maui's human communities

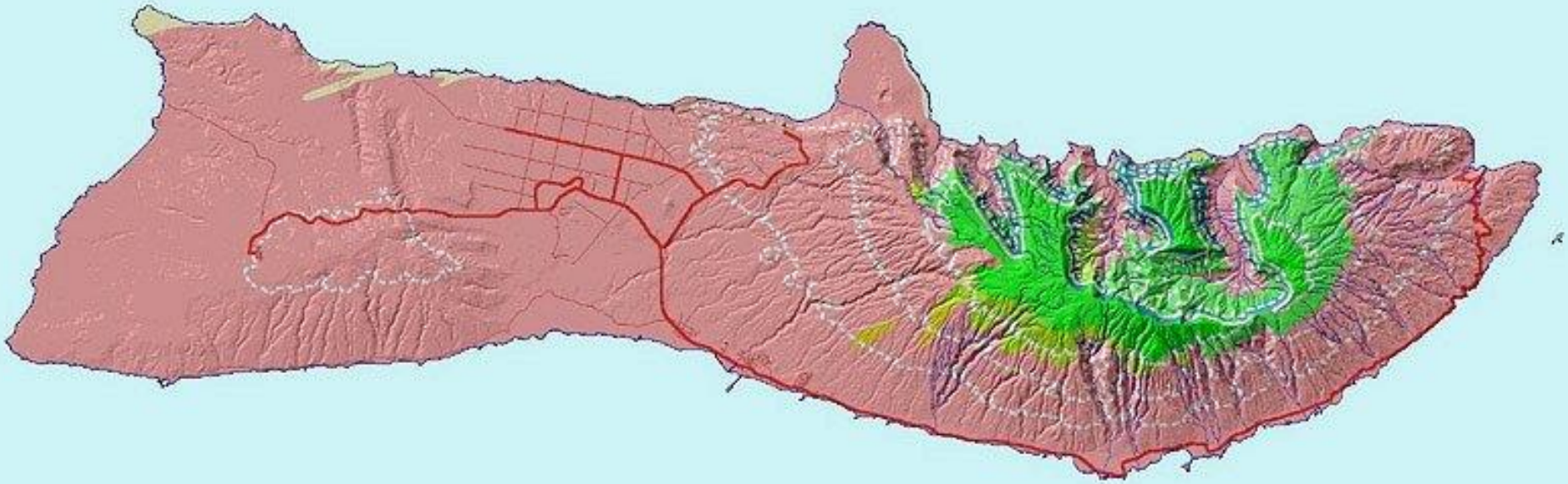
Auwahi Forest Restoration Project
Art Medeiros, Ph.D. program manager

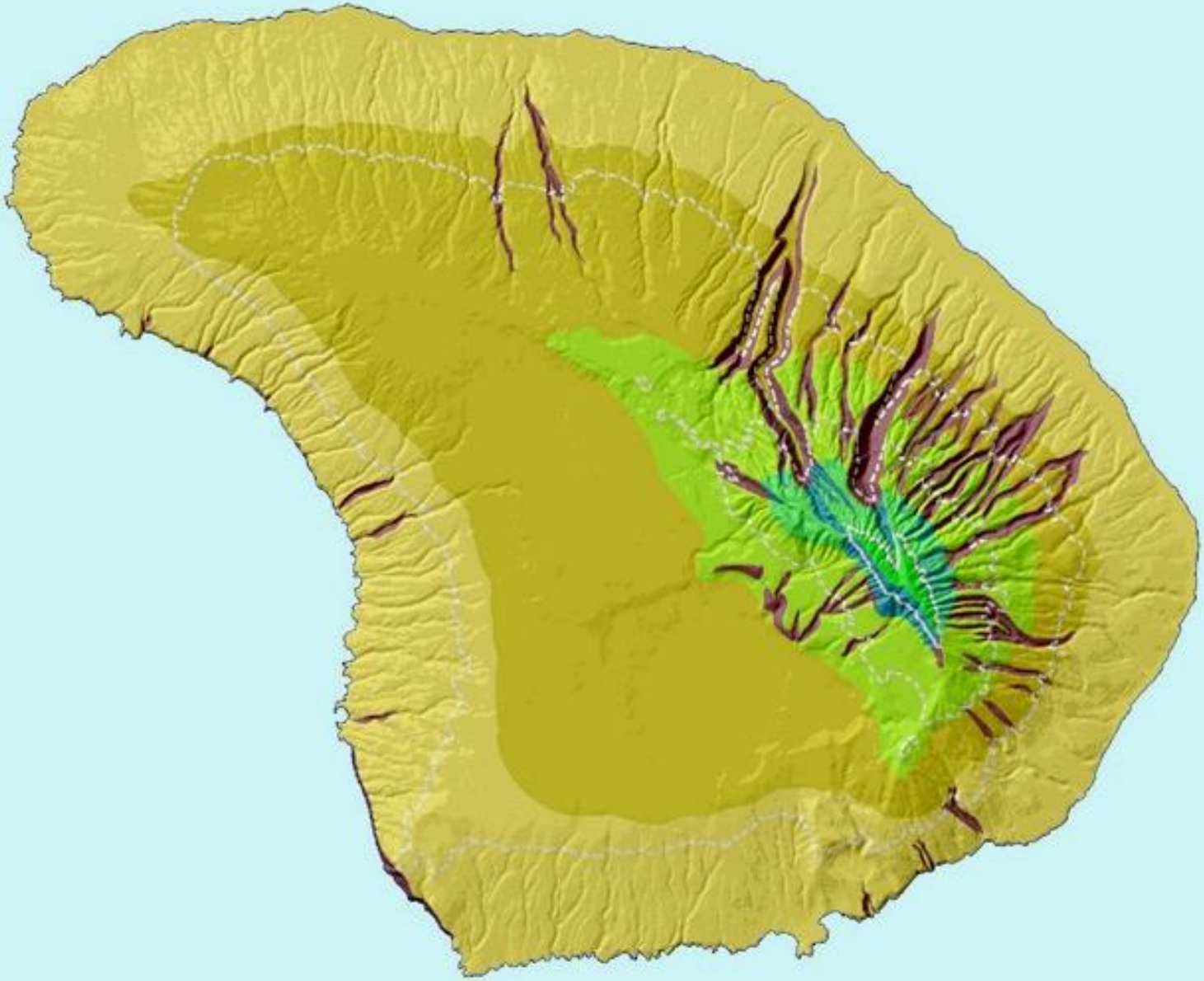

Dubautia waialealae
Asteraceae
A. C. Medeiros

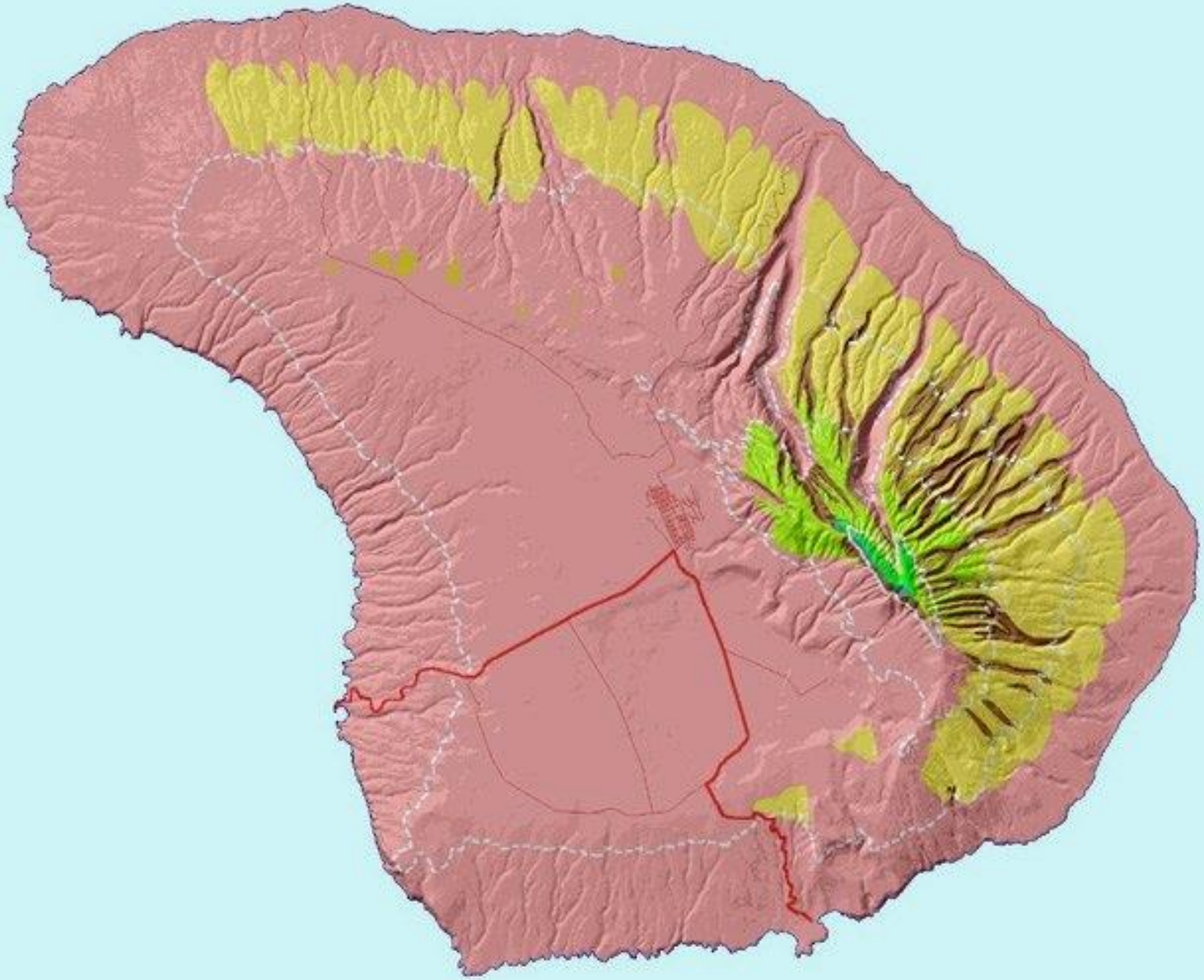


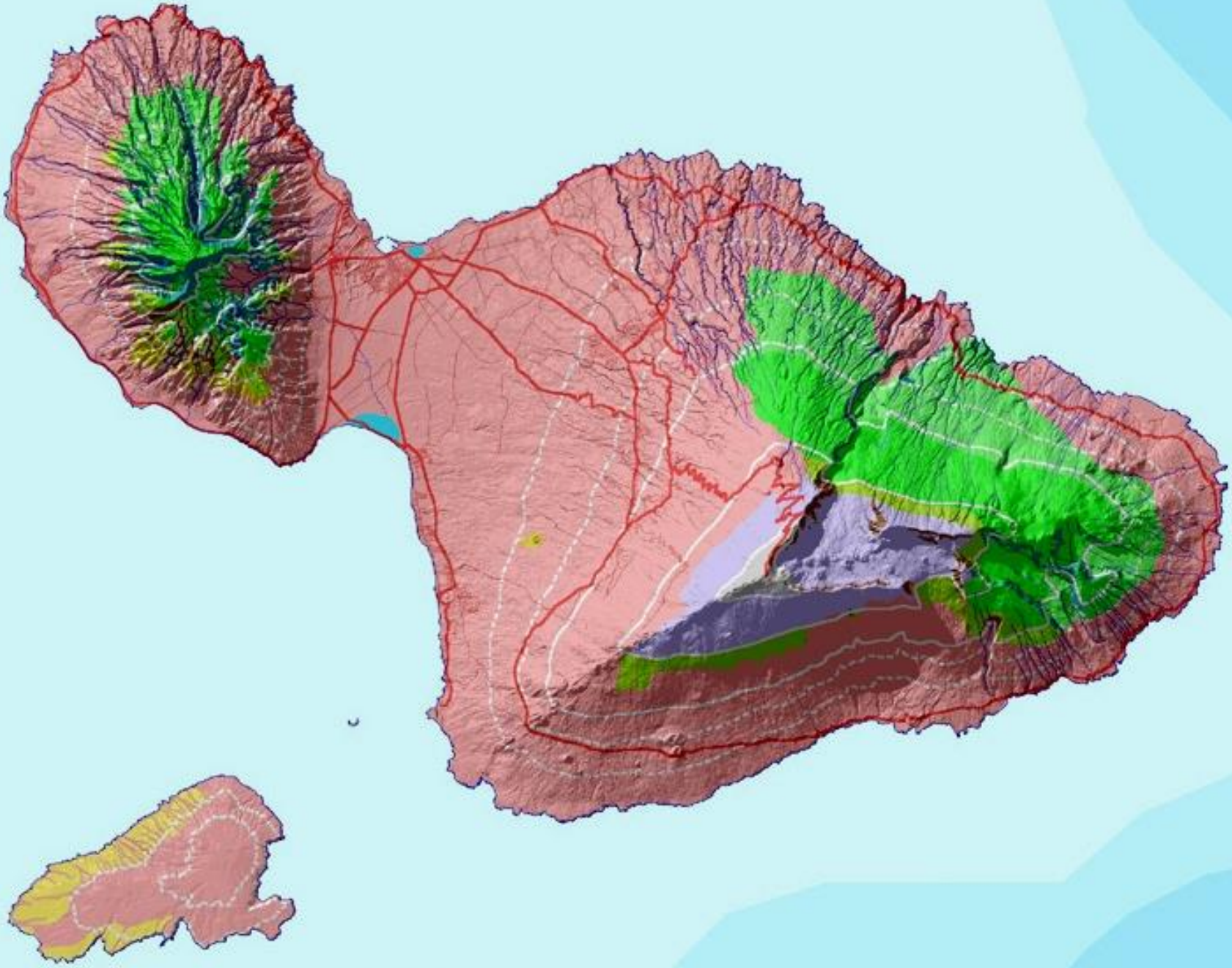




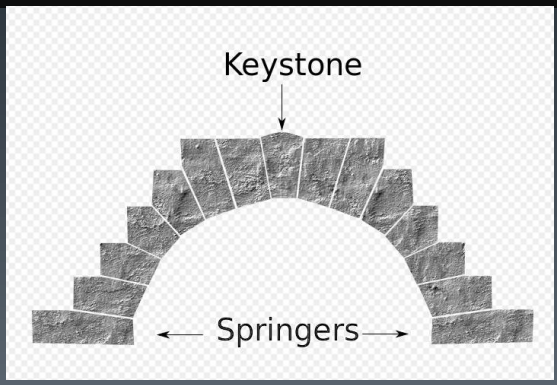




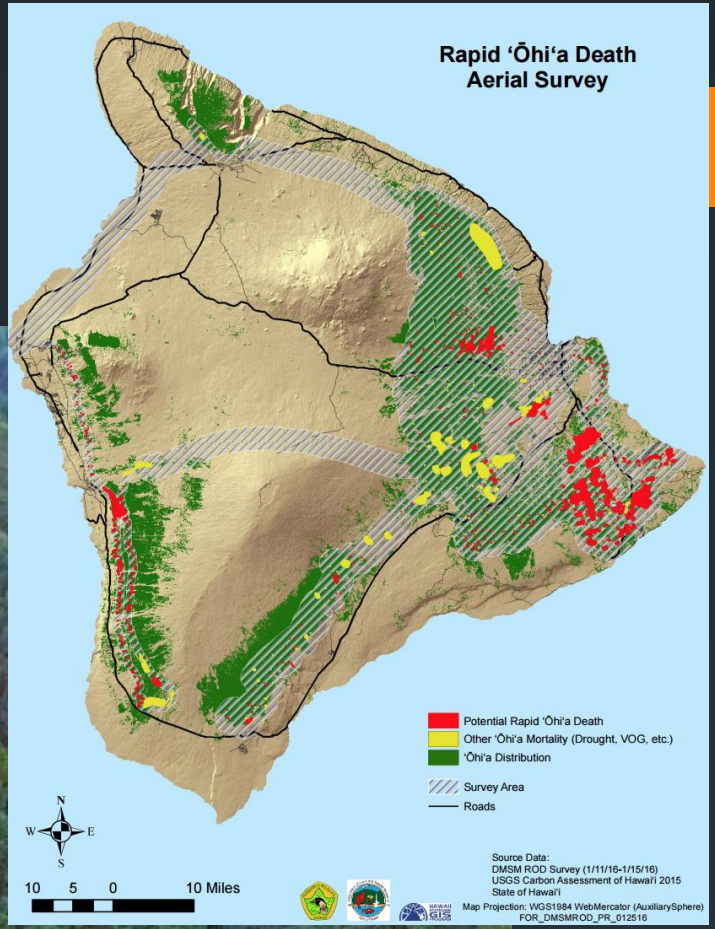


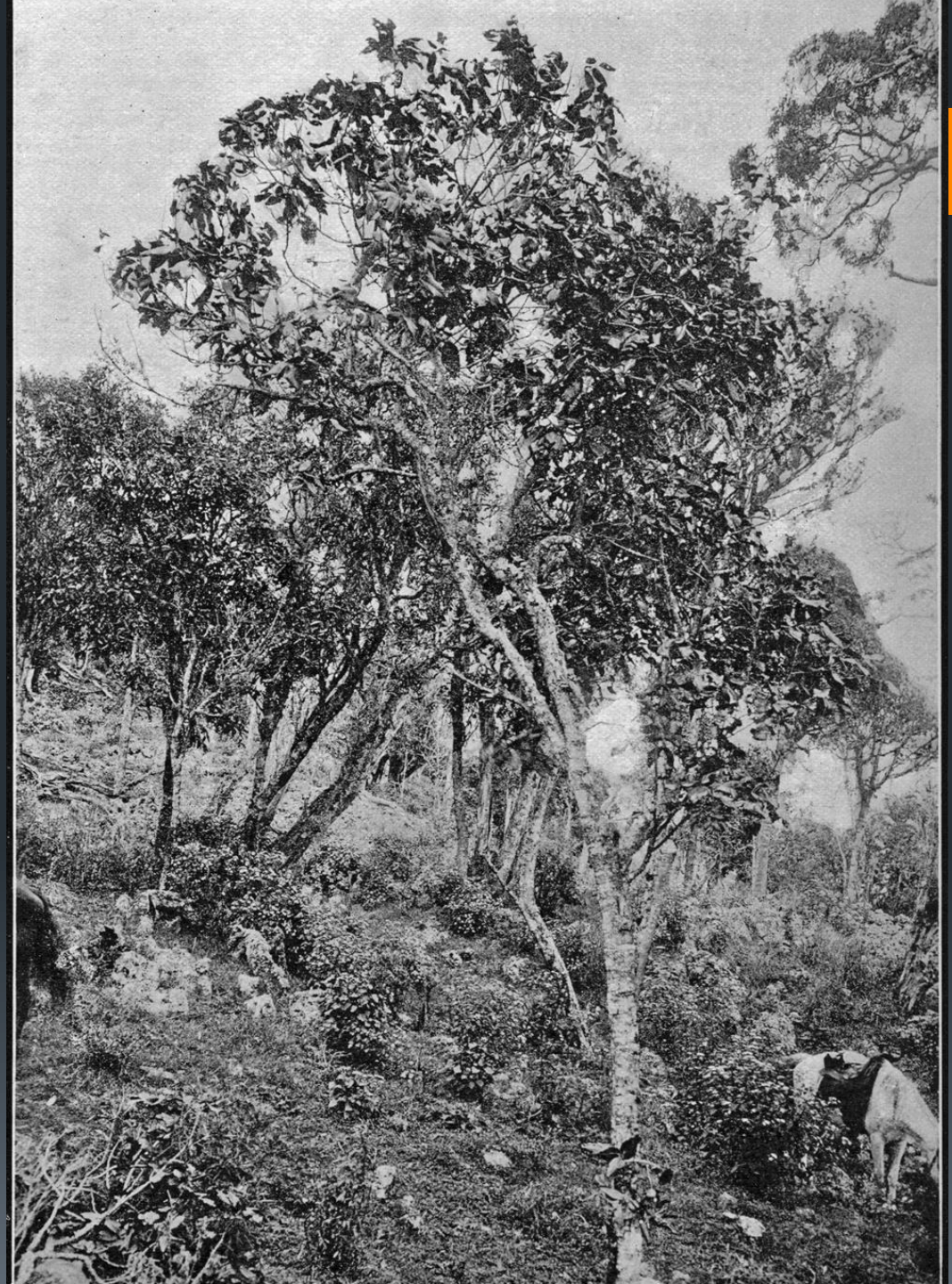


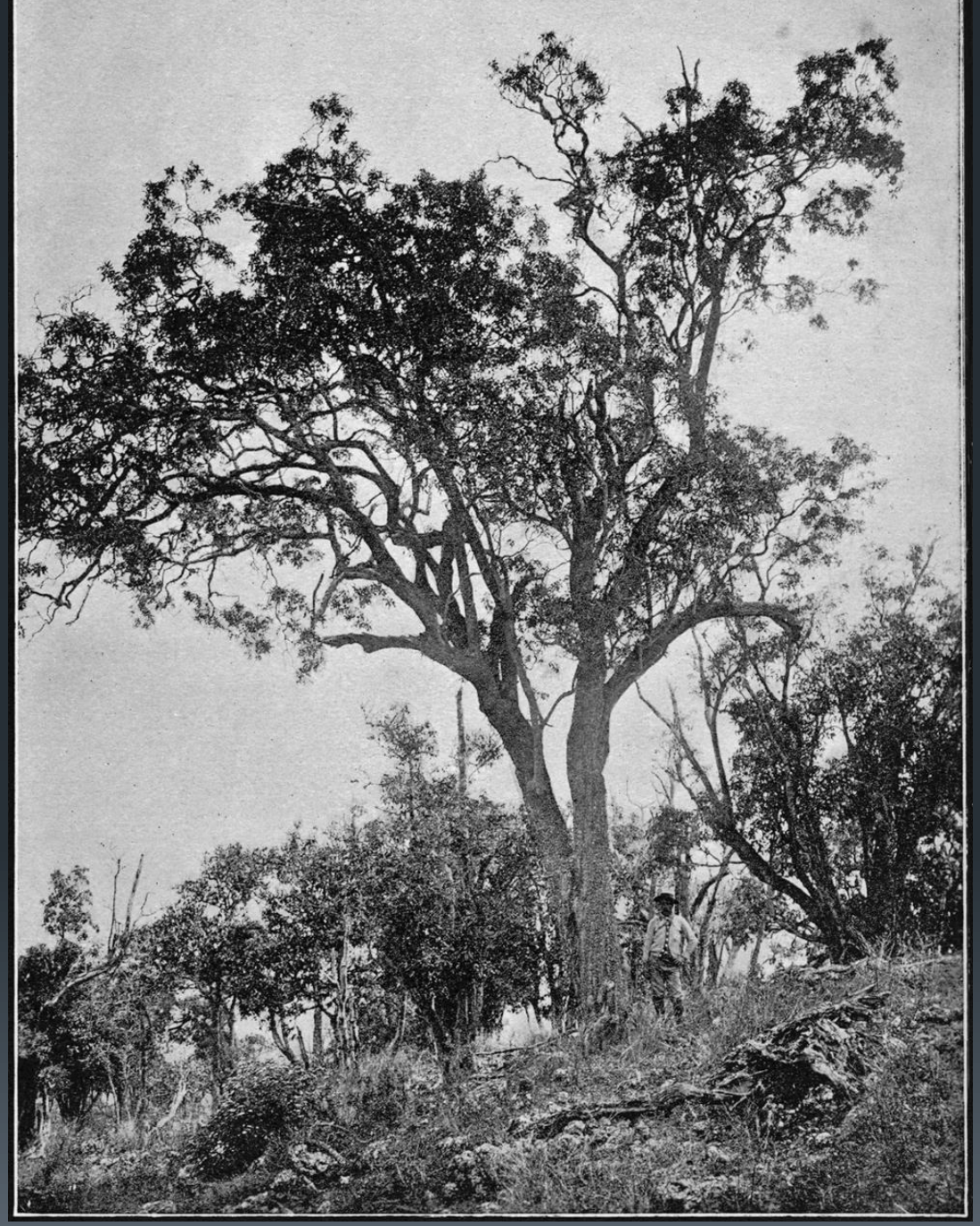
keystone species: a species on which other species in an ecosystem largely depend, such that if it were removed, the ecosystem would change drastically



Rapid ʻŌhiʻa Death (ROD)
Two new species of fungi
Ceratocystis huliohia and *C. lukuohia*







"Hawaiian dry forests were *wahi pana* (literally 'celebrated or legendary place"). If the oceans were the refrigerator of the earlu Hawaiians, the dry forests were their toolboxes."

Dr. Isabella Abbott, Hawaiian ethnobotanist

Auwahi has more species of native tree species than any other forest in Maui County.

Of the 50 species of trees at Auwahi:

19 species (38%) for medicine,

13 species (26%) for tool-making,

13 species (26%) for canoe building

13 species (26%) for house building

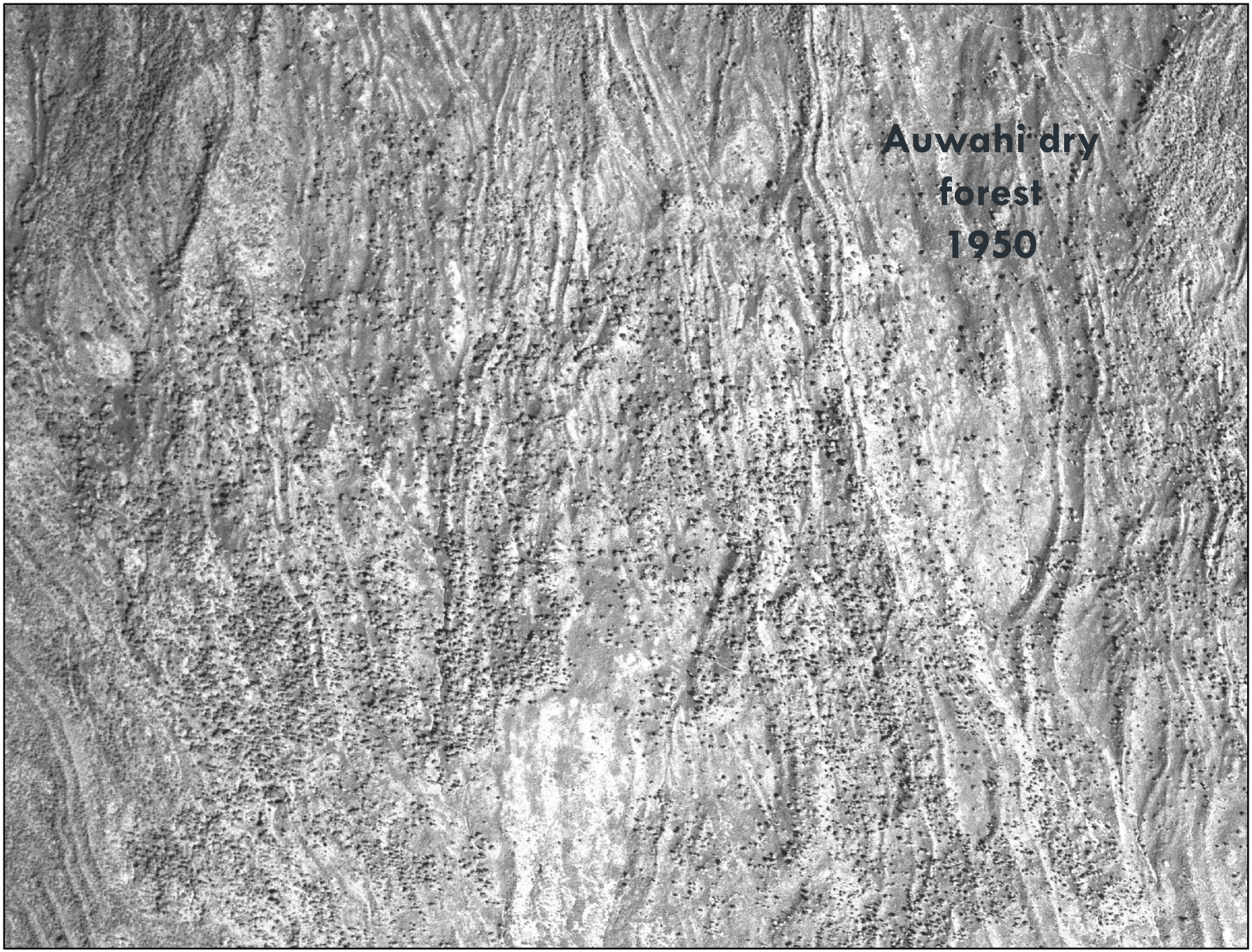
8 species (16%) for tools for making *kapa*

8 species (16%) for weapons

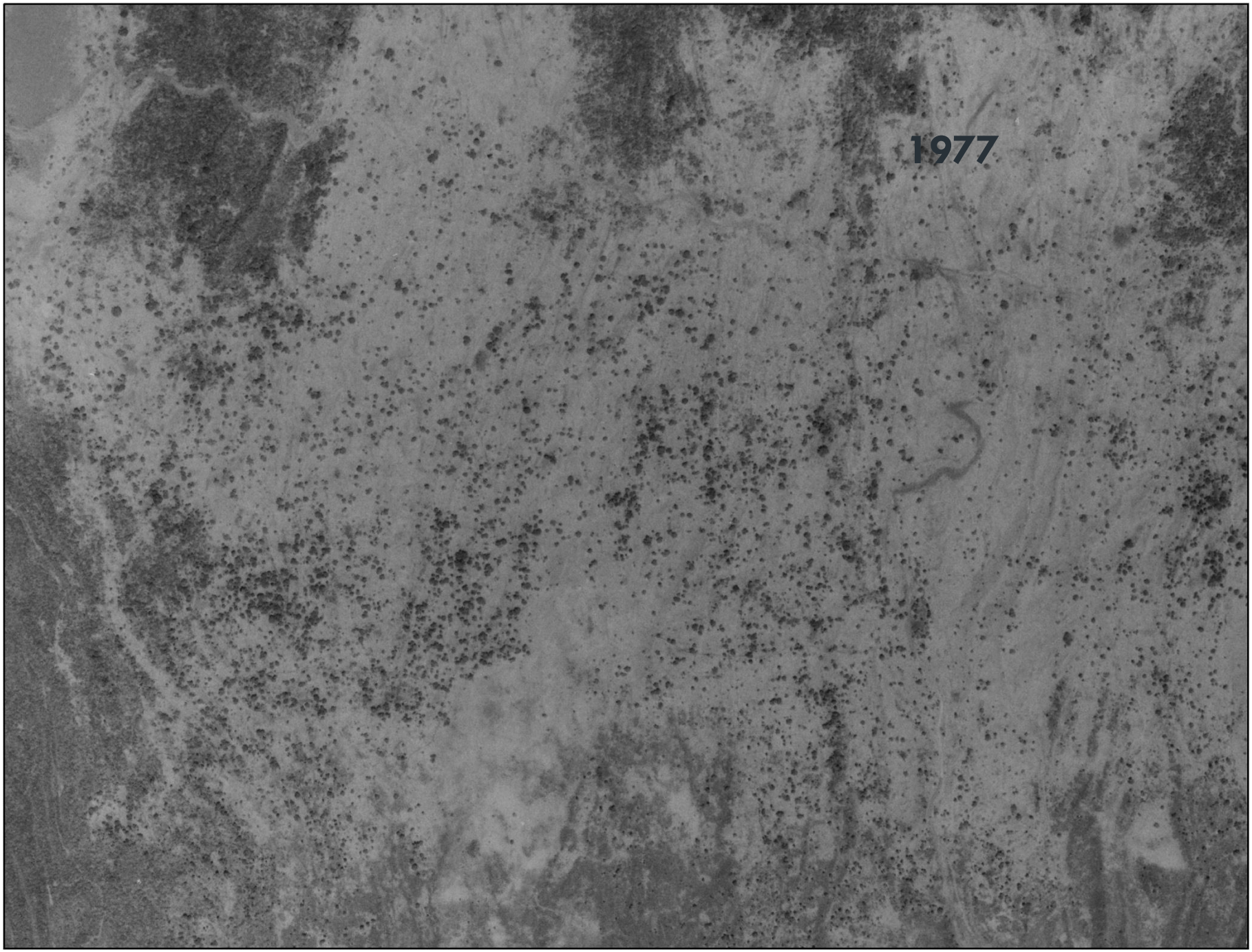
8 species (16%) for fishing,

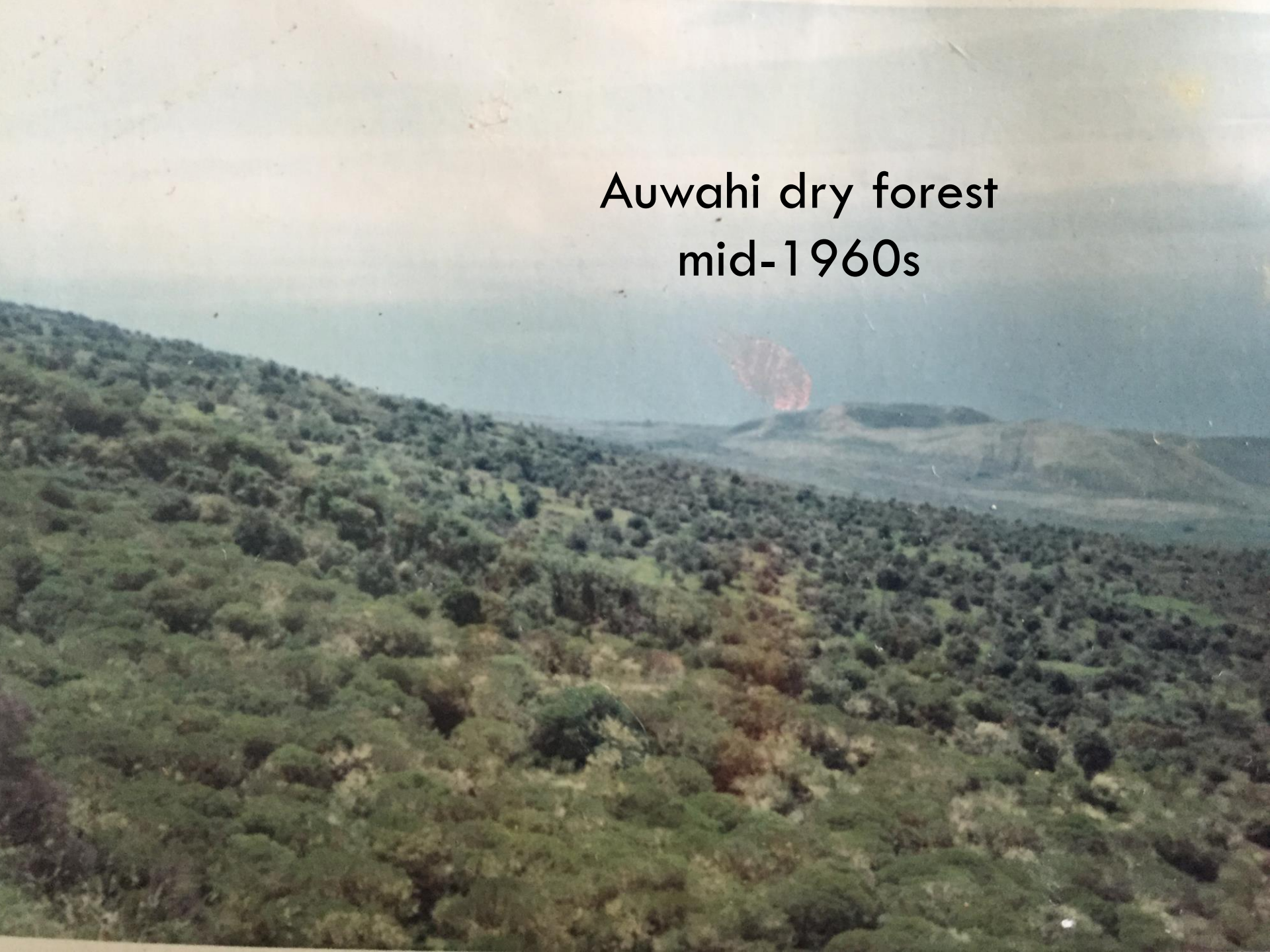
8 species (16%) for dyes, and

7 species (14 %) for religious purposes


Auwahi dry
forest
1950


1965


1977


Auwahi dry forest
mid-1960s


Auwahi dry forest
2005

Ecological restoration:

the practice of renewing and restoring degraded, damaged, or destroyed ecosystems and habitats by active human intervention.

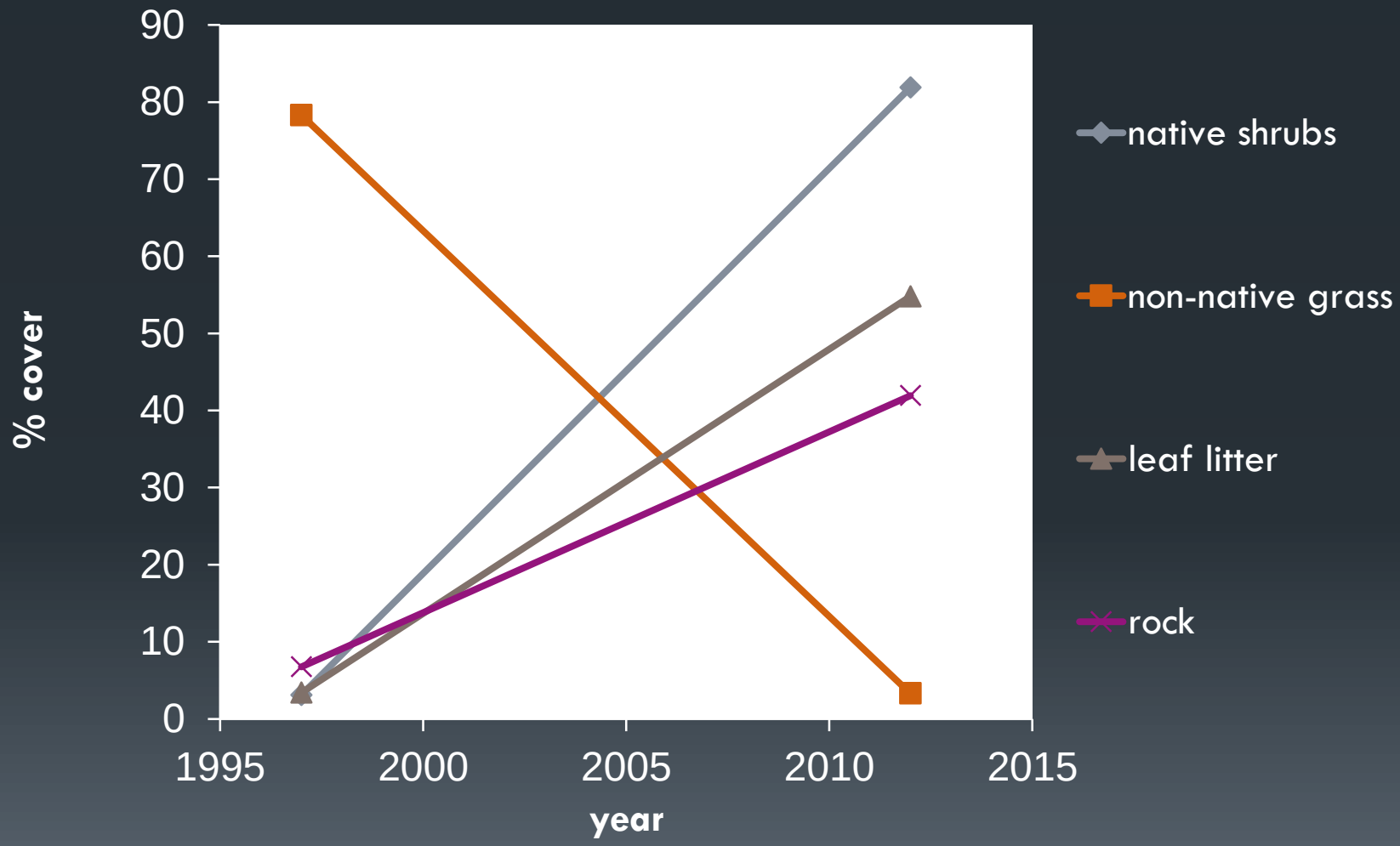
In ecological restoration, there are few tools in the toolbox

a single new technique, such as the nurse shrub technique developed and honed at Auwahi, can be a game changer

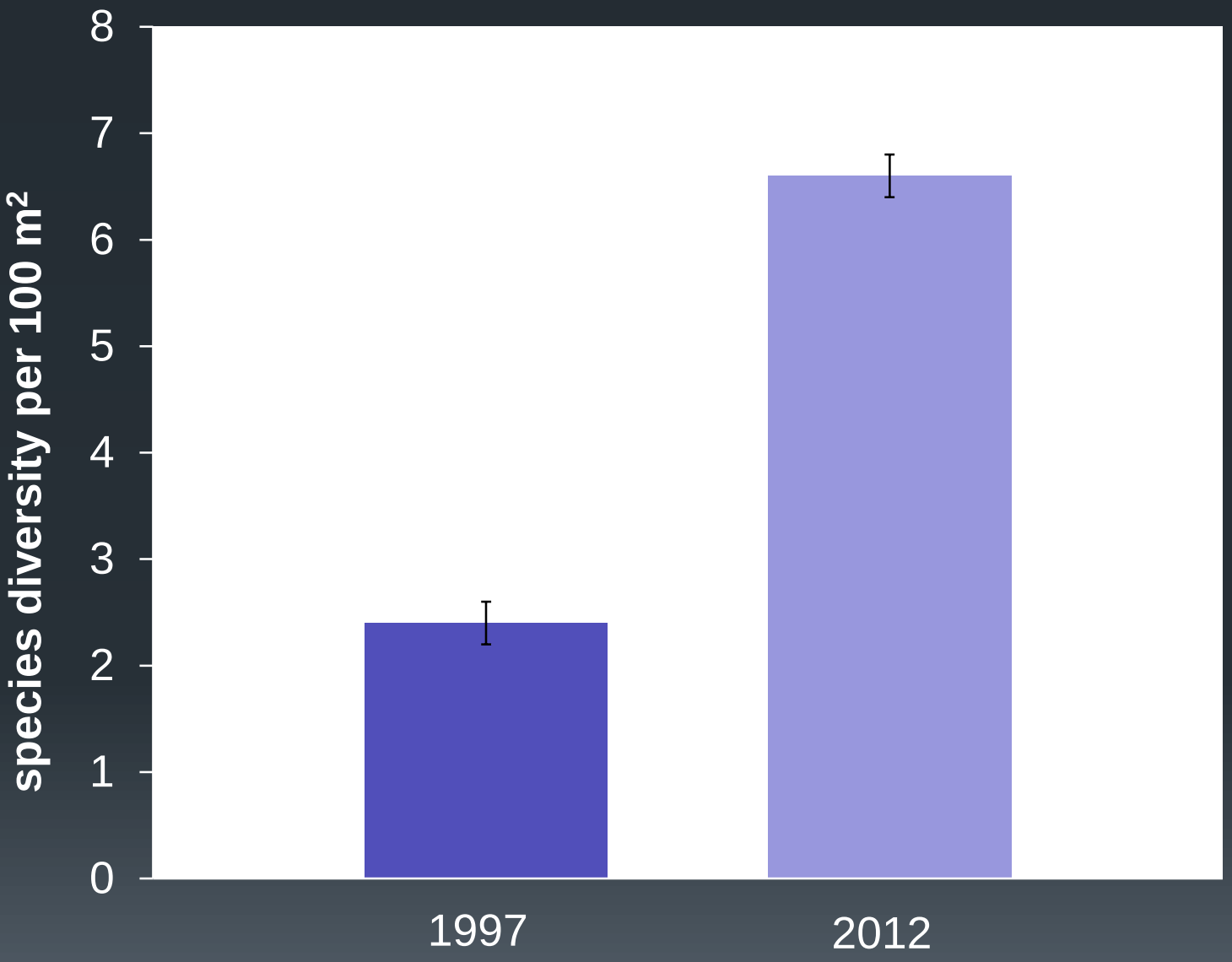
In this case, working smart is much more effective than working hard

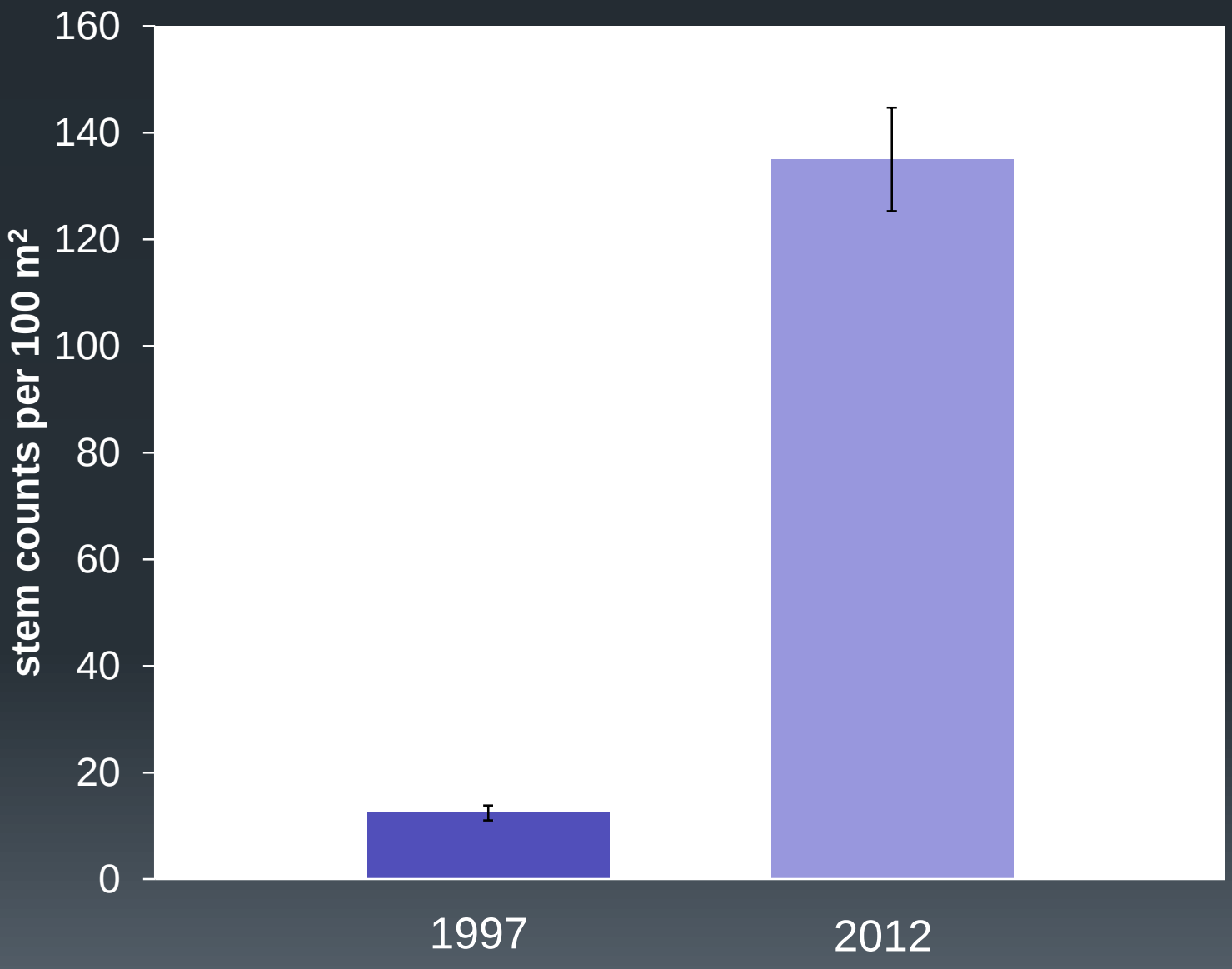
10-acre Auwahi exclosure as viewed from Google Earth

Post-restoration vegetation changes Auwahi forest restoration area (1997-2012):



Medeiros, vonAllmen and Chimera, 2014


species diversity per 100 m²
0
1
2
3
4
5
6
7
8
1997
2012


160
140
120
100
80
60
40
20
0
stem counts per 100 m²
1997
2012

Native species naturally reproducing by seed, Auwahi I exclosure:

TREE AND TALL SHRUB SPECIES:

Charpentiera obovata
Claoxylon sandwicense
Pipturus albidus
Chrysodracon auwahiense
Coprosma foliosa
Diospyros sandwicense
Dodonaea viscosa
Leptecophylla tameiameiae
Myrsine lanaiensis
Myrsine lessertiana
Nestegis sandwicensis
Ochrosia haleakalae
Osteomeles anthyllidifolia
Planchonella sandwicensis
Santalum ellipticum
Santalum haleakalae var. lanaiense
Sophora chrysophylla
Streblus pendulinus
Wikstroemia monticola

HERB AND LOW SHRUB SPECIES:

Alyxia oliviformis var. myrtillifolia
Argemone glauca
Bidens micrantha var. kalealaha
Carex wahuensis
Cocculus trilobus
Euphorbia celastroides var. lorifolia
Mariscus hillebrandii ssp. hillebrandii
Panicum tenuifolium
Peperomia leptostachya
Sicyos pachycarpus
Vigna o-wahuensis


Big question: does forest restoration
equate to aquifer restoration?

pasture
woodland

restored
native
forest

results:

	Average velocity (cm/min)		Increase in % volumetric water	
Depth of sensors	Forest	Grassland	Forest	Grassland
0-50 cm	6.7	4.7	0.096	0.054
50-75 cm	10.6	8.2*	0.44	0.10*
75-100 cm	15.8	0.9**	0.11	0.025**

P-values are calculated from 2-sample t-tests, assuming unequal variance.
* significant at 95% confidence level, ** significant at 99.9% confidence level

results:

- in restored native forest at the 1m depth, water transport was significantly faster (99% confidence level) and more efficient (greater water content) than in the kikuyu grasslands (99% confidence level)

- the Auwahi experiment demonstrated that native forest restoration altered soil-water properties on decadal time scale, increasing deep percolation, a fundamental component of aquifer recharge.

- non-native kikuyu grasslands at Auwahi and likely elsewhere appear to strongly deter downwards water movement and blocking deep percolation.

Perkins, K. S., J. R. Nimmo, A. C. Medeiros , D.J. Szutu, and E.I. von Allmen. 2014. Assessing effects of native reforestation on soil moisture dynamics and potential aquifer recharge, Auwahi, Maui. Ecohydrology DOI:10.1002/eco.1469.

Perkins, K. S., J. R. Nimmo, and A. C. Medeiros. 2012. Effects of native forest restoration on soil hydraulic properties, Auwahi, Maui, Hawaiian Islands. Geophysical Research Letters 39 (5): L05405.

GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L05405, doi:10.1029/2012GL051120, 2012

Effects of native forest restoration on soil hydraulic properties, Auwahi, Maui, Hawaiian Islands

K. S. Perkins,[1] J. R. Nimmo,[1] and A. C. Medeiros[2]

Received 25 January 2012; revised 15 February 2012; accepted 17 February 2012; published 14 March 2012.

[1] Over historic time Hawai'i's dryland forests have been largely replaced by grasslands for grazing livestock. On-going efforts have been undertaken to restore dryland forests to bring back native species and reduce erosion. The reestablishment of native ecosystems on land severely degraded by long-term alternative use requires reversal of the impacts of erosion, organic-matter loss, and soil structural damage on soil hydraulic properties. This issue is perhaps especially critical in dryland forests where the soil must facilitate native plants' optimal use of limited water. These reforestation efforts depend on restoring soil ecological function, including soil hydraulic properties. We hypothesized that reforestation can measurably change soil hydraulic properties over restoration timescales. At a site on the island of Maui (Hawai'i, USA), we measured infiltration capacity, hydrophobicity, and abundance of preferential flow channels in a deforested grassland and in an adjacent area where active reforestation has been going on for fourteen years. Compared to the nearby deforested rangeland, mean field-saturated hydraulic conductivity in the newly restored forest measured by 55 infiltrometer tests was greater by a factor of 2.0. Hydrophobicity on an 8-point scale increased from average category 6.0 to 6.9. A 4-point empirical categorization of preferentiality in subsurface wetting patterns increased from an average 1.3 in grasslands to 2.6 in the restored forest. All of these changes act to distribute infiltrated water faster and deeper, as appropriate for native plant needs. This study indicates that vegetation restoration can lead to ecohydrologically important changes in soil hydraulic properties over decadal time scales. Citation: Perkins, K. S., J. R. Nimmo, and A. C. Medeiros (2012), Effects of native forest restoration on soil hydraulic properties, Auwahi, Maui, Hawaiian Islands, *Geophys. Res. Lett.*, *39*, L05405, doi:10.1029/2012GL051120.

1. Introduction

[2] Dryland forests in Hawai'i have been heavily impacted

hypothesize that reestablis
reverse these soil hydraulic
short time scales (e.g., deca
of how this process occurs i
term impacts of restoratio
changing environment.

[3] In 1997, land owners
and volunteers began an eff
of Auwahi, on the leewa
(Figure 1). They aimed to
ecosystem [*Bruegmann*, 19
once an important reso
[*Medeiros*, 2003; *Medeiros*
was chosen at about 122
exclude grazing animals, gr
Mats of the invasive kikuy
rum) were eliminated with

ECOHYDROLOGY
Ecohydrol. (2014)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/eco.1469

Assessing effects of native forest restoration on soil moisture dynamics and potential aquifer recharge, Auwahi, Maui

Kim S. Perkins,[1]* John R. Nimmo,[1] Arthur C. Medeiros,[2] Daphne J. Szutu[1] and Erica von Allmen[2]

[1] *U.S. Geological Survey, 345 Middlefield Rd., MS-421, Menlo Park, California, 95119, USA*

[2] *U.S. Geological Survey, Pacific Island Ecosystems Research Center, Haleakalā National Park Field Station, P.O. Box 369, Makawao, Hawai'i, 96768, USA*

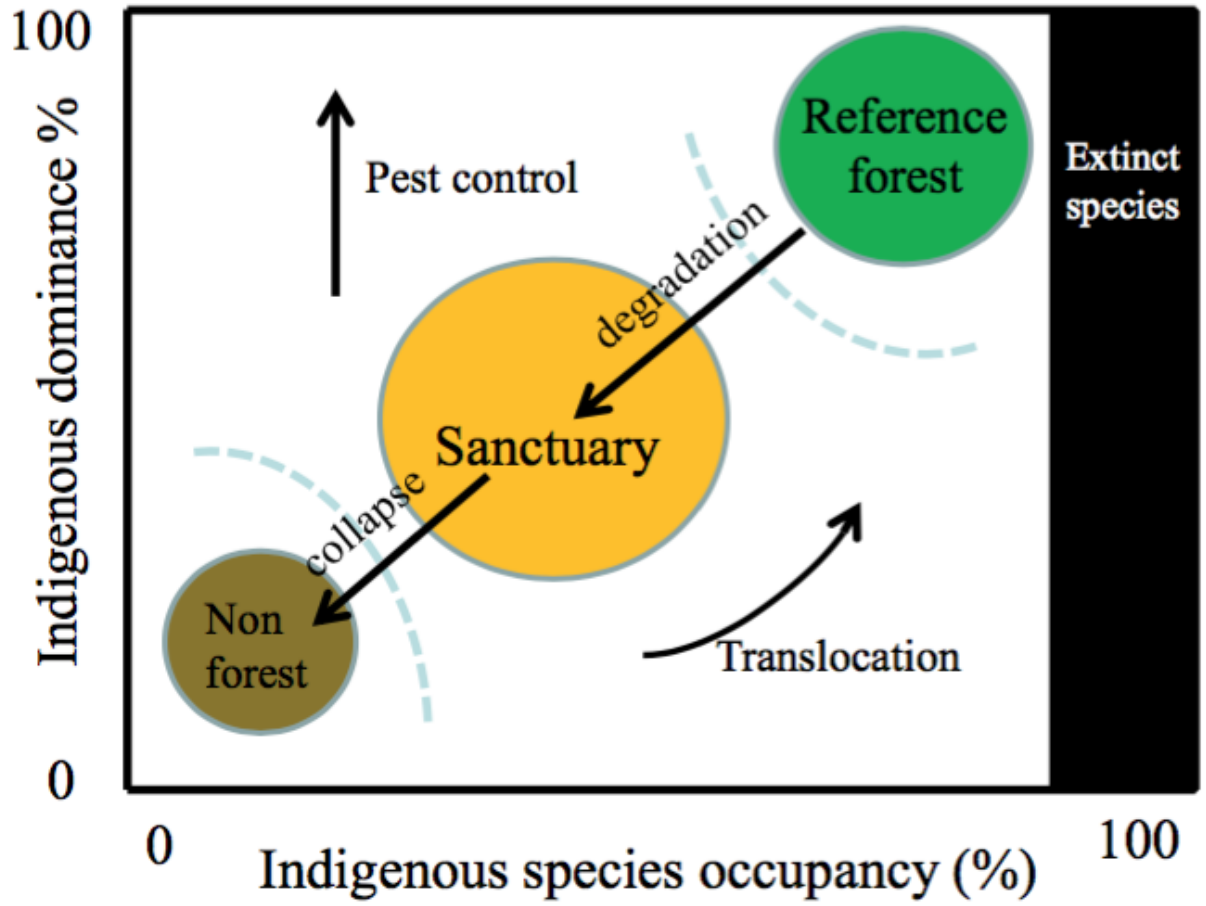
ABSTRACT

Understanding the role of soils in regulating water flow through the unsaturated zone is critical in assessing the influence of vegetation on soil moisture dynamics and aquifer recharge. Because of fire, introduced ungulates and landscape-level invasion of non-native grasses, less than 10% of original dry forest (~730 mm precipitation annually) still exists on leeward Haleakalā, Maui, Hawaiian Islands. Native dry forest restoration at Auwahi has demonstrated the potential for dramatic revegetation, allowing a unique experimental comparison of hydrologic function between tracts of restored forest and adjacent grasslands. We hypothesized that even relatively recent forest restoration can assist in the recovery of impaired hydrologic function, potentially increasing aquifer recharge. To compare restored forest and grassland sites, we experimentally irrigated and measured soil moisture and temperature with subsurface instrumentation at four locations within the reforested area and four within the grassland, each with a 2·5 × 2·5-m plot. Compared with grassland areas, water in reforested sites moved to depth faster with larger magnitude changes in water content. The median first arrival velocity of water was greater by a factor of about 13 in the reforested sites compared with the grassland sites. This rapid transport of water to depths of 1 m or greater suggests increased potential aquifer recharge. Improved characterization of how vegetation and soils influence recharge is crucial for understanding the long-term impacts of forest restoration on aquifer recharge and water resources, especially in moisture-limited regions. Published 2014. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS infiltration; preferential flow; reforestation; unsaturated zone; aquifer recharge; soil moisture

Received 27 March 2013; Revised 20 December 2013; Accepted 20 December 2013


kikuyu dominated areas
Data MBARI
Data USGS
Data SOEST/UHM
Google ea
Imagery Date: 1/12/2013 20°47'34.99" N 156°20'30.20" W elev 1825 ft eye alt 48



Conceptual restoration model

After Dodd 2009, Lee et al. 2005

“Native forests and grasslands worldwide have been converted to developed lands or invaded by exotic species due to human activities. These pressures are predicted to increase with population growth and climatic stress in coming decades, escalating concerns for the viability of native species and communities that are affected. Ecological restoration is frequently offered as a partial solution to these changes because less stressed ecosystems may be more tolerant of novel changes in the environment. In this sense, restoration could provide a strategy for enhancing ecological resilience, given escalating problems associated with invasives and a changing climate. “

Improving restoration to control plant invasions under climate change (Guo and Norman 2012)

"By aiming to restore ecosystem resilience, plant communities can endure in the face of drastic disturbance-whether induced by climate change or biotic invasion"

"Resilient ecosystems come back even after severe disturbances, but ecosystems that are not resilient will slowly drift or suddenly shift away from what's desired or expected"

Improving restoration to control plant invasions under climate change (Guo and Norman 2012)

Restoration requires many hands…

When beginning the volunteer tree planting program over 20 years ago, a decision was made that this was an important opportunity for the public to actually participate and witness an important watershed restoration effort


70% Isopropyl
Rubbing Alcohol
25 fl. oz.
20 fl. oz.
15 fl. oz.
10 fl. oz.
5 fl. oz.


PRIMUS


Maui Built

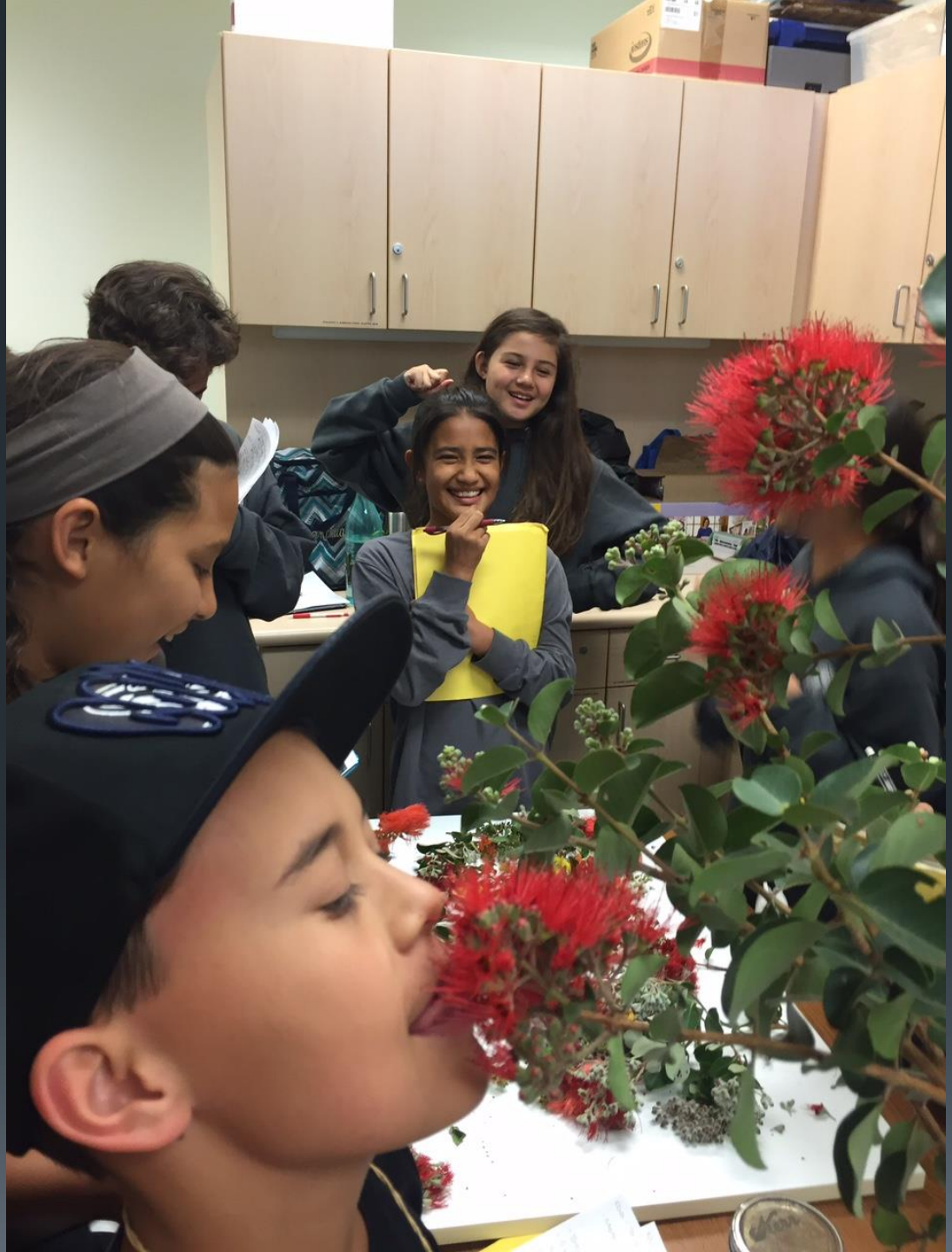

SoCal


FIRM GRIP


SUNPOWER


HAWAI'I PACIFIC COLLECTION
Ka Waihona 'Ike Hawai'i me ka Pākipika


TAPOUT



Auwahi Forest Restoration Project

volunteer trips have run continuously for the past 20 years involving 4,547 community volunteers

113,000 saplings of 42 native forest species planted in Auwahi

volunteer tree planting trips every other Saturday

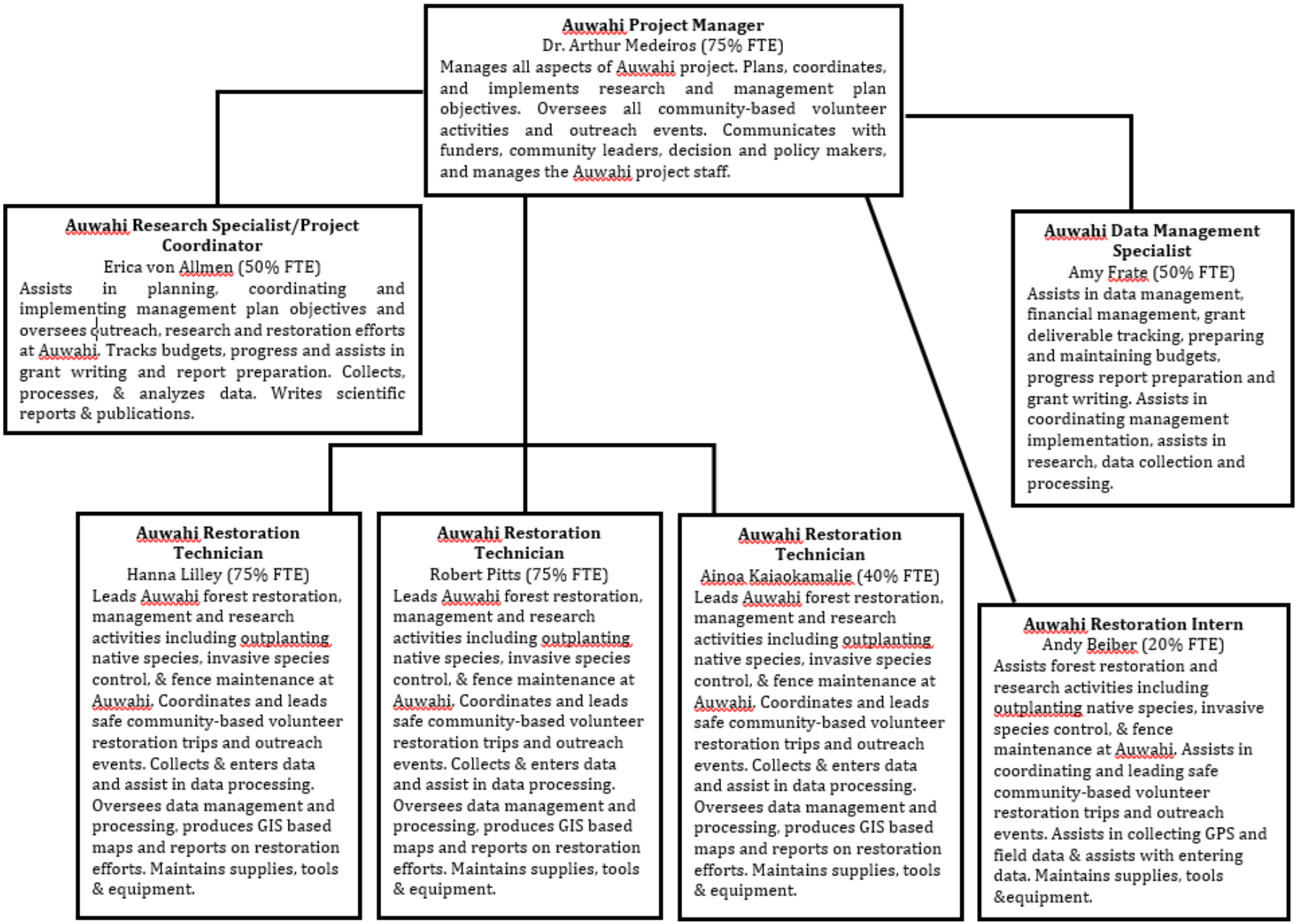
all seeds gathered within 1 mile of exclosure and grown in dibble tubes by two commercial nurseries

to be on our volunteer list, email us at volunteer@auwahi.org

Education is the most powerful weapon which you can use to change the world.

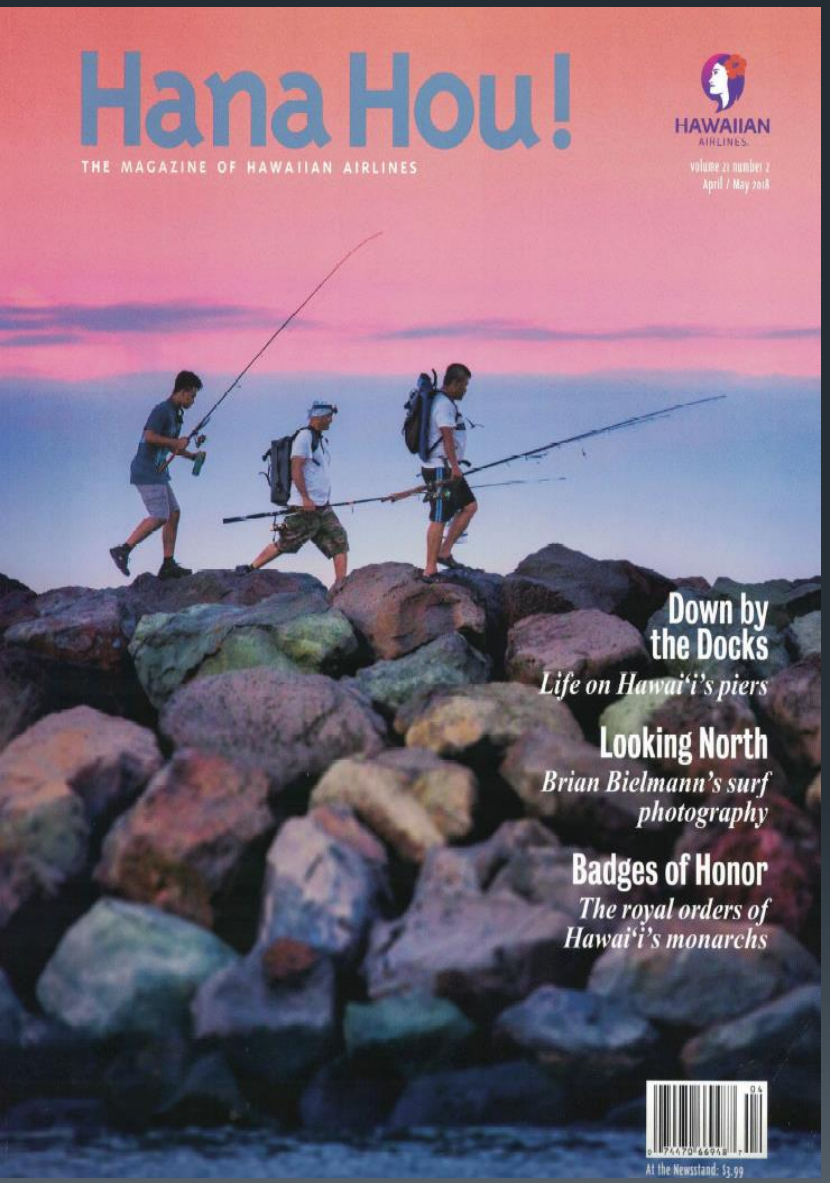
Nelson Mandela

Auwahi Forest Restoration Project Organization Chart




MAUI
BEACH BOY
HAWAII
LEARN·SERVE·RESTOR

Auwahi's regional position assists in early detection of priority invaders across Haleakala



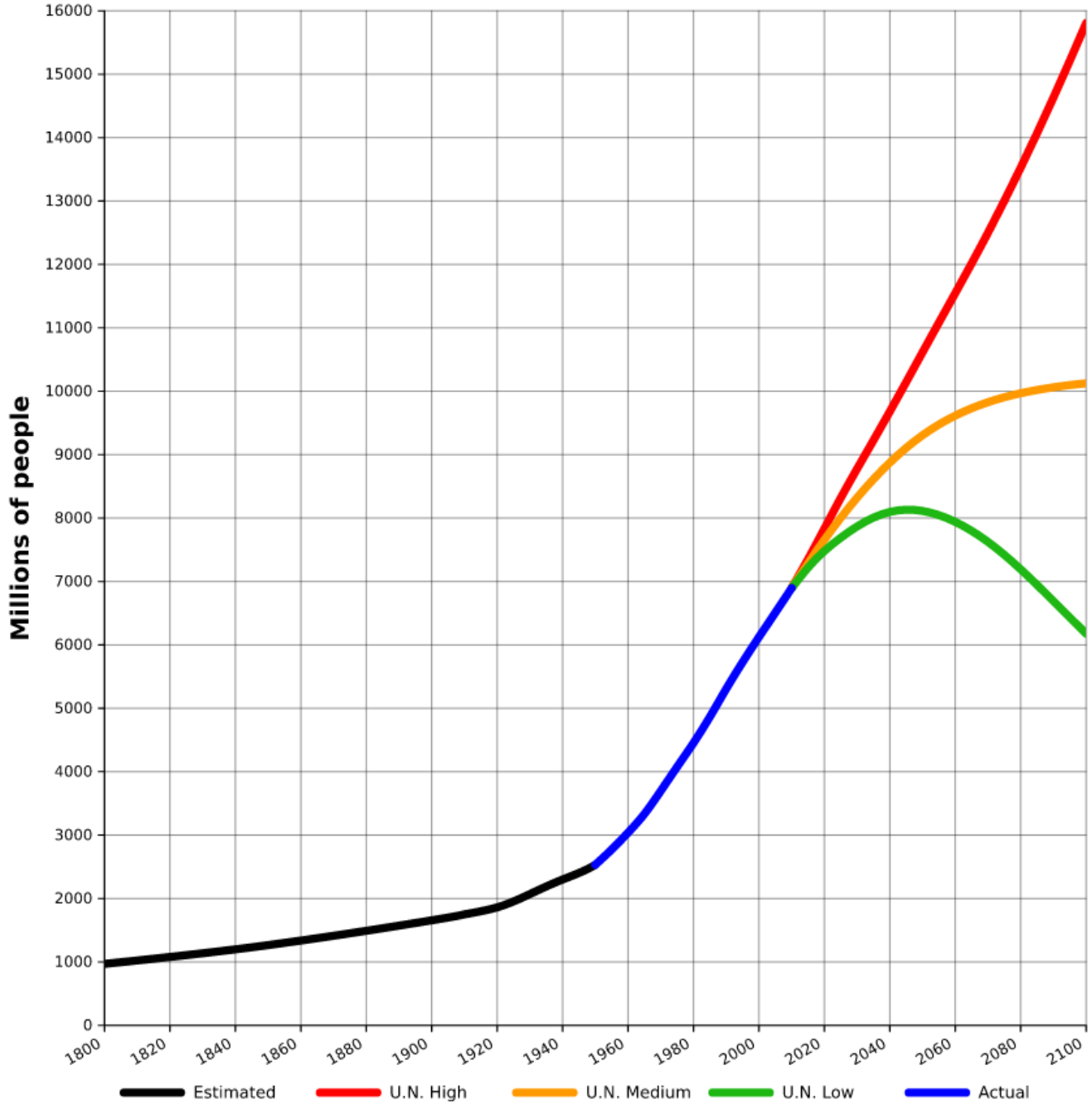
THE FOREST OF DREAMS

To revive a vanishing habitat, Art Medeiros started planting it

STORY BY
SHANNON WIANECKI

PHOTOS BY
BAILEY REBECCA ROBERTS


Columbia



World population growth from 1800 to 2100

Source : United Nation

University of Hawaii students sit together to show the ethnic differences of Hawaii's population in 1948.

Eliot Elisofon/The LIFE Picture Collection/Getty Images

Ho'okuleana

to foster or promote a sense of responsibility

Auwahi project synopsis:

Involving and educating the community in the stewardship for native watersheds and their care

As arguably the leading restoration project Statewide, Auwahi has for two decades been developing regional ecological restoration best practices for Maui County and Hawai'i as a whole.

Auwahi's 'green squares', the forest restoration areas, still offer perhaps the most compelling proof positive in the Hawaiian islands that reforestation with native species is feasible.

Globally, quantitative evidence linking restored forests and aquifer function is rare. I am honored to have contributed to that global data base with our hydrological publications and research at Auwahi

Auwahi is a powerful living botanical garden, for over 40 species of native trees, especially important in light of ROD and climate change impacts

Auwahi Forest Restoration Project
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