Hawaii & Pacific Island Watershed Management

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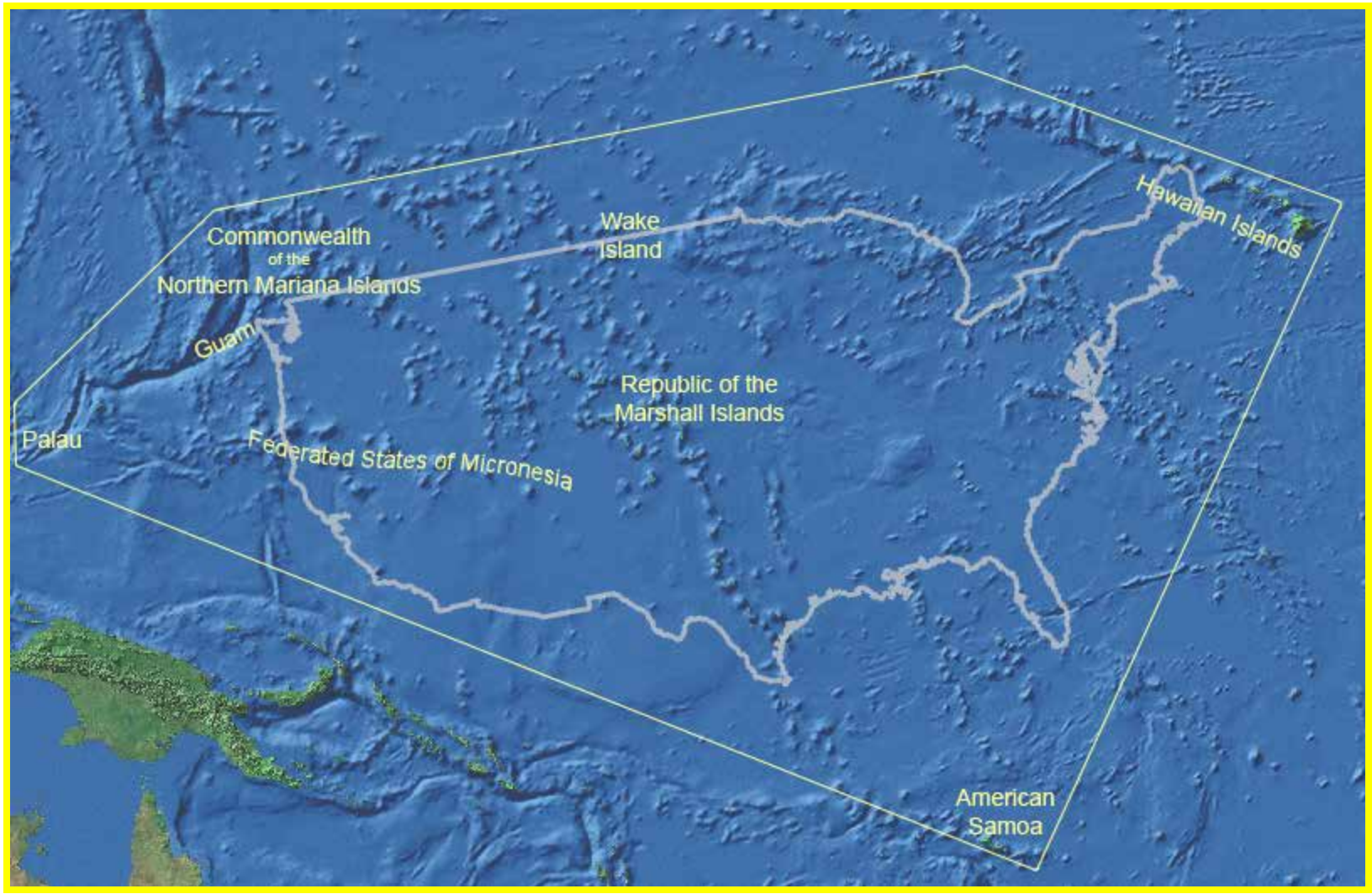
Watershed Management Overview:

- **Pacific Island Hydrology/Geology**
- **Hawaiian Watershed Management**
- **Land Use Change in Hawaii**
- **Management / mismanagement of Hawaii's agroecosystems**

Pacific Islands Area



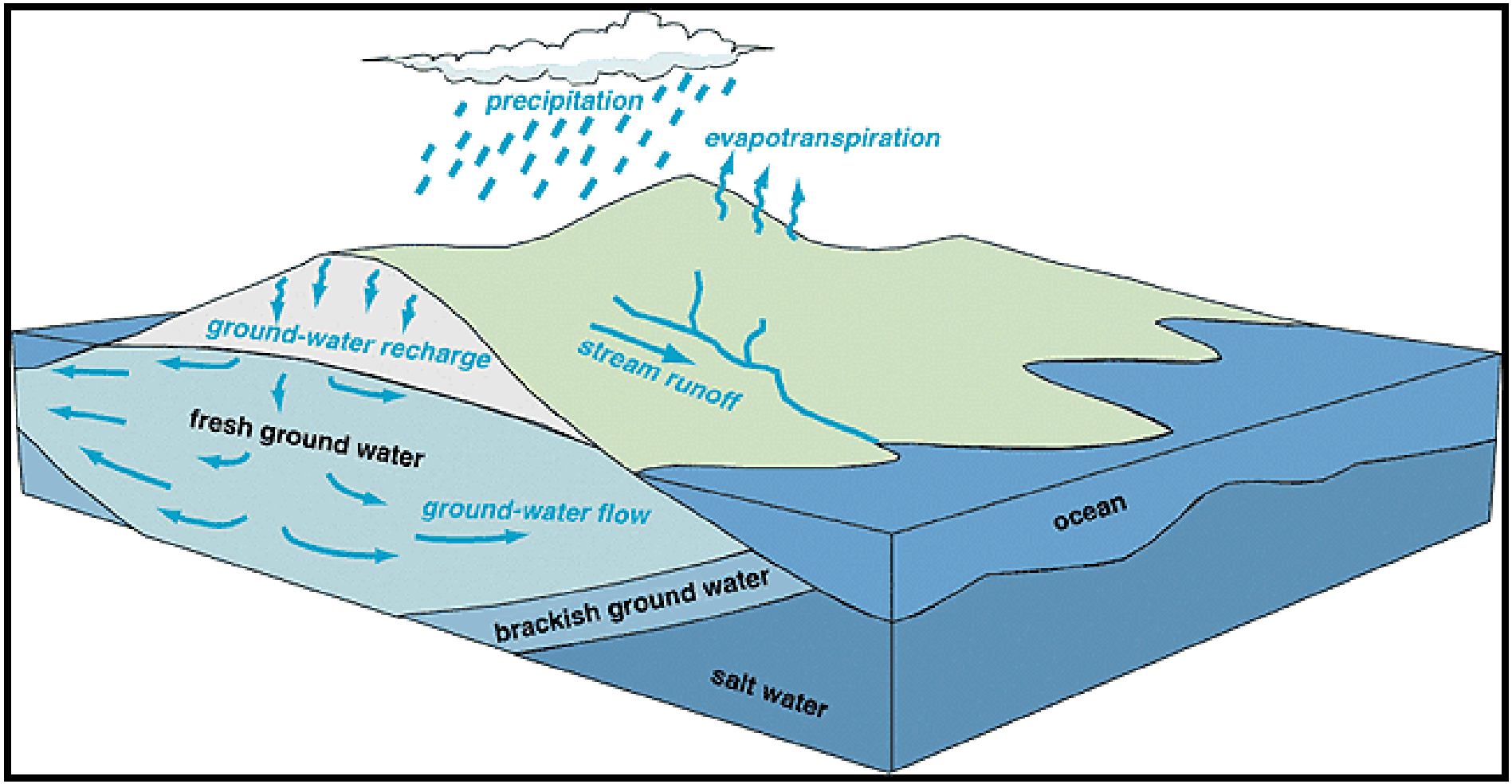
Source: NRCS

Geologic Setting

- High Volcanic Islands
- High Limestone Islands
- Low-lying coral Atolls

Pingelap Atoll, FSM

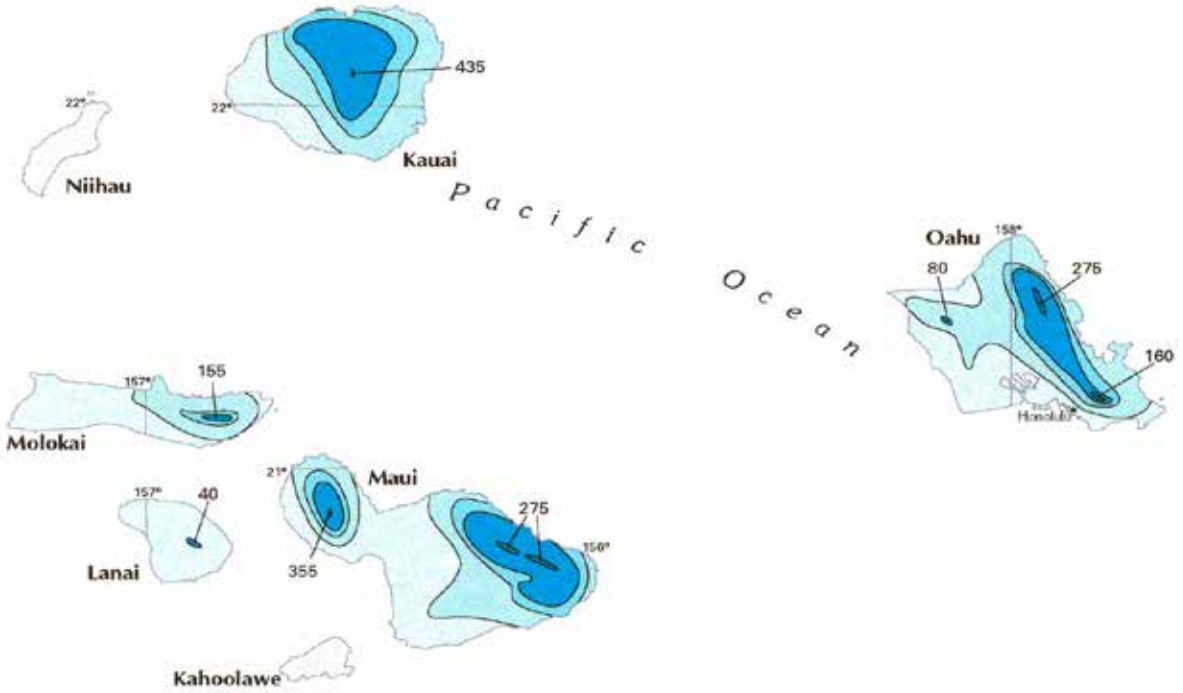
Island Water Resources

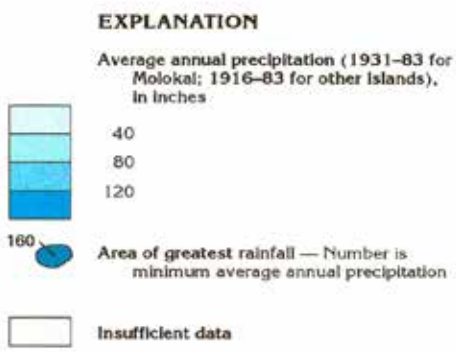


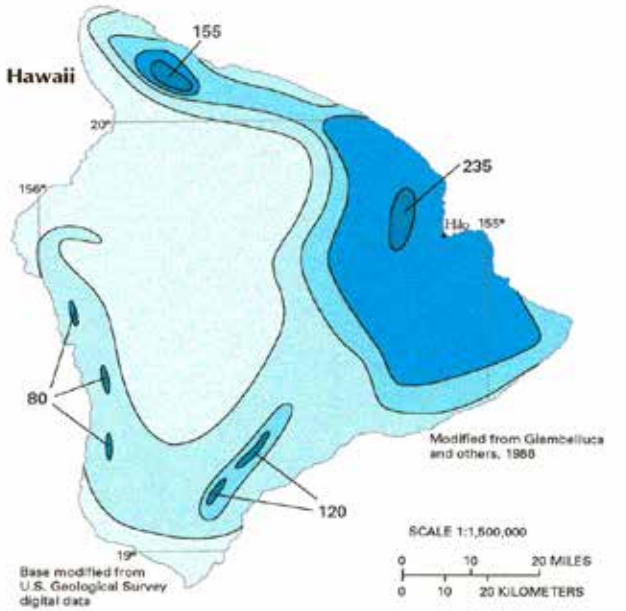
(Source: USGS)

Rainfall Distribution in Hawaii

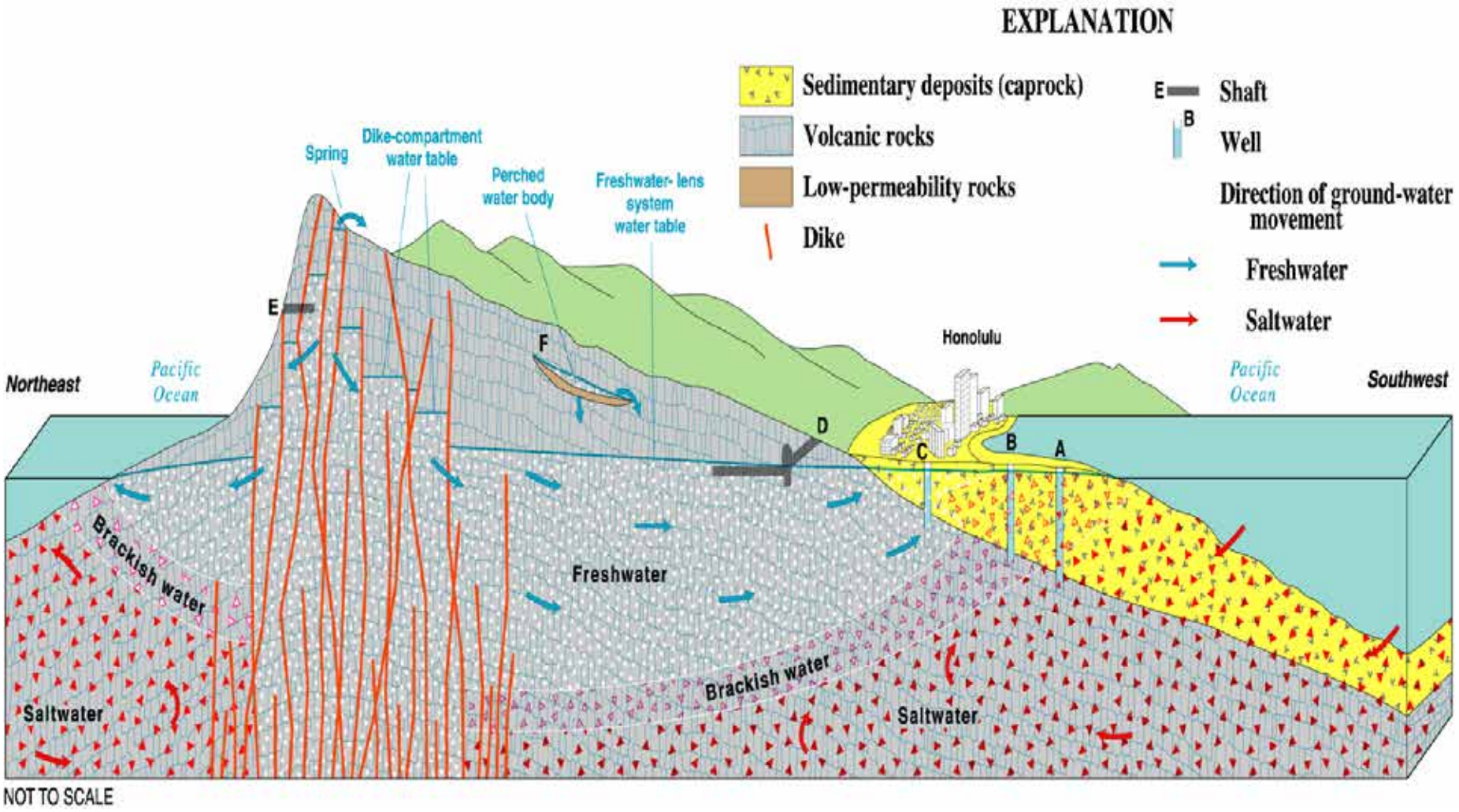
- **Orographic rainfall**
- **Extreme variation over short distances**



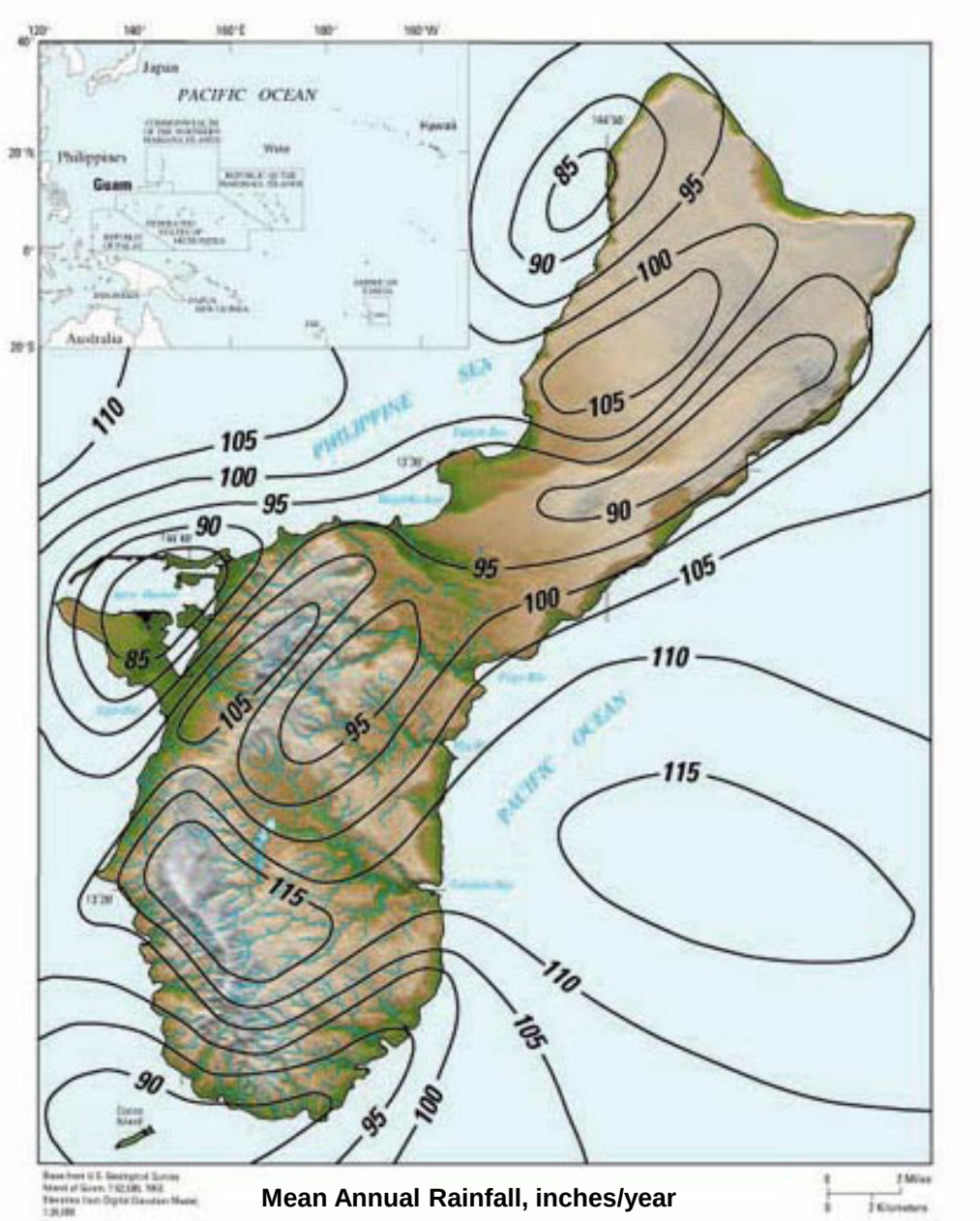




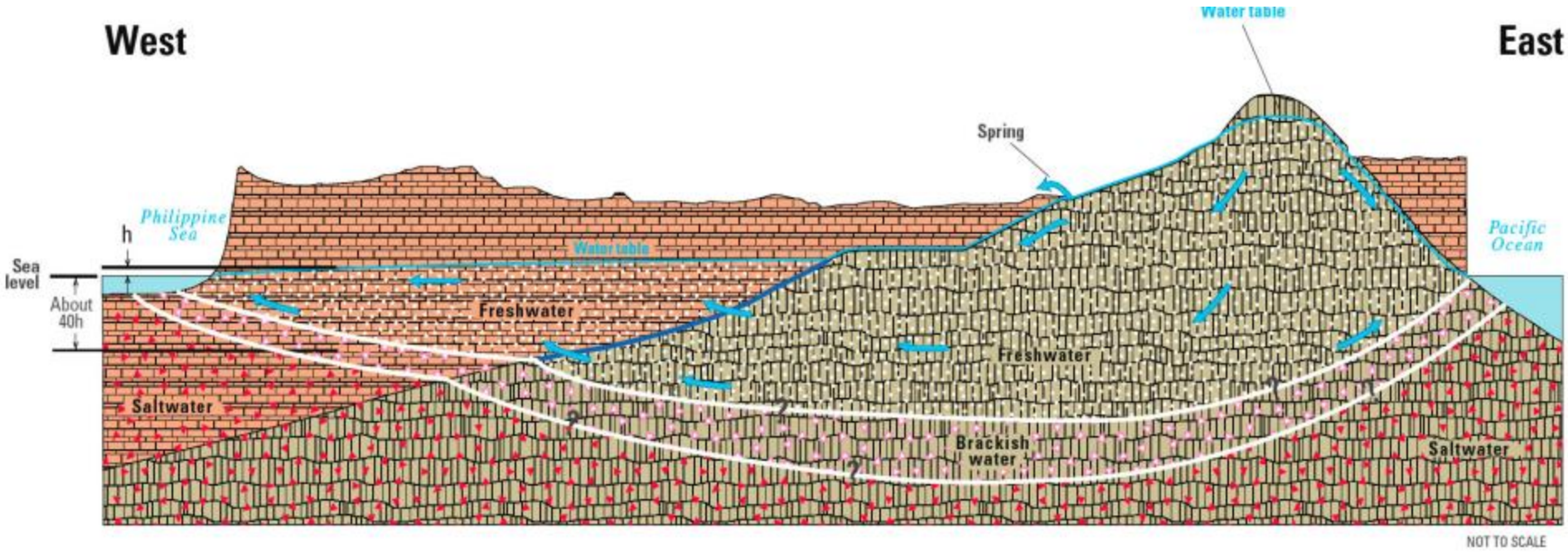
Groundwater in Oahu, Hawaii



Geohydrology of Guam



Mean Annual Rainfall, inches/year



EXPLANATION

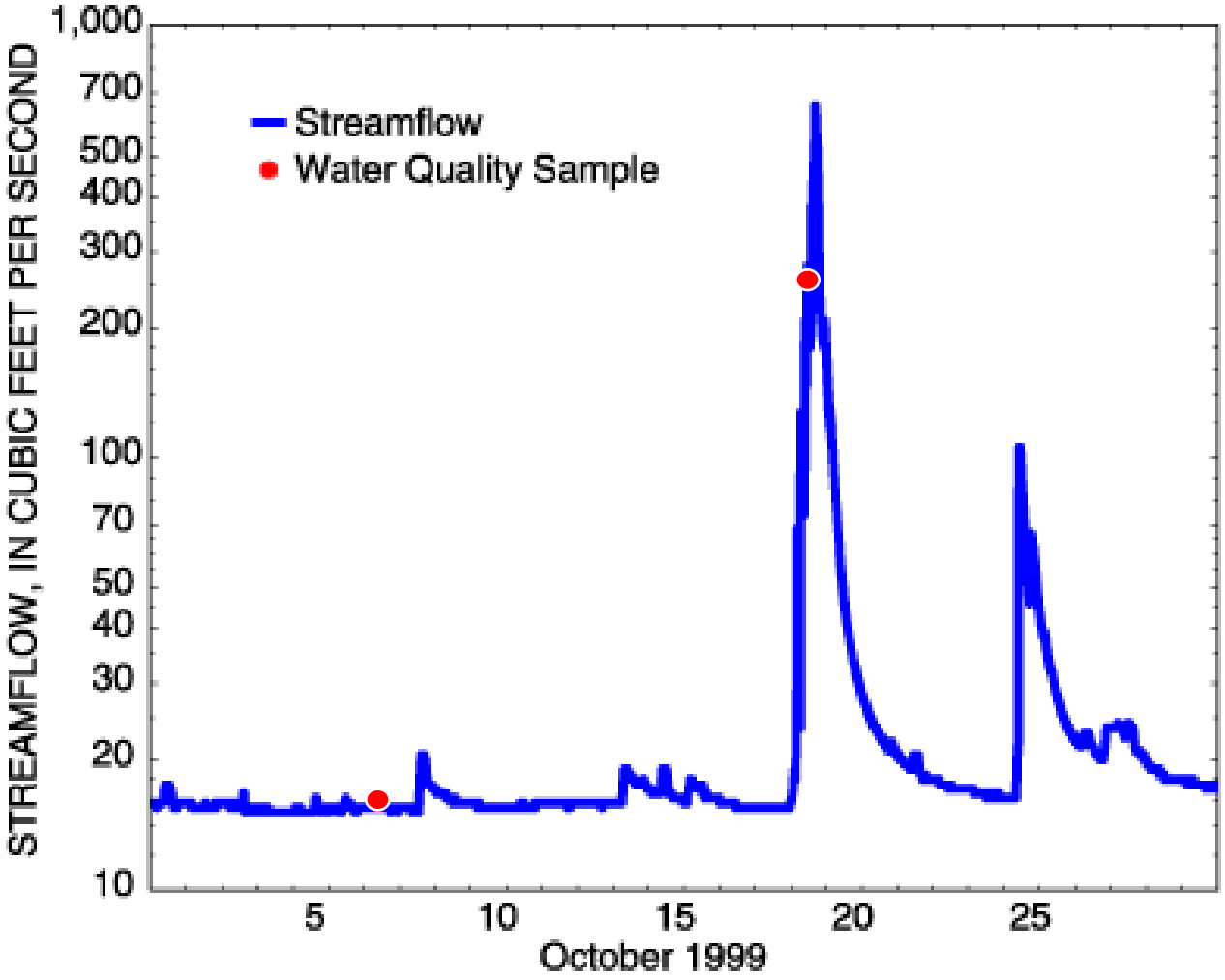
- LIMESTONE
- VOLCANIC ROCKS
- GENERAL DIRECTION OF FRESH GROUND-WATER FLOW
- ZONE WHERE FRESHWATER IN LIMESTONE IS IN DIRECT CONTACT WITH FRESHWATER IN UNDERLYING VOLCANICS (PARA-BASAL)

Limestone Cliffs of Western Tinian, CNMI

Island Streamflow Characteristics

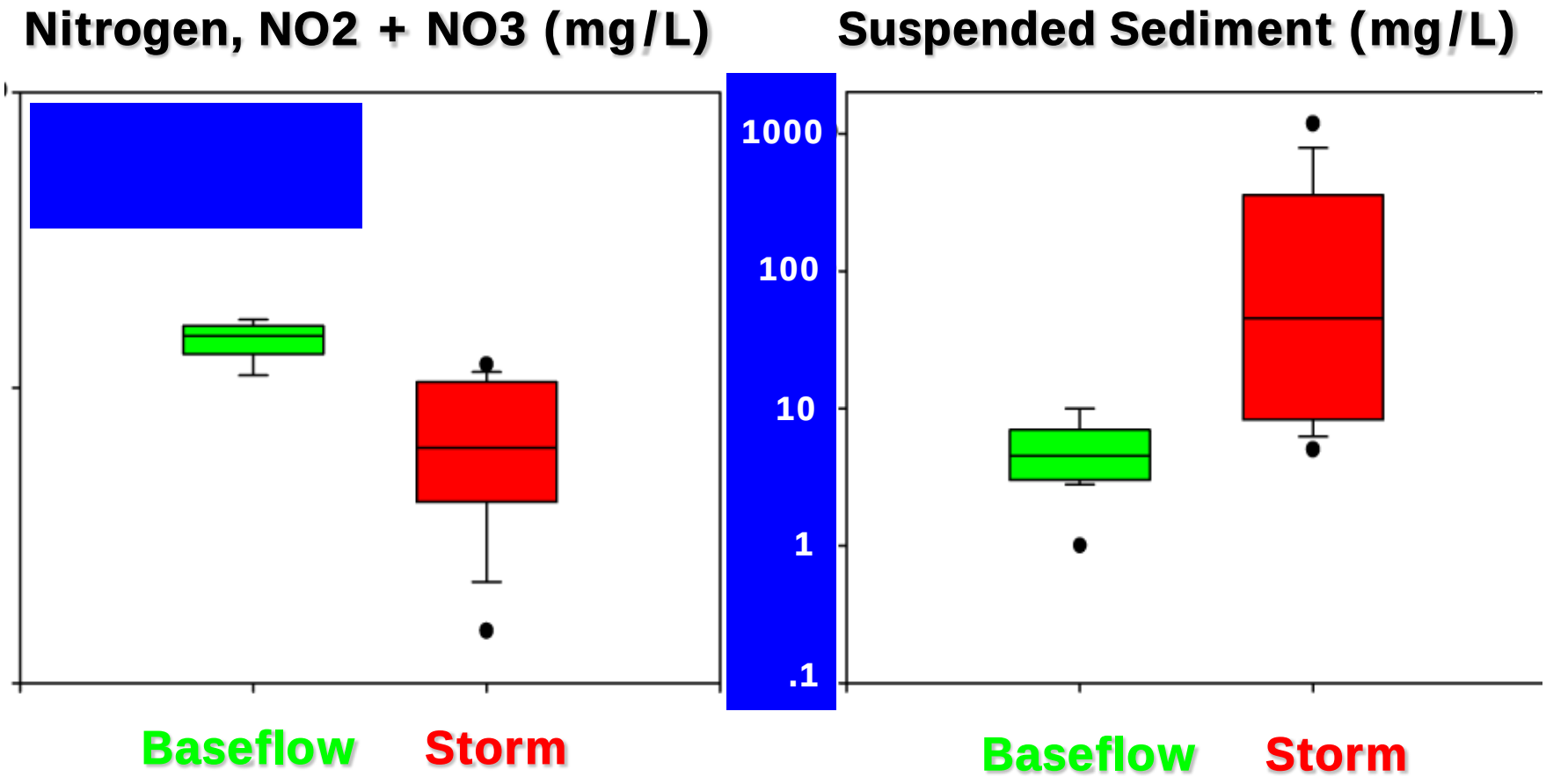
- Streams are short with steep gradients and small drainage areas
- Few streams are perennial over their entire reaches
- Flow is highly variable
  - Low flows from ground-water discharge
  - High flows from rain storms

Rapid runoff with high peak flows

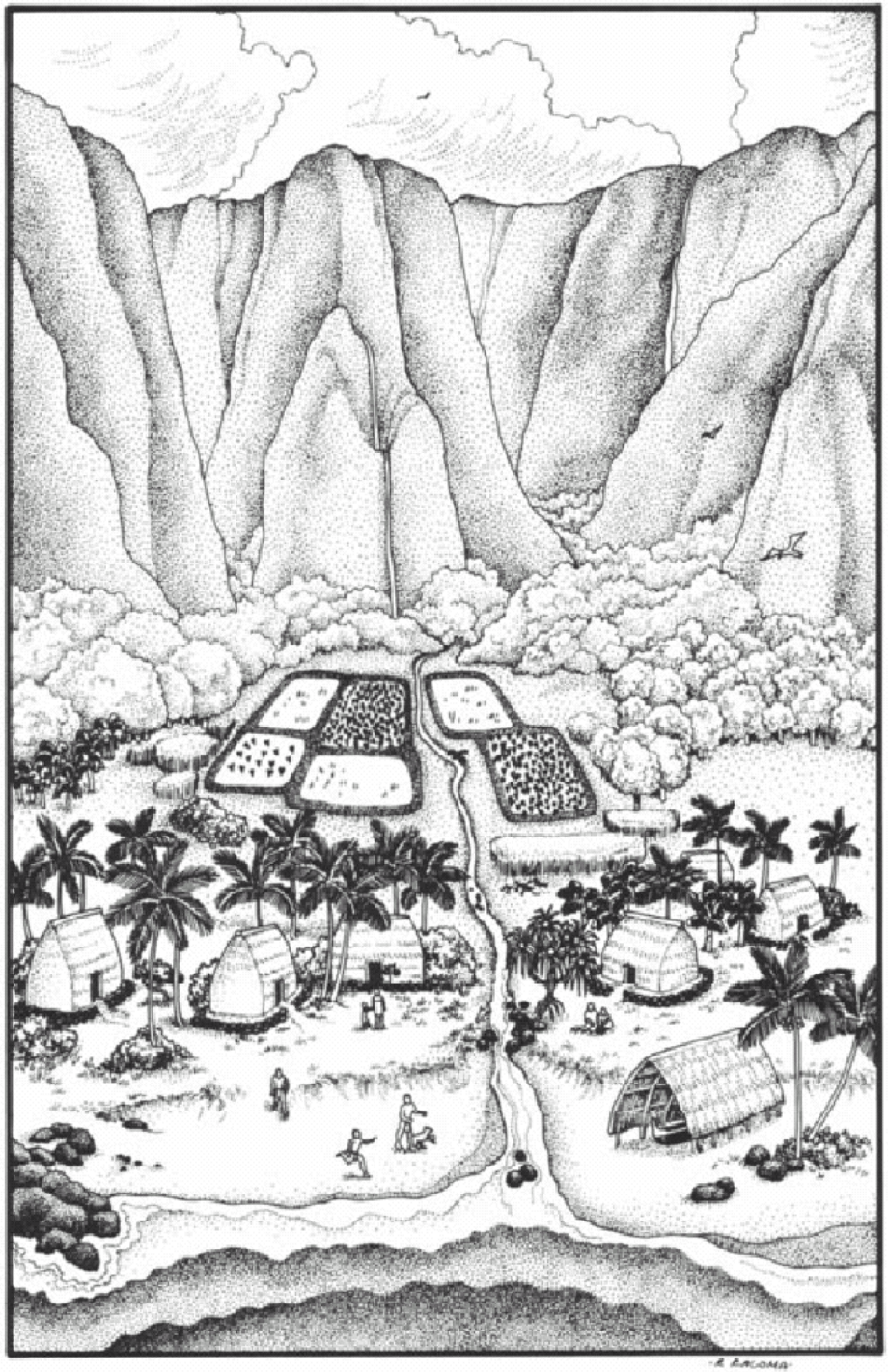


(Source: USGS)

Baseflow vs. Storm Sample Concentrations, Waikele Stream

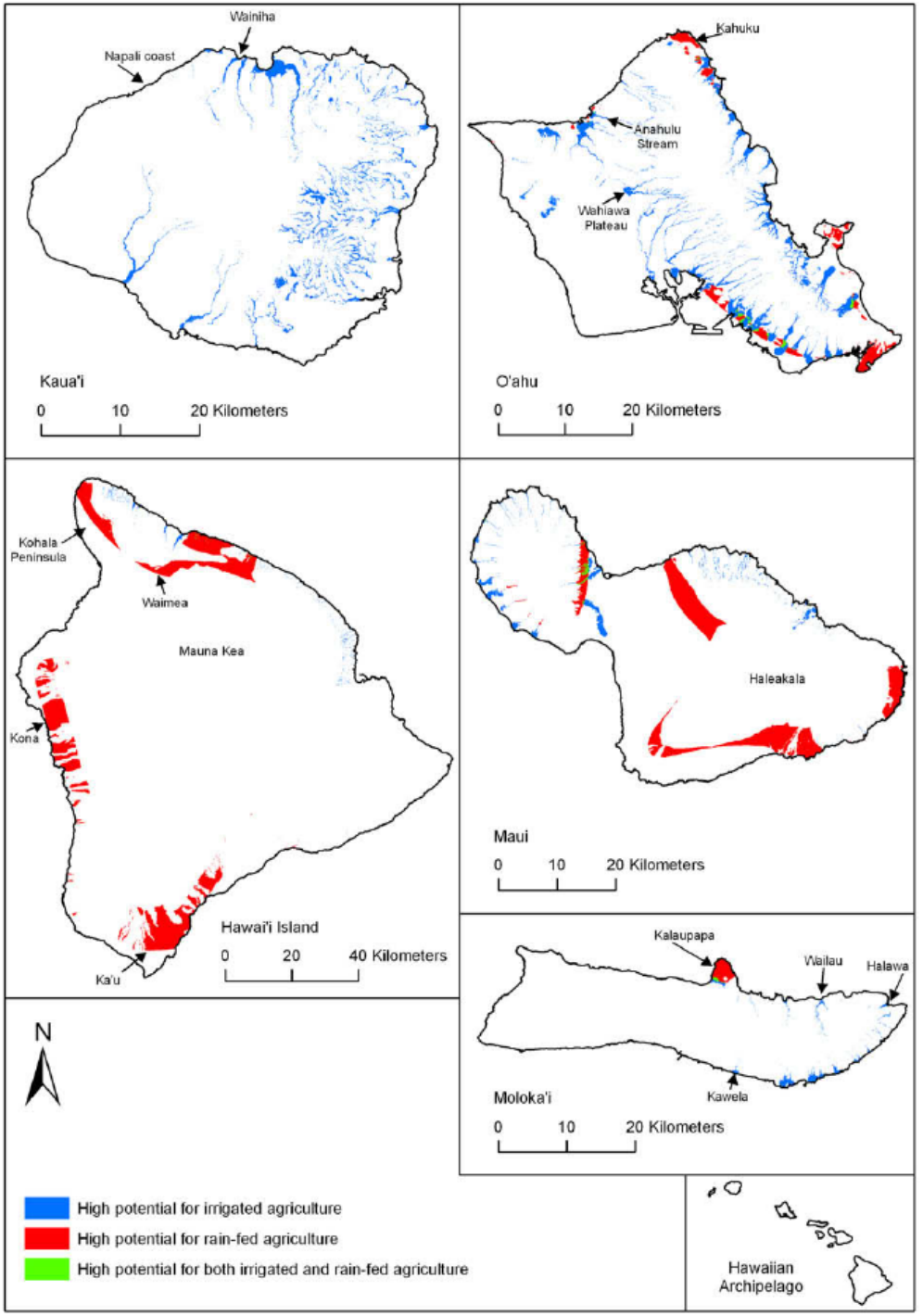


USGS
science for a changing world



GIS Model of potential agricultural sites prior to European contact.
(Ladefoged et al., 2009)

- **<u>Irrigated taro</u> in windward areas and deep valley, mainly on older islands**
- **<u>Rain-fed agriculture</u> mainly on younger (eastern) islands**
- **Hypothesized development of irrigated then rainfed systems across substrate age and soil fertility transects.**



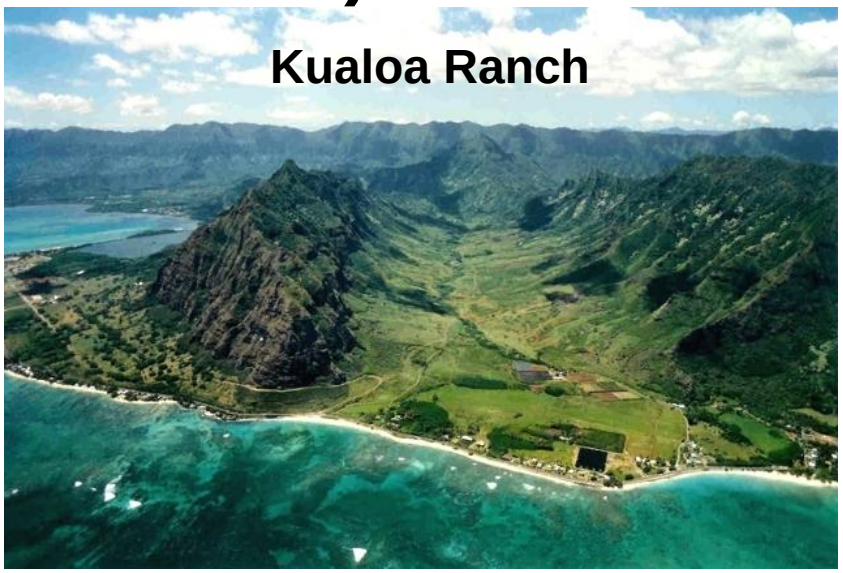
Changes in Land & Water Use following Western contact

- **Land title / private ownership "The Great Mahele" (1850s)**
- **Sugarcane, pineapple plantations & ranches**
- **Water diversions / water rights**
- **Deforestation & subsequent reforestation**

Sugarcane
(~ 1830 →)

Pineapple
(~ 1900 →)

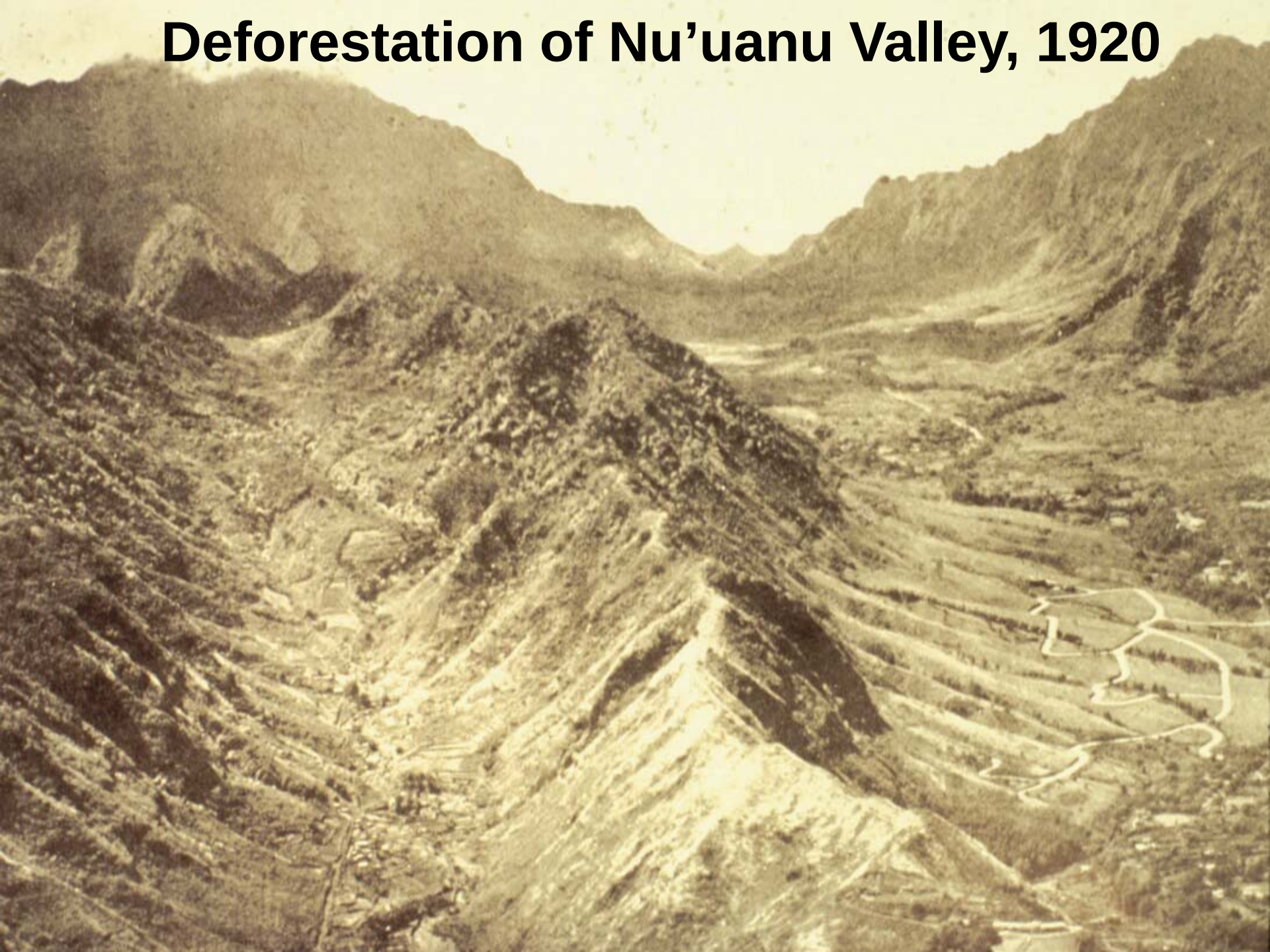
Ranching (~ 1840s →)



Water diversions

Honokohau Valley, Maui, about 1820

Deforestation of Nu’uanu Valley, 1920



Manoa Valley deforestation, 1919

Same view, 1926 (Lyon Arboretum)

Current Land Use Change

Plantation Agriculture

Diversified Agriculture

Suburban Development

Urban Watersheds

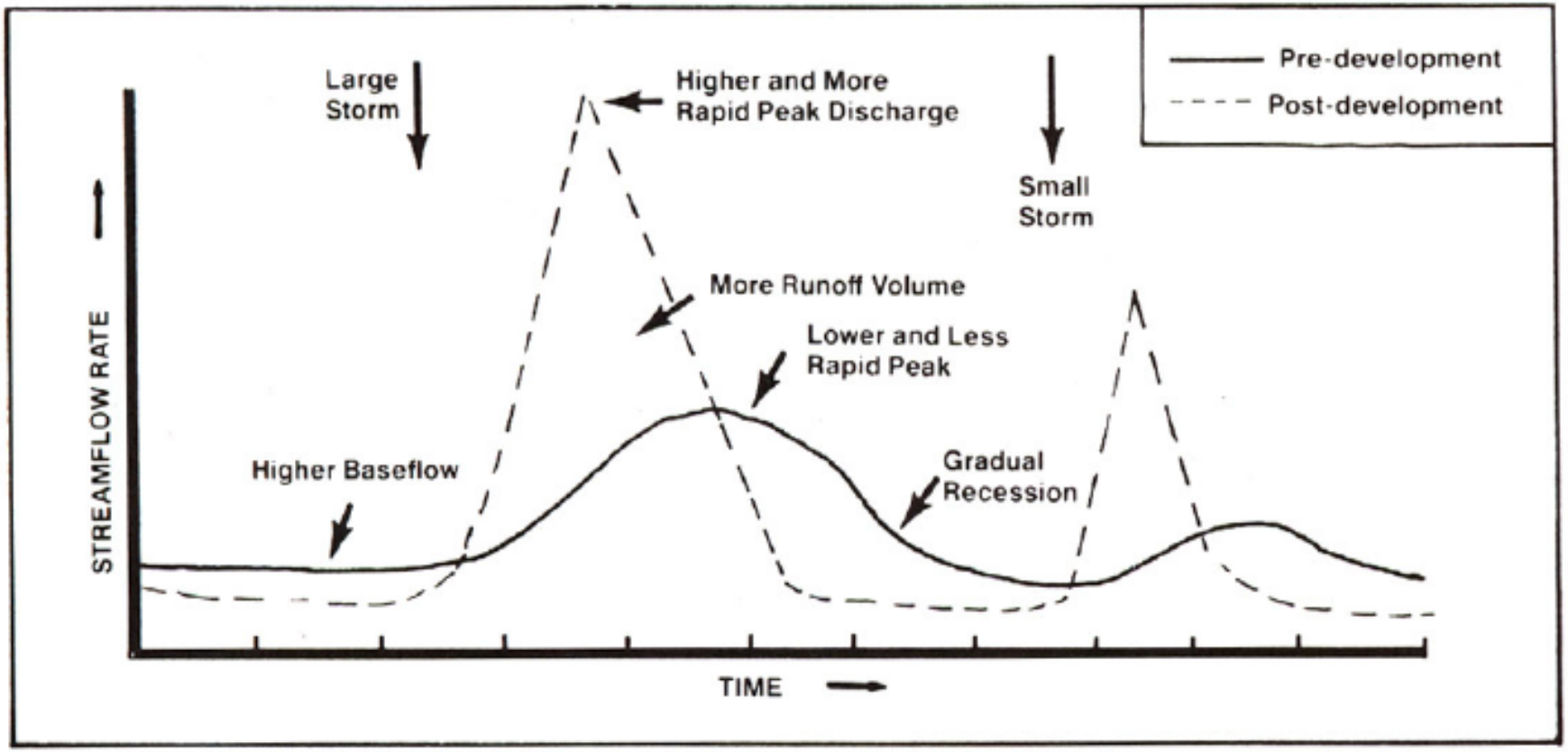


Figure 3.3 Hydrographs Before and After Development

Streets in urban areas should be considered as “tributaries” to streams.

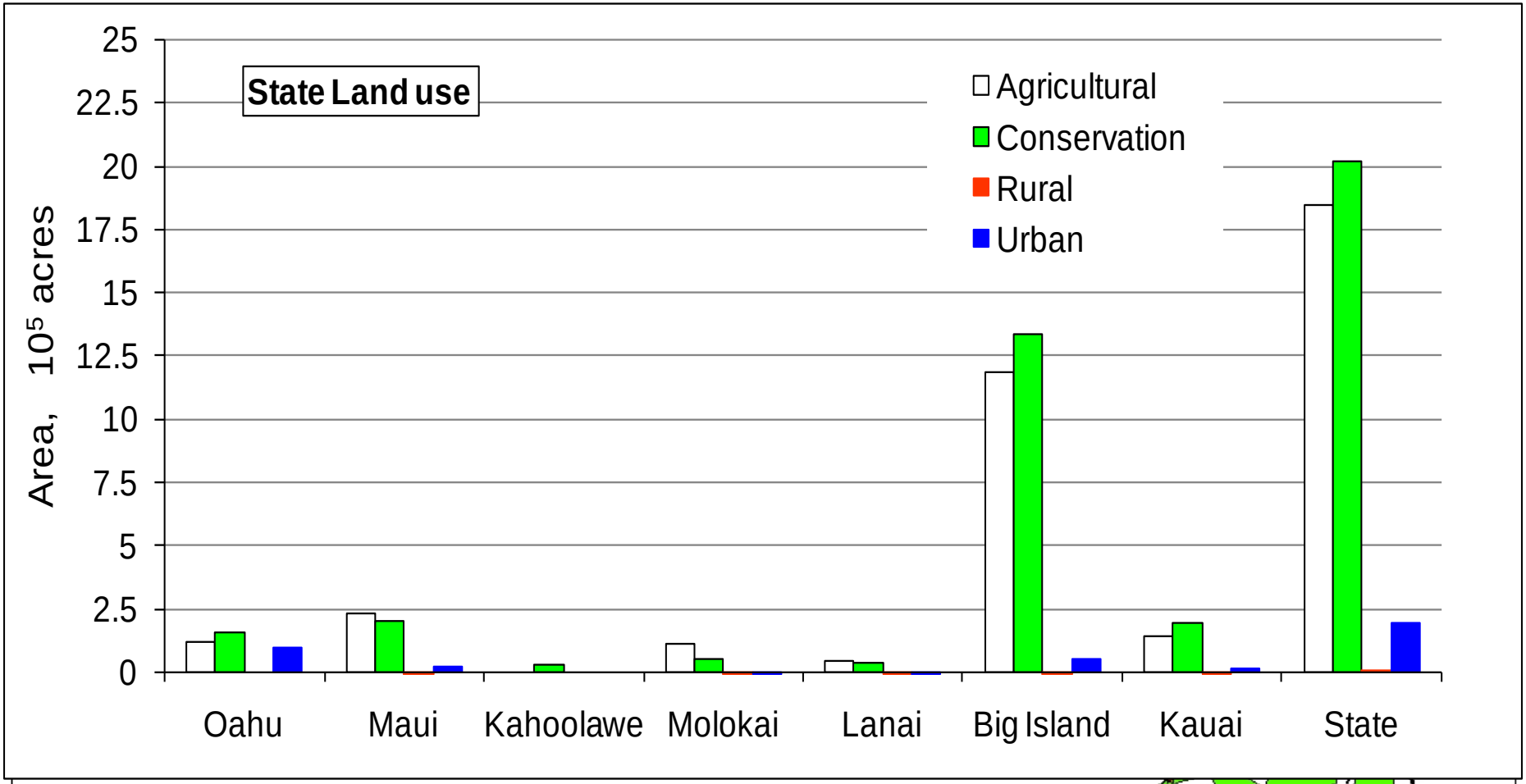
Sediment from culvert – Manoa

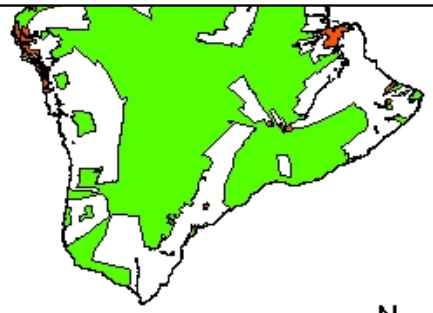
Drainage near Manoa Elementary School

Algae growth on drainage canal water

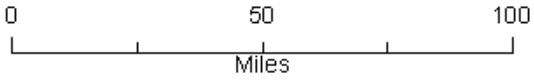
Stream near Manoa Elementary School

Urban Soil Erosion


State Land use
Agricultural
Conservation
Rural
Urban
Area, 10^5 acres
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
Oahu
Maui
Kahoolawe
Molokai
Lanai
Big Island
Kauai
State




HAWAII
STATEWIDE
GIS
PROGRAM

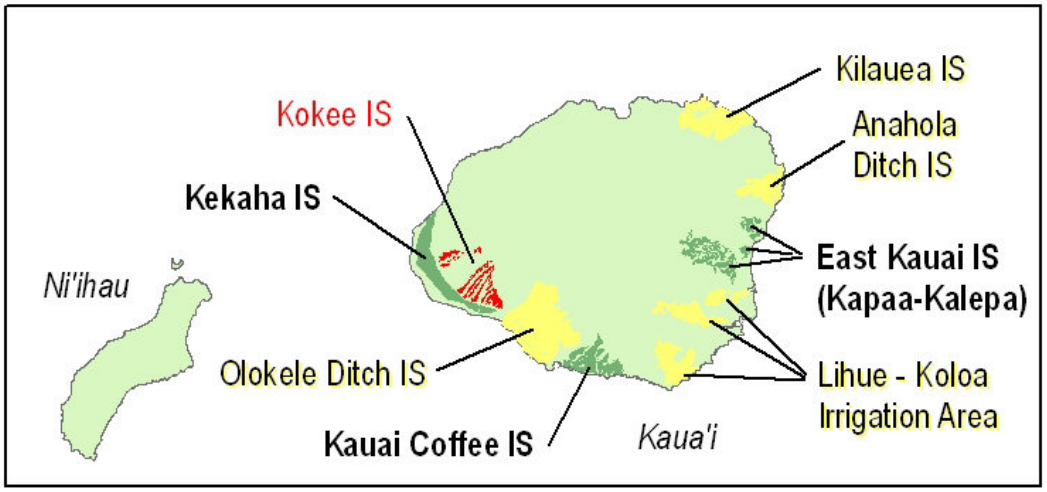

0
50
100
Miles

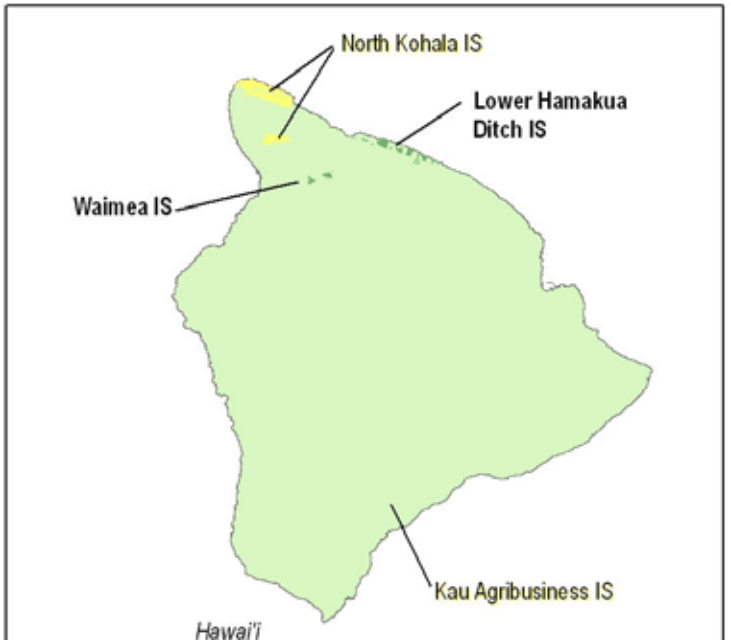

N

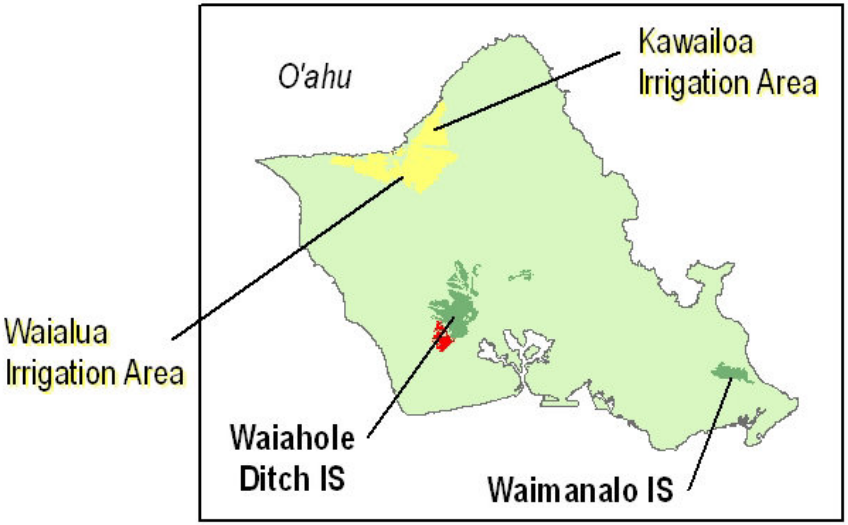
Land Use Districts in Hawaii (acres)

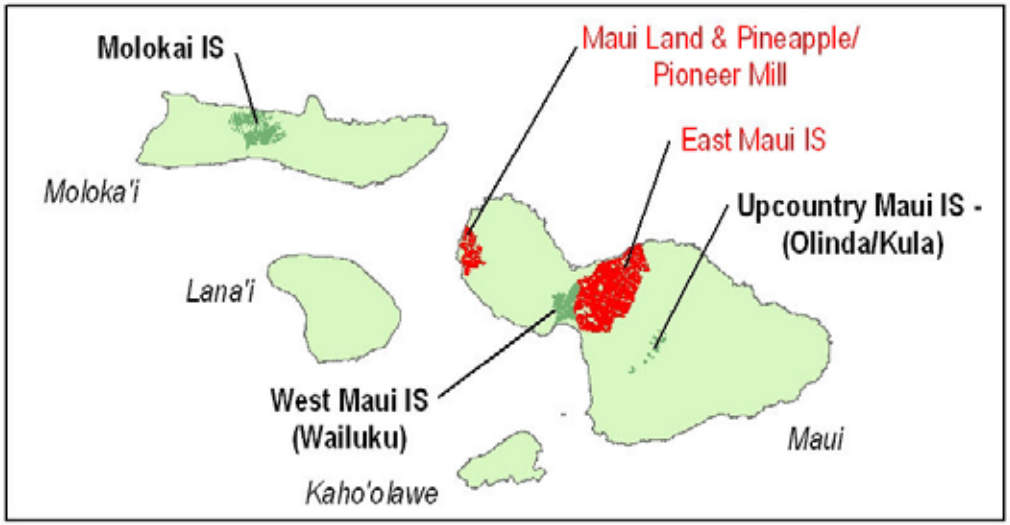
Year	Agricultural	Conservation	Urban	Rural
2006	1,930,000	1,974,000	198,000	10,870
1987	1,968,524	1,967,168	166,507	10,180
1964	2,124,400	1,862,600	117,800	6,700

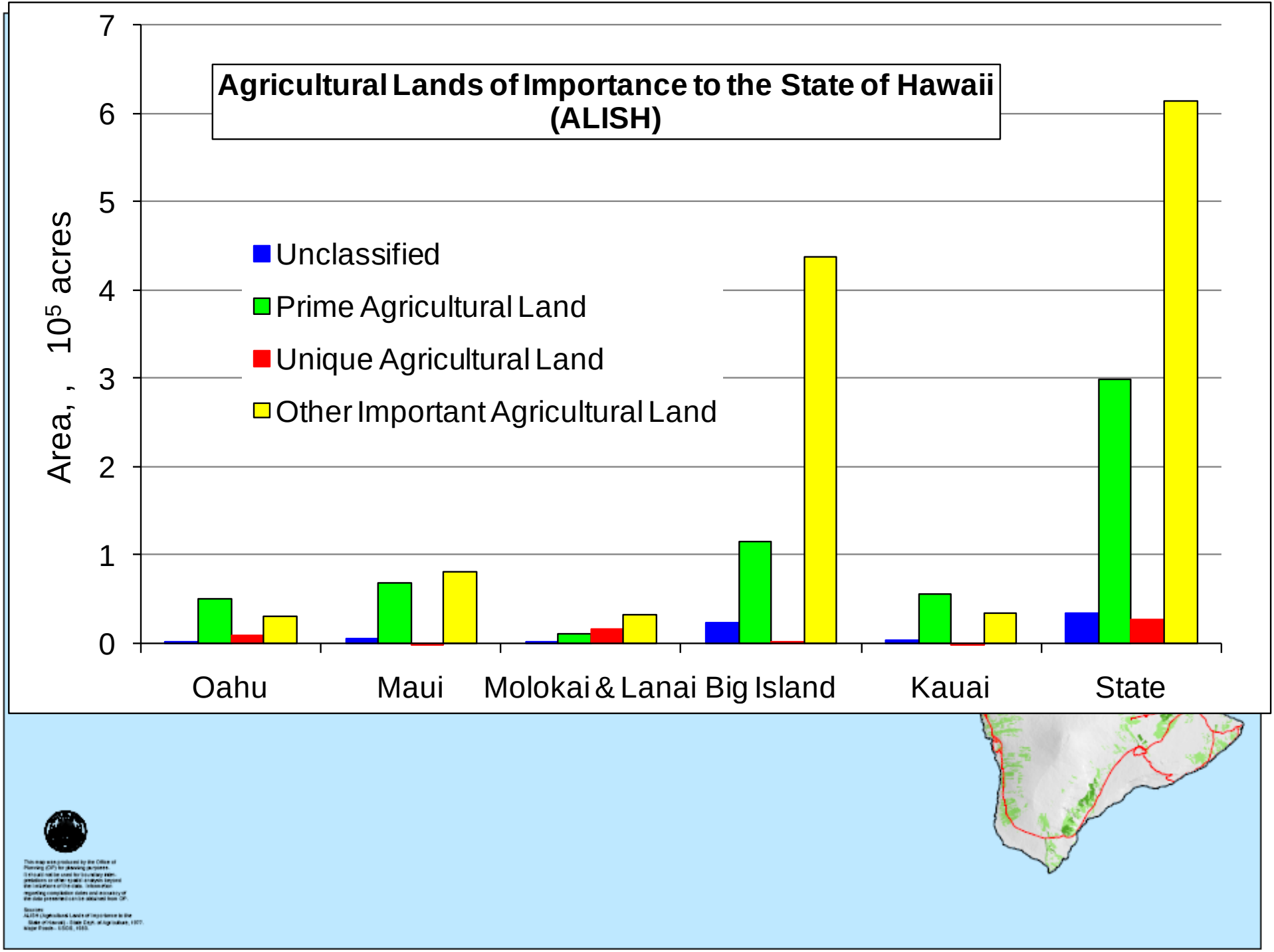
Hawaii Ag Irrigation Systems

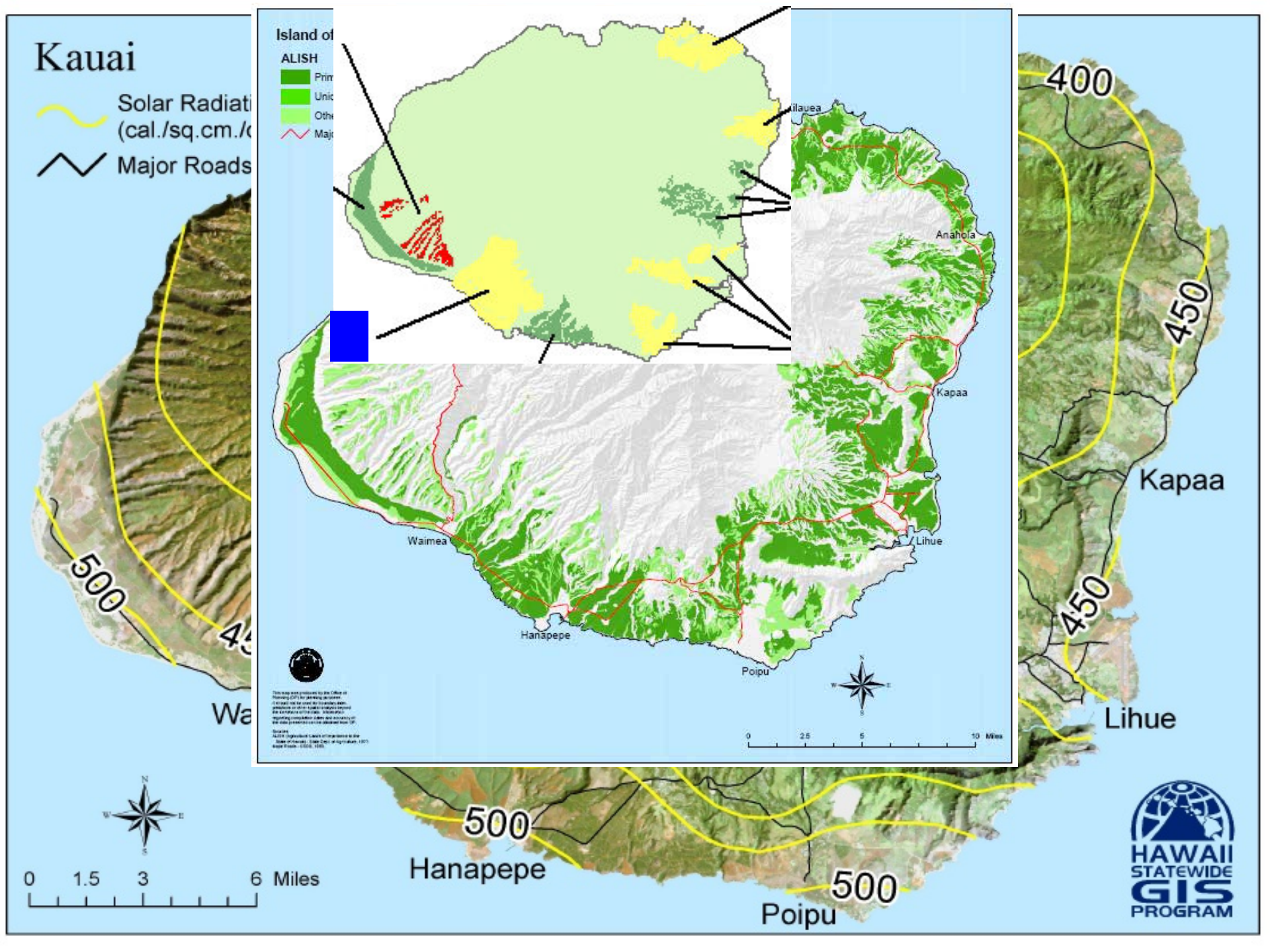




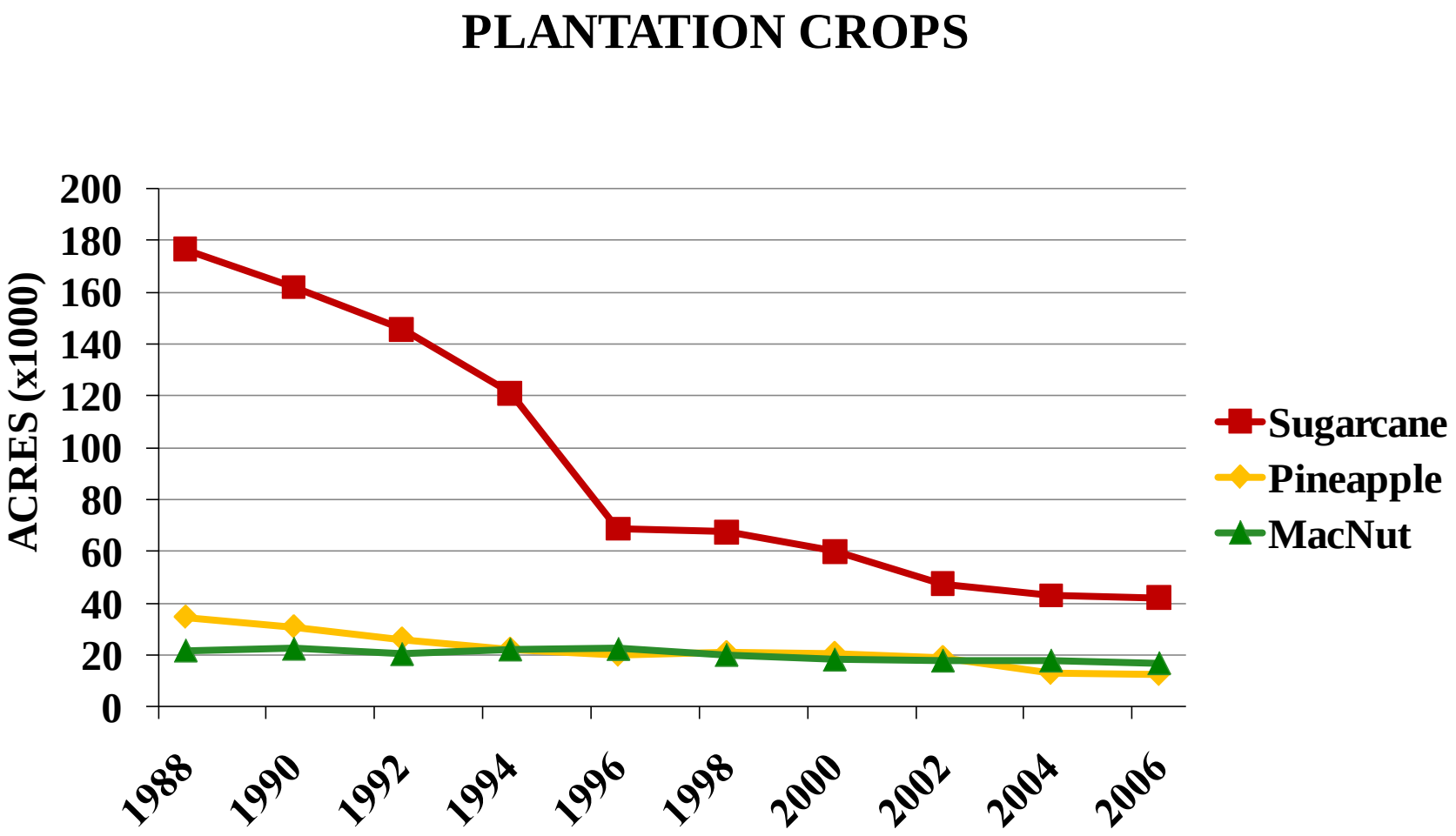





Agricultural Lands of Importance to the State of Hawaii (ALISH)
Area, , , 10^5 acres
0
1
2
3
4
5
6
7
Unclassified
Prime Agricultural Land
Unique Agricultural Land
Other Important Agricultural Land
Oahu
Maui
Molokai & Lanai
Big Island
Kauai
State


Kauai
Solar Radiati
(cal./sq.cm./
Major Roads
Island of
ALISH
Prim
Unic
Othe
Maj
Anahola
Kapaa
Waimea
Lihue
Hanapepe
Poipu
400
450
500
Kapaa
Lihue
Hanapepe
Poipu
0 1.5 3 6 Miles
0 2.5 5 10 Miles
HAWAII
STATEWIDE
GIS
PROGRAM

Changes in Hawaii's Agriculture



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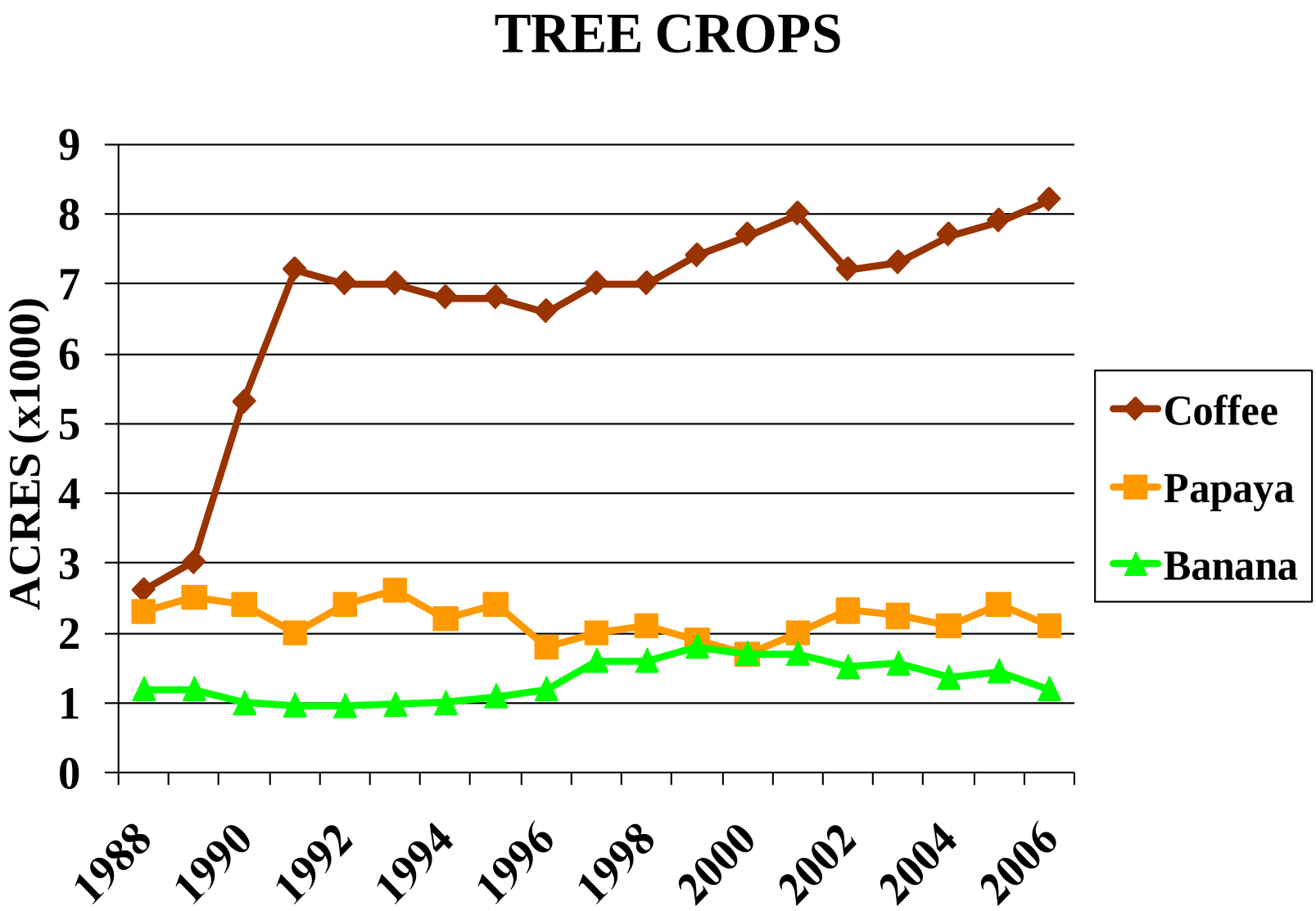
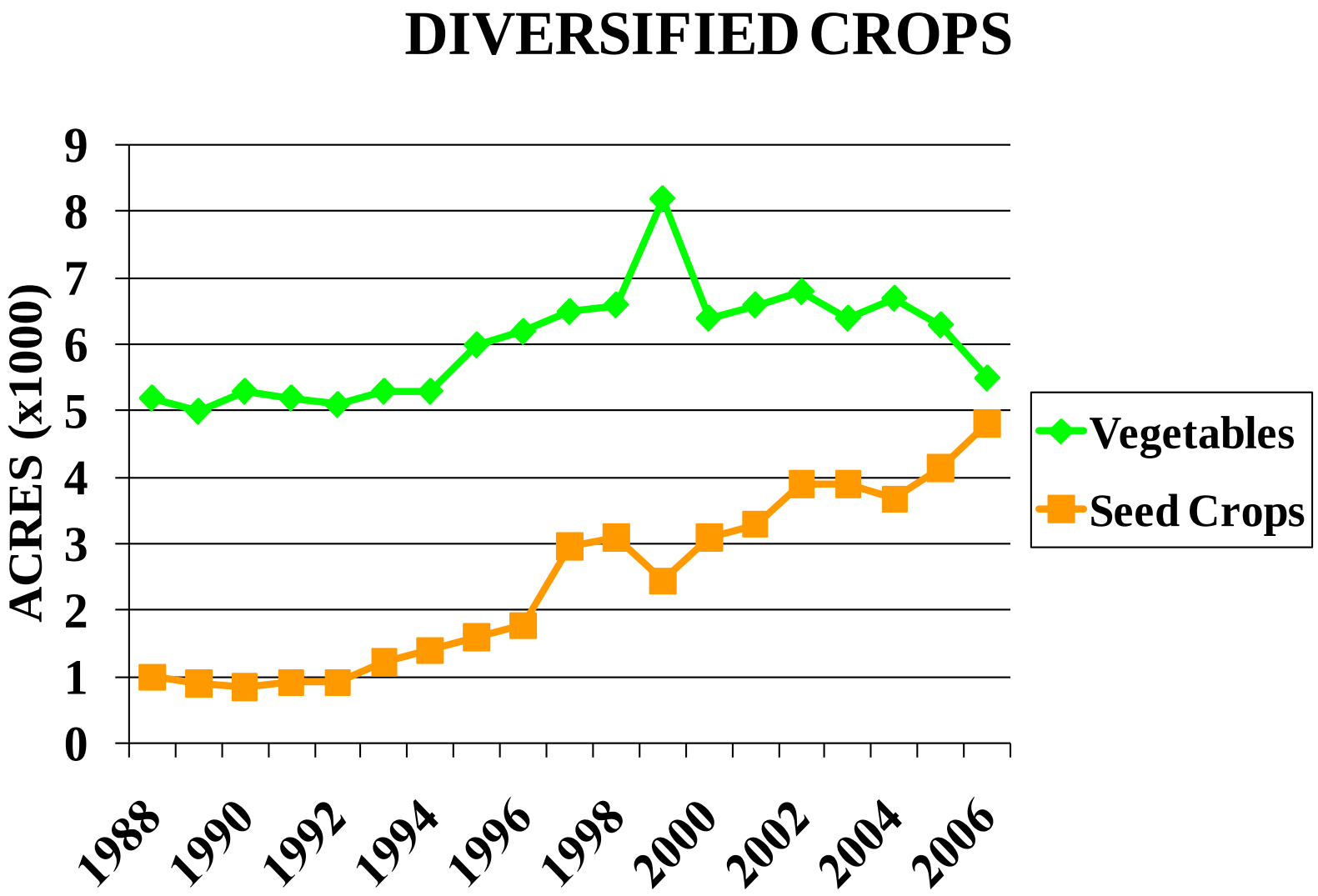


Changes in Hawaii's Agriculture



Changes in Hawaii's Agriculture

LIVESTOCK OPERATIONS

Livestock	1987	1996	2009	% decline
Cattle	199,000	174,000	152,000	24
Dairy Cows	11,900	9,400	1,700	86
Pigs	50,000	34,000	15,000	70
Chickens	1,212,000	846,000	373,000	69
Egg Production (million eggs)	223	181	73	67
Milk Production (million lbs.)	156	129	19	88

(Source: Fukumoto 2010, USDA-NASS)

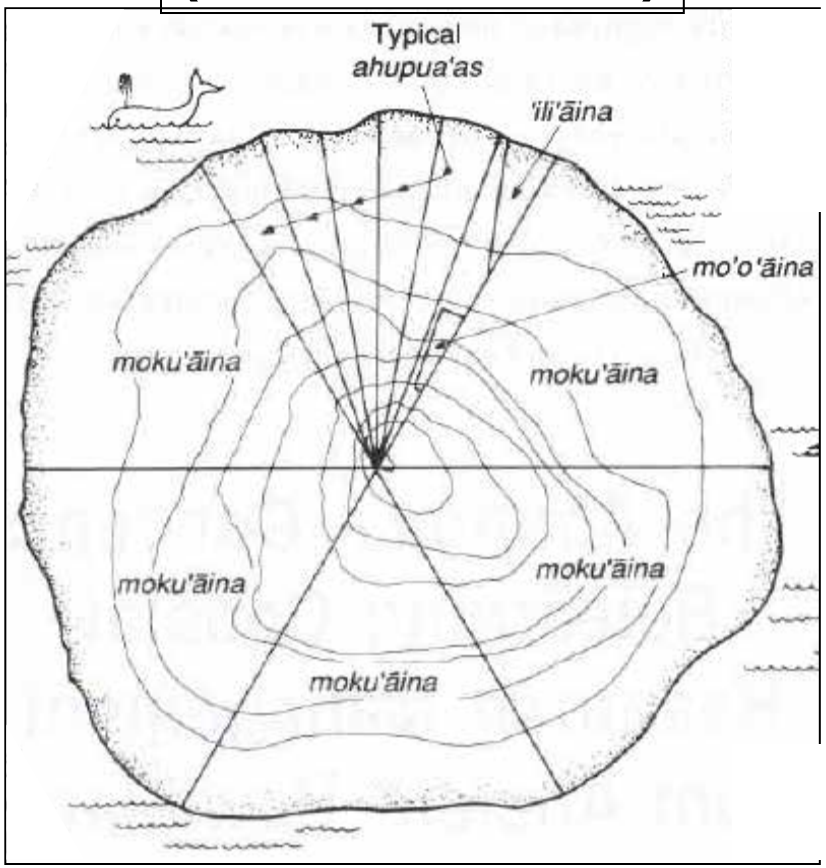
Summary of Changes in Land Use

- **Plantation crops have been replaced to a small extent by diversified crops, forestry and grazing.**
- **Agricultural chemical use is lower in total quantity but much more diverse.**
- **Large areas of land are now idle, presenting problems of exotic weed growth, erosion and fire.**
- **Urban growth and pressure on agricultural land continue to increase.**

Watershed-level Management

Ahupua'a -- "radial" land divisions, which recognized interconnections between land and sea.

(Smith & Pai, 1992)



- **Current land ownership and agency jurisdictions often run at cross angles to the *mauka-makai* orientation of ahupua'a. ie. "concentric circle"**
- **Agroecosystem management and conservation planning at the watershed level should be encouraged.**
- **Increase local responsibility (*kuleana)* of communities for sustainable management of land, water, and coastal resources.**

Integrated watershed scale management could provide:

- **better erosion and flooding control through increased water infiltration and reduced runoff across the landscape**
- **better control of the spread of diseases, pests, and weeds**
- **Improved coordination of infrastructure requirements for agriculture and communities**

Summary

- **Hawaii's agroecosystems have a history of change, which continues today**

  humans modified ecosystems to the extent of their technology to provide for changing goals/needs)

- **Well managed farms and watersheds can provide ecosystem services, while controlling water pollution, land degradation, pests/diseases, etc.**

  natural resource conservation planning required at individual farm and watershed levels)

- **Farmers and agricultural scientists must be aware of societal and environmental needs and concerns.**


MAHALO

Planning for natural resource conservation

Agricultural BMPs

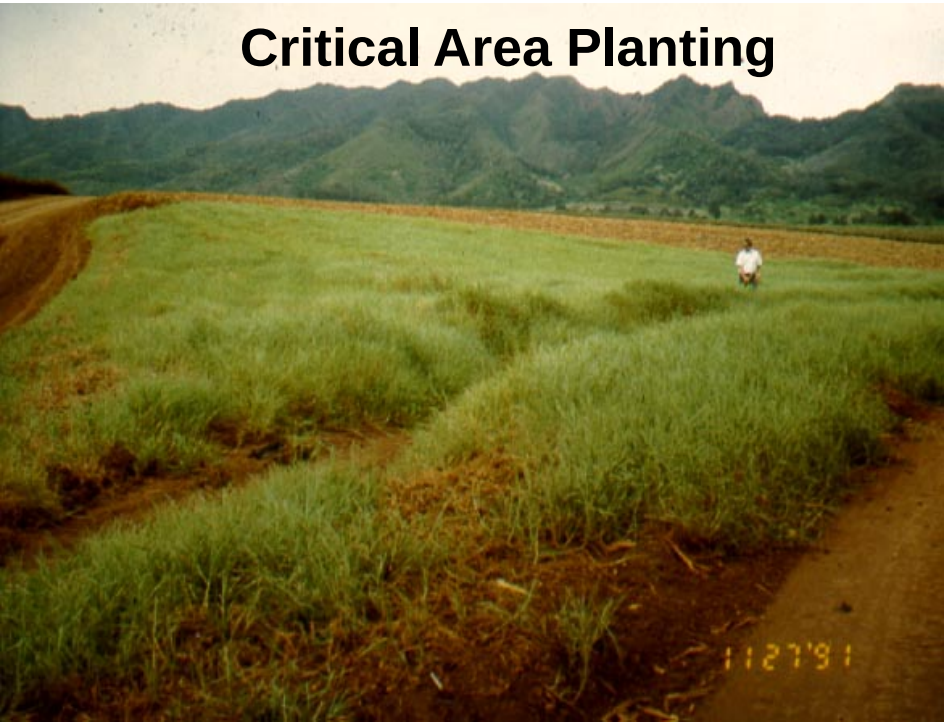
Agricultural BMPs are structures, treatments, or management techniques that minimizes the effects of agricultural operations on the natural resources

Sometimes called natural resource conservation practices, BMPs are normally used in combinations to be effective. Single practices seldom address all the natural resource concerns created by an agricultural operation.

Contour Farming

Sediment Basins

Critical Area Planting



Windbreaks

Riparian Area Management

- Maintain or restore vegetation as buffer strips between agricultural land and stream
- Restrict access of livestock to streams
- Construct appropriate stream crossings