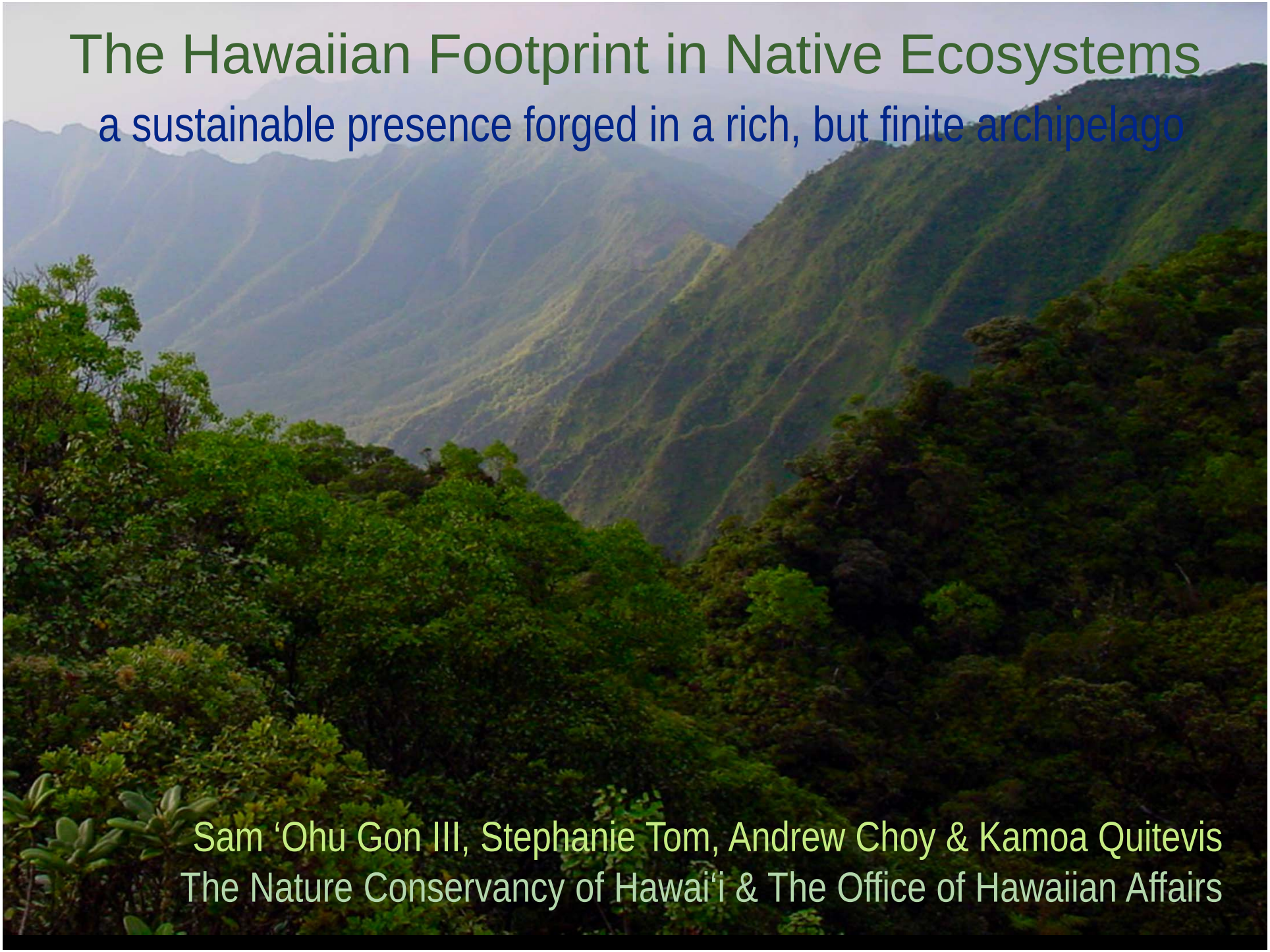
The Hawaiian Footprint in Native Ecosystems

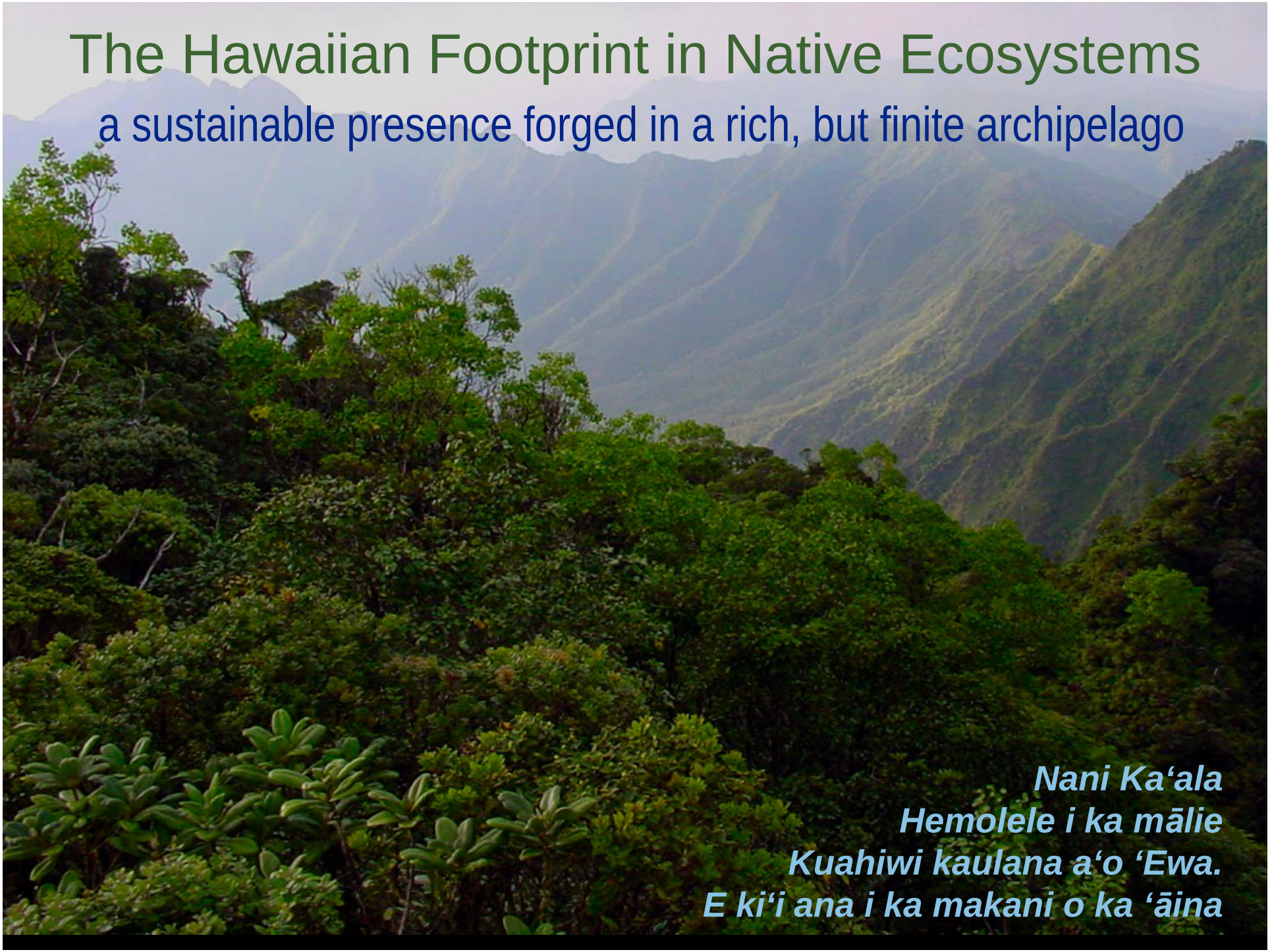
a sustainable presence forged in a rich, but finite archipelago



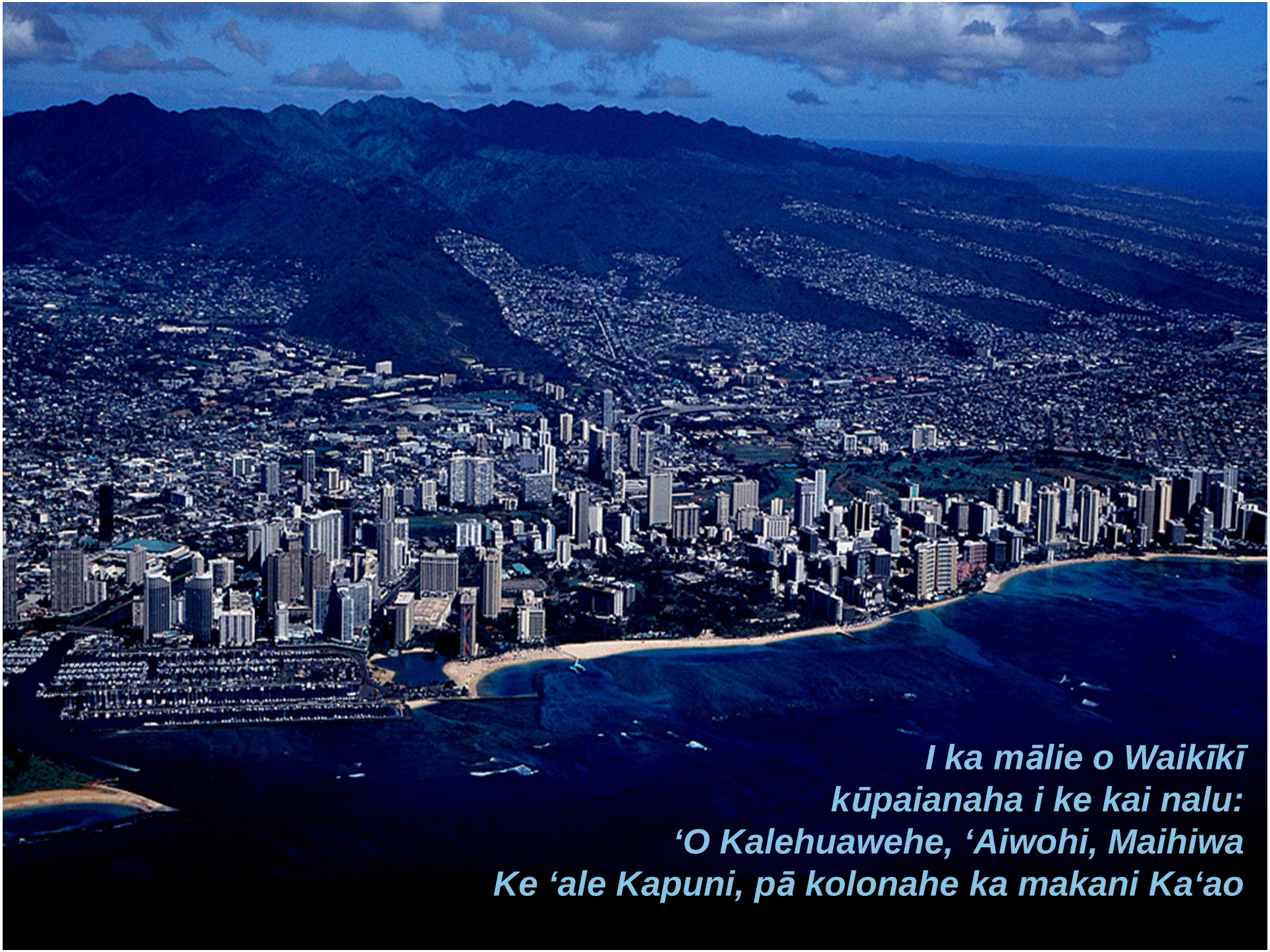
Sam ‘Ohu Gon III, Stephanie Tom, Andrew Choy & Kamoa Quitevis
The Nature Conservancy of Hawai‘i & The Office of Hawaiian Affairs

The Hawaiian Footprint in Native Ecosystems

a sustainable presence forged in a rich, but finite archipelago



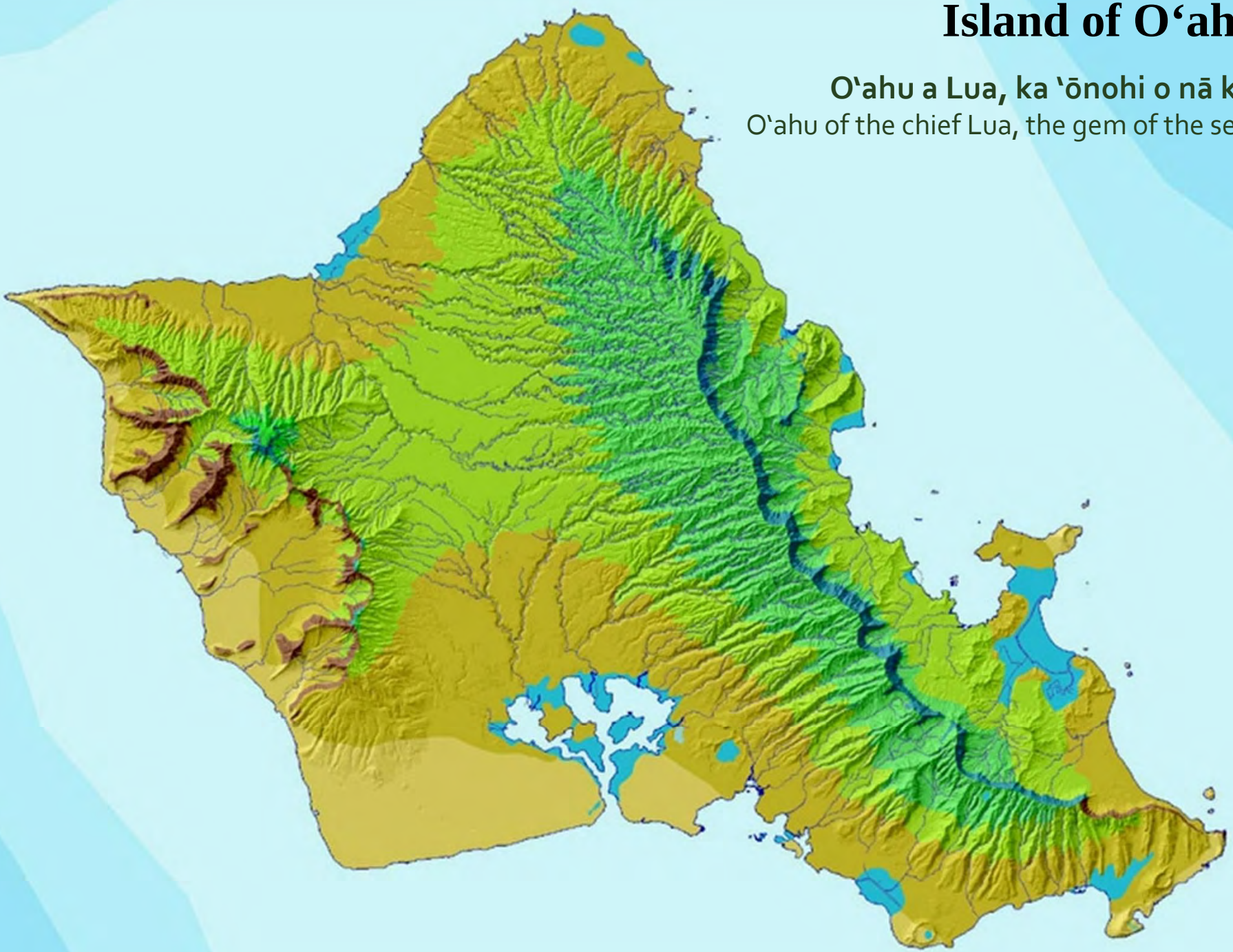
Nani Ka‘ala
Hemolele i ka mālie
Kuahiwi kaulana a‘o ‘Ewa.
E ki‘i ana i ka makani o ka ‘āina


I ka mālie o Waikīkī
kūpaianaha i ke kai nalu:
‘O Kalehuawehe, ‘Aiwohi, Maihiwa
Ke ‘ale Kapuni, pā kolonahe ka makani Ka‘ao

Island of O‘ahu

O‘ahu a Lua, ka ‘ōnohi o nā kai

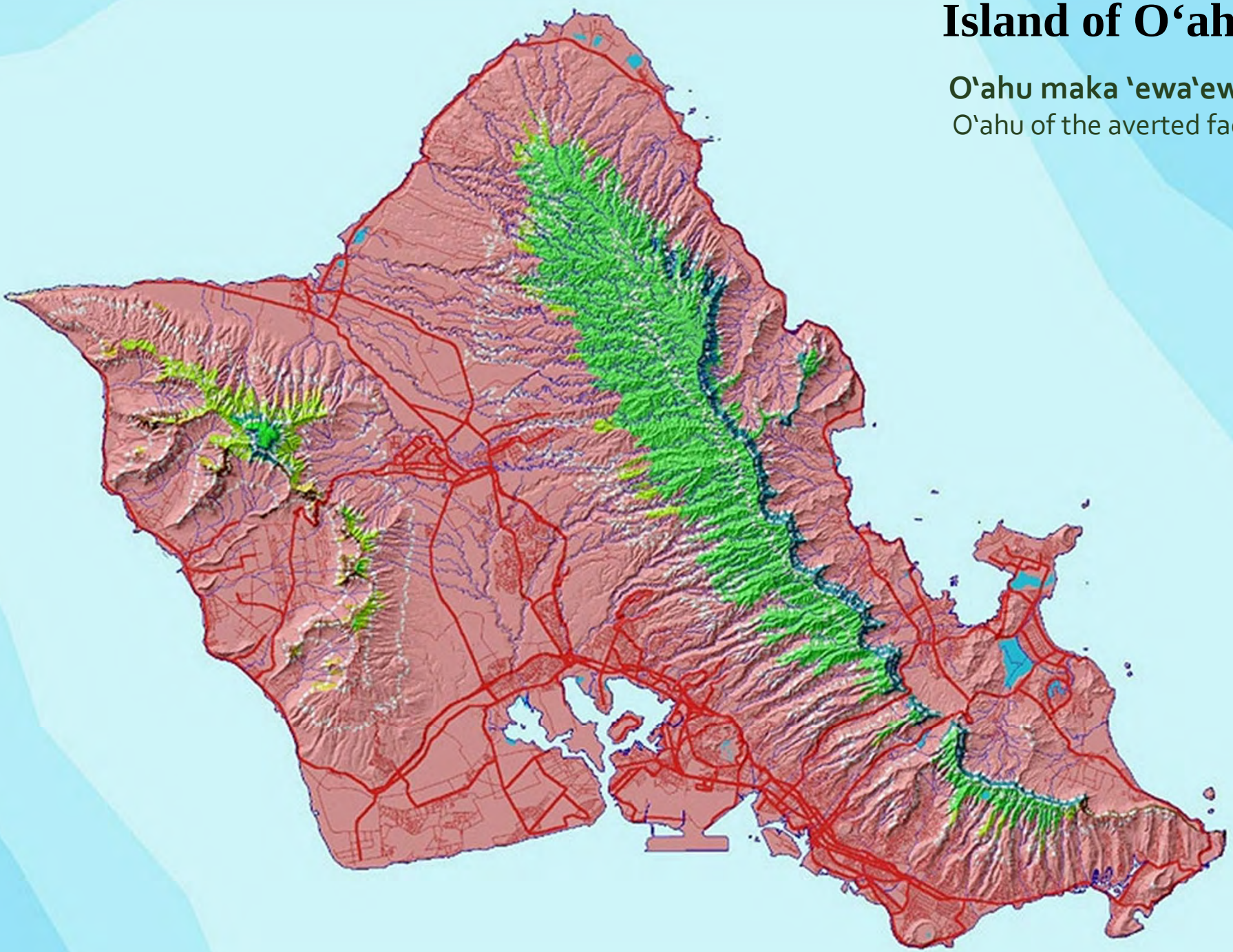
O‘ahu of the chief Lua, the gem of the seas

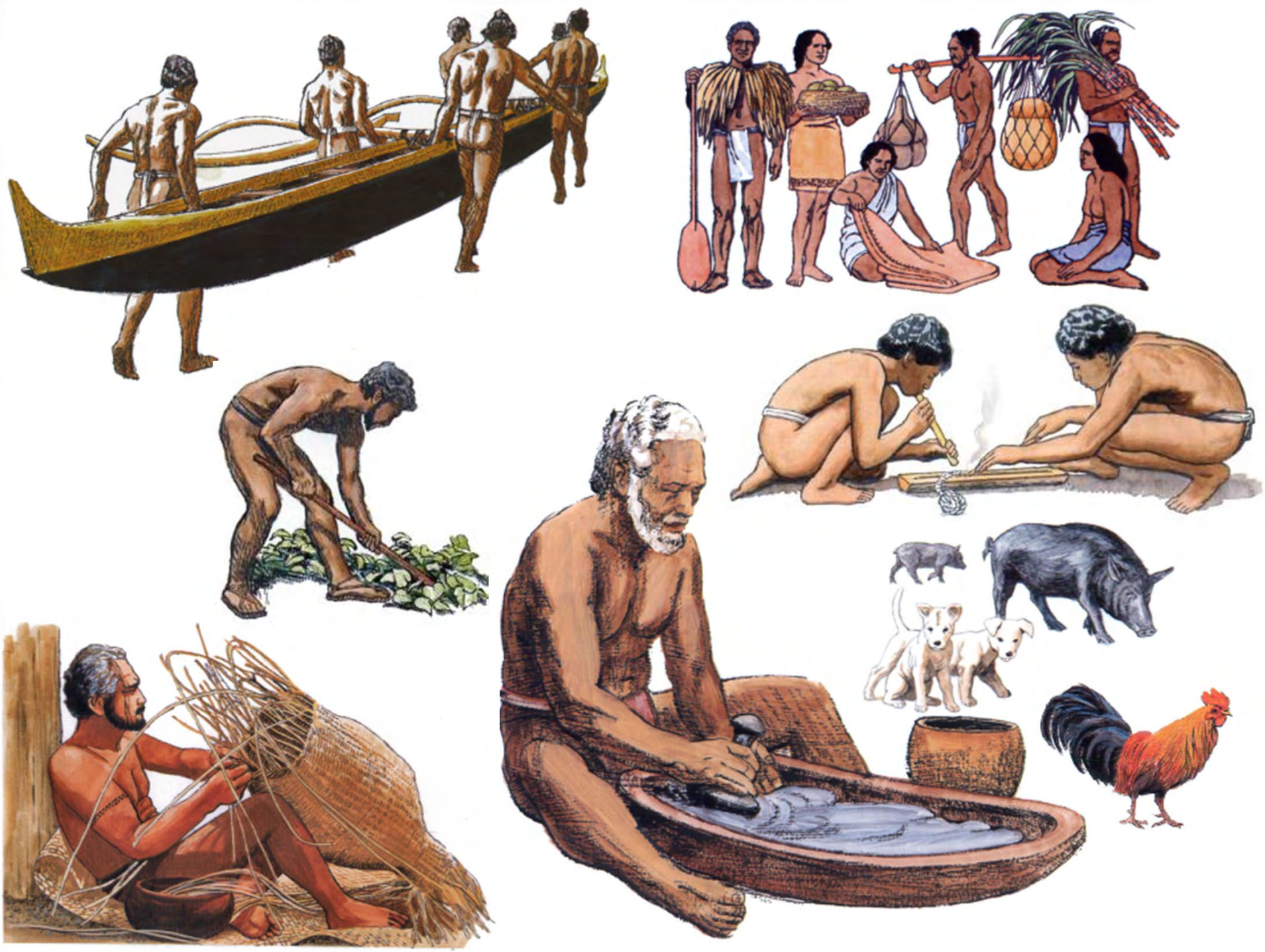


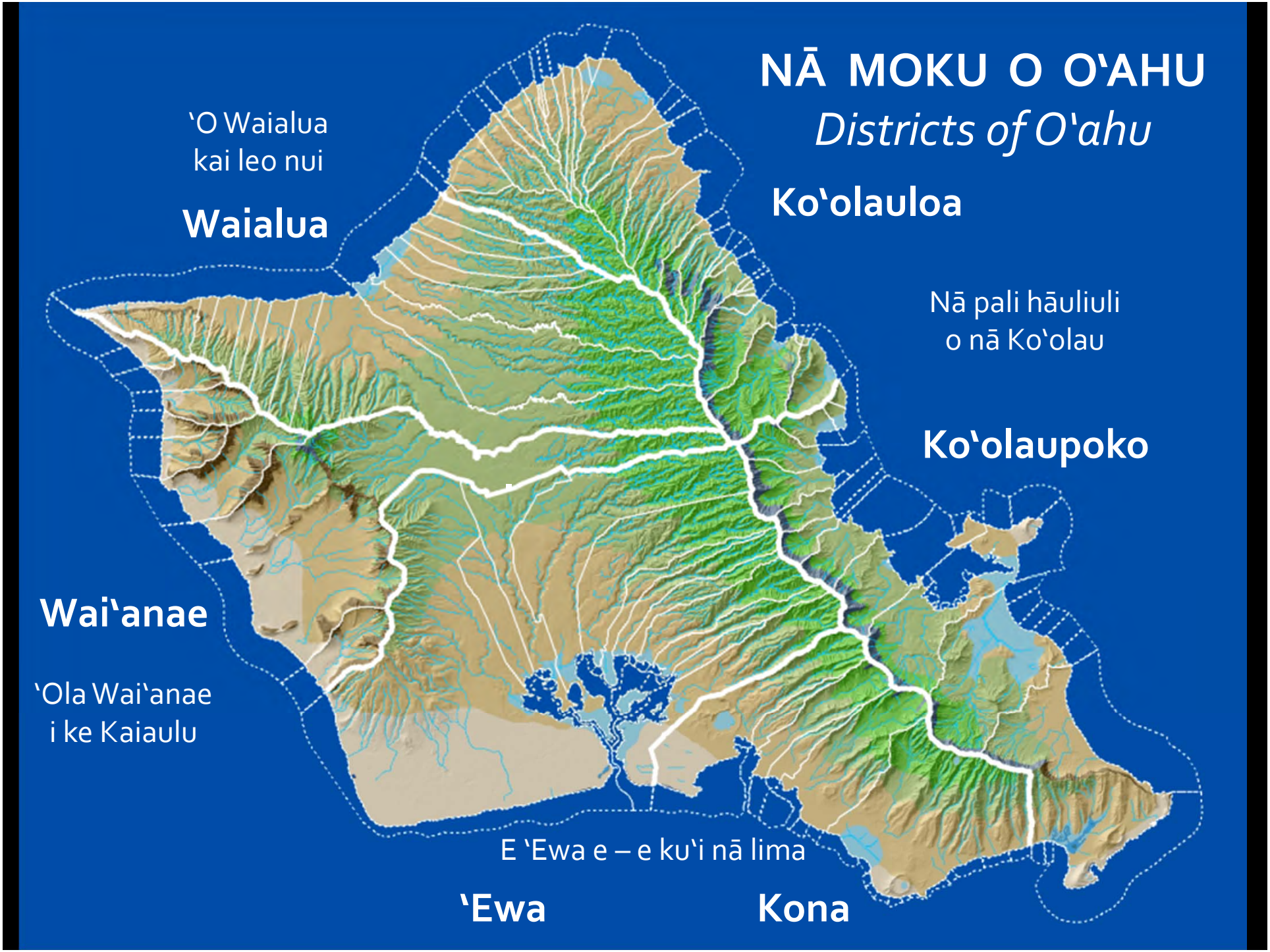
Island of O‘ahu

O‘ahu maka ‘ewa‘ewa

O‘ahu of the averted face






NĀ MOKU O OʻAHU
Districts of Oʻahu
ʻO Waialua
kai leo nui
Waialua
Koʻolauloa
Nā pali hāuliuli
o nā Koʻolau
Koʻolaupoko
Waiʻanae
ʻOla Waiʻanae
i ke Kaiaulu
E ʻEwa e – e kuʻi nā lima
ʻEwa
Kona

Mala ʻai

Loko iʻa

Heiau

Ala hele

Wahi pana

Kauhale

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Opportunities and constraints for intensive agriculture in the Hawaiian archipelago prior to European contact

Thegn N. Ladefoged [a,*], Patrick V. Kirch [b], Samuel M. Gon III [c], Oliver A. Chadwick [d], Anthony S. Hartshorn [e], Peter M. Vitousek [f]

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[b] Departments of Anthropology and Integrative Biology, University of California, Berkeley, CA 94720, USA
[c] The Nature Conservancy, Hawai'i Field Office, Honolulu, HI 96817, USA
[d] Department of Geography, University of California, Santa Barbara, CA 93106, USA
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Pondfields
Rain-fed agriculture
Hawai'i
GIS

ABSTRACT

Intensive agricultural systems interact strongly and reciprocally with features of the lands they occupy, and with features of the societies that they support. We modeled the distribution of two forms of pre-European contact intensive agriculture – irrigated pondfields and rain-fed dryland systems – across the Hawaiian archipelago using a GIS approach based on climate, hydrology, topography, substrate age, and soil fertility. Model results closely match the archaeological evidence in defined locations. On a broader scale, we calculate that the youngest island, Hawai'i, could have supported 572 km^2 of intensive agriculture, 97% as rain-fed dryland field systems, while Kaua'i, the oldest island, could have supported 58 km^2, all as irrigated wetland systems. Irrigated systems have higher, more reliable yields and lower labor requirements than rain-fed dryland systems, so the total potential yield from Kaua'i (~49k metric tons) was almost half that of Hawai'i (~97k metric tons), although Kaua'i systems required only ~0.05 of the agricultural labor (~8400 workers, versus ~165,000 on Hawai'i) to produce the crops. We conclude that environmental constraints to intensive agriculture across the archipelago created asymmetric production efficiencies, and therefore varying potentials for agricultural surplus. The implications both

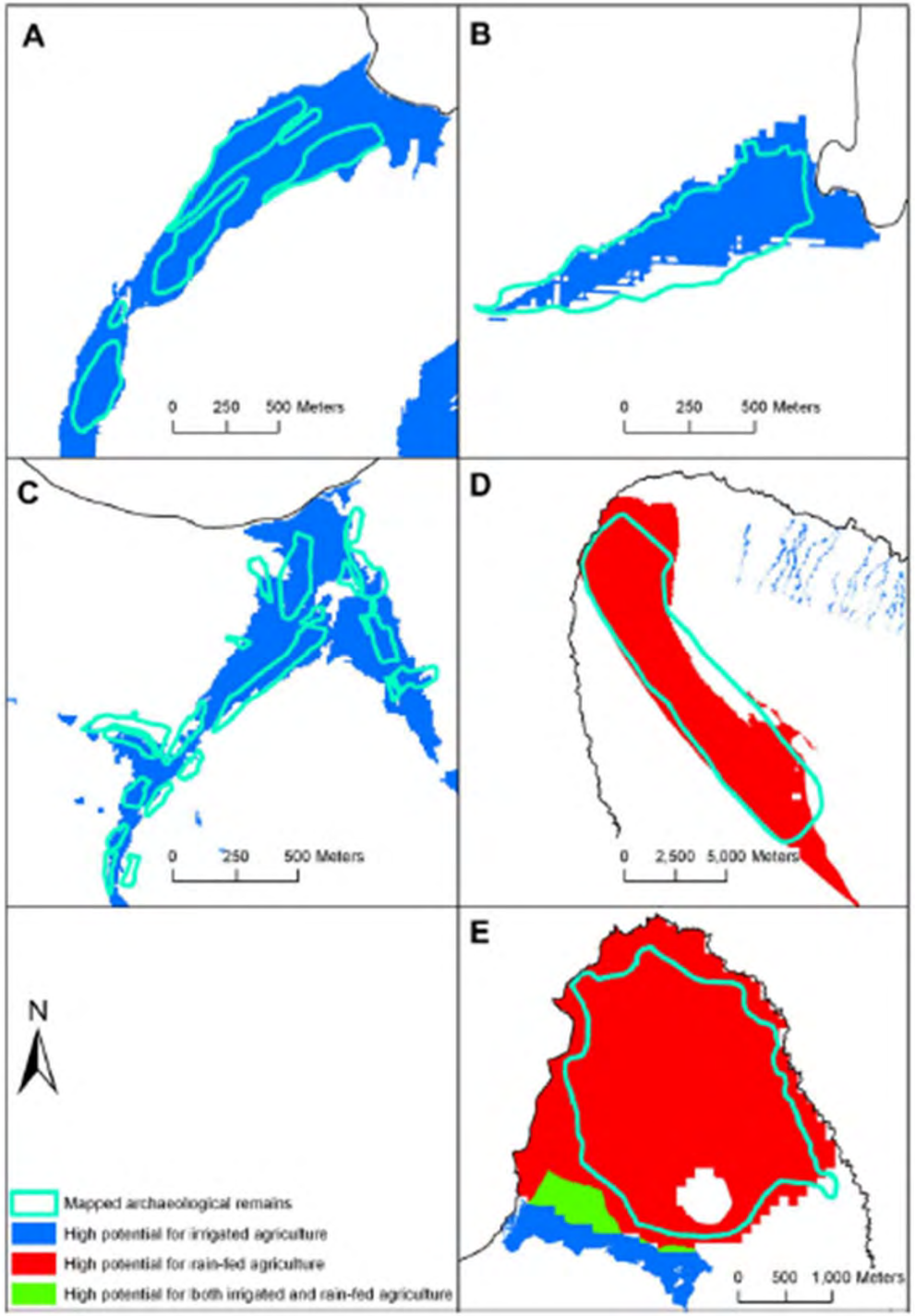
REQUIREMENTS FOR AGRICULTURE

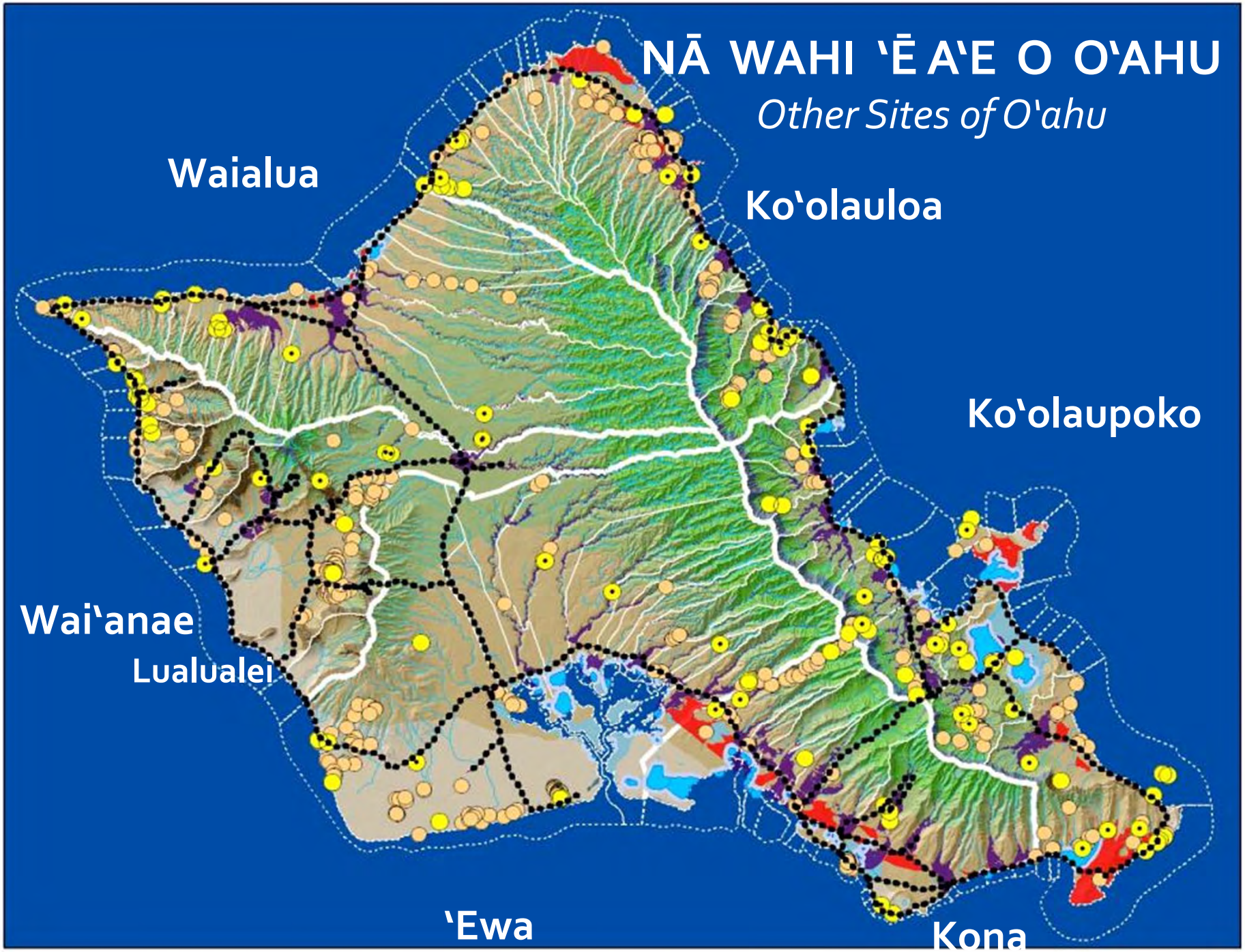
- WET (kalo):
  - Gentle slope
  - Sufficient water
  - Low elevation
- DRY (uala):
  - Mid-mesic settings
  - Sufficient soil fertility
  - Younger substrate age

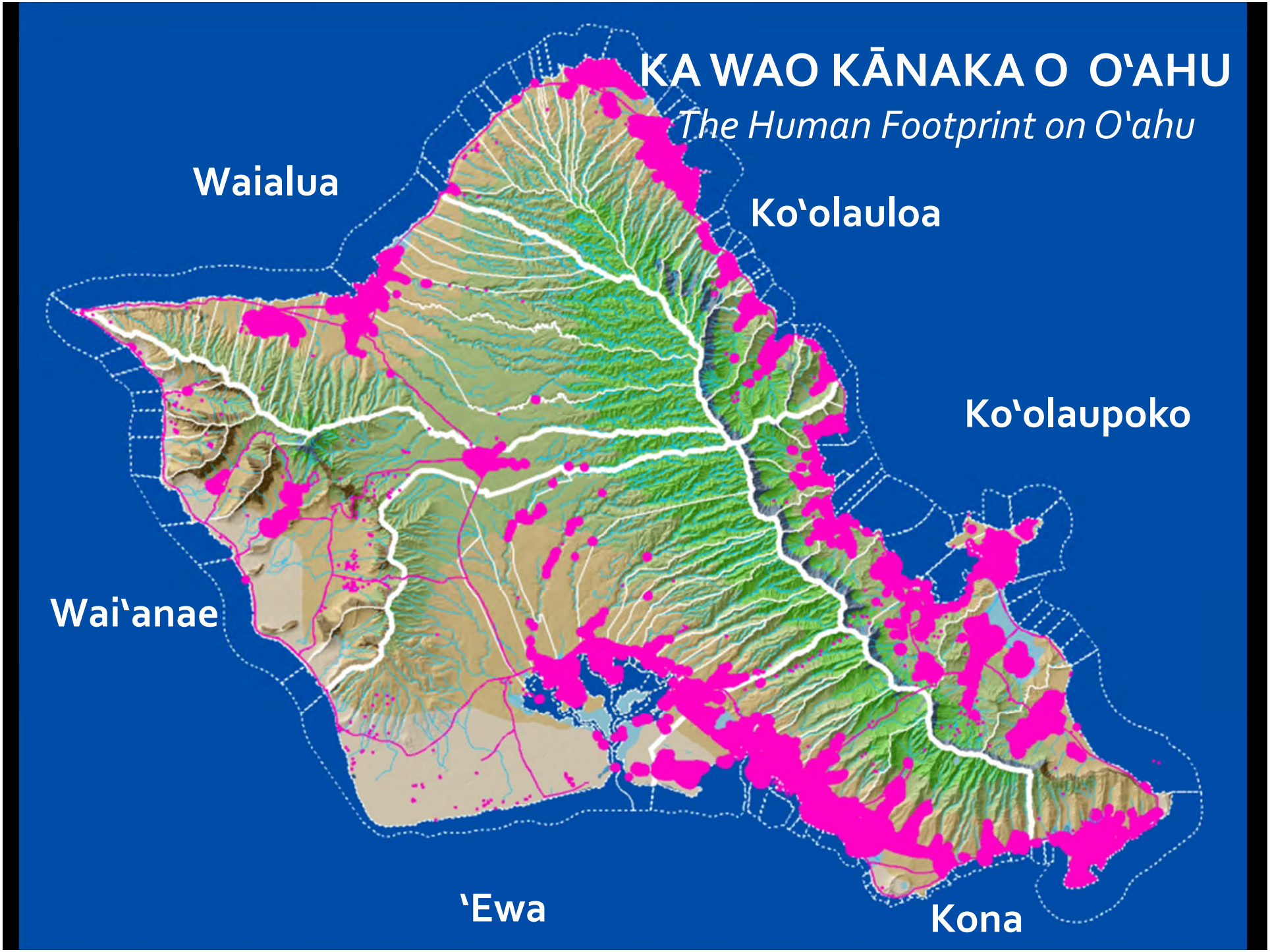
- A: Wainiha, Kaua‘i
- B: Halawa, Moloka‘i
- C. Wailau, Moloka‘i
- D. Waimea, Hawai‘i
- E. Kalaupapa, Moloka‘i

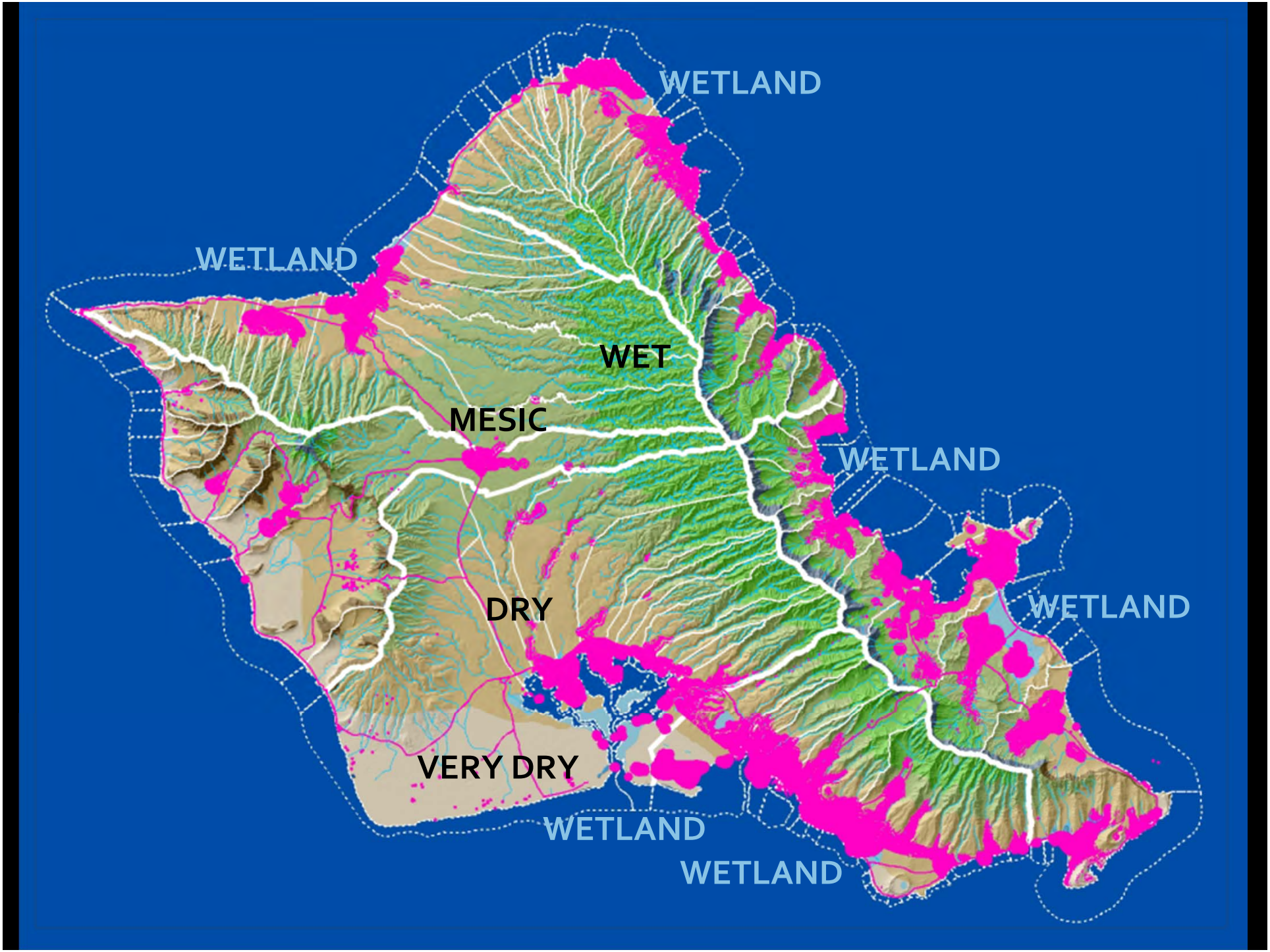
Blue and red indicate model predictions.

Light blue indicates archeological complexes.




NĀ WAHI ʻĒ AʻE O OʻAHU
Other Sites of Oʻahu
Waialua
Koʻolauloa
Koʻolaupoko
Waiʻanae
Lualualei
ʻEwa
Kona


KA WAO KĀNAKA O O'AHU
The Human Footprint on O'ahu
Waialua
Ko'olauloa
Ko'olaupoko
Wai'anae
'Ewa
Kona

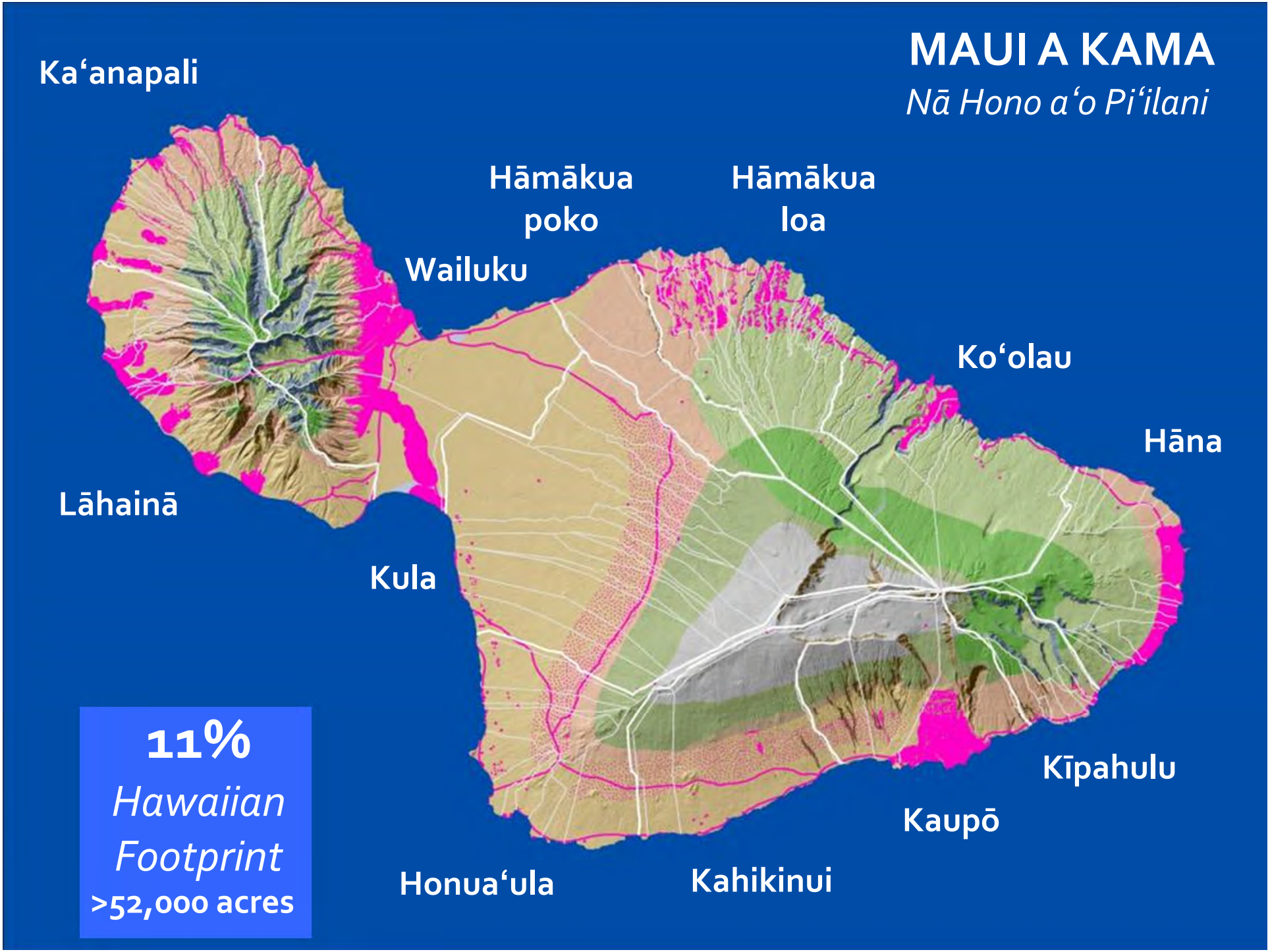

WETLAND
WETLAND
WET
MESIC
WETLAND
WETLAND
DRY
VERY DRY
WETLAND
WETLAND

Ecosystem Type	Original extent (acres)	Footprint (acres)	Percent Affected
Wetlands	12,712	7,914	62.3%
Lowland Dry Forest & Shrubland	122,505	28,253	23.1%
Lowland Dry Shrubland & Grassland	39,660	4,752	12.0%
Lowland Mesic Forest & Shrubland	125,863	11,500	9.1%
Lowland Wet Forest & Shrubland	63,553	942	1.5%

All told, 14.1% of the native landscape of O‘ahu was displaced by the Hawaiian footprint.

wao akua

wao kanaka


MAUI A KAMA
Nā Hono a‘o Pi‘ilani
Ka‘anapali
Hāmākua poko
Hāmākua loa
Wailuku
Ko‘olau
Hāna
Lāhainā
Kula
Kīpahulu
Kaupō
Honua‘ula
Kahikinui
11%
Hawaiian Footprint
>52,000 acres

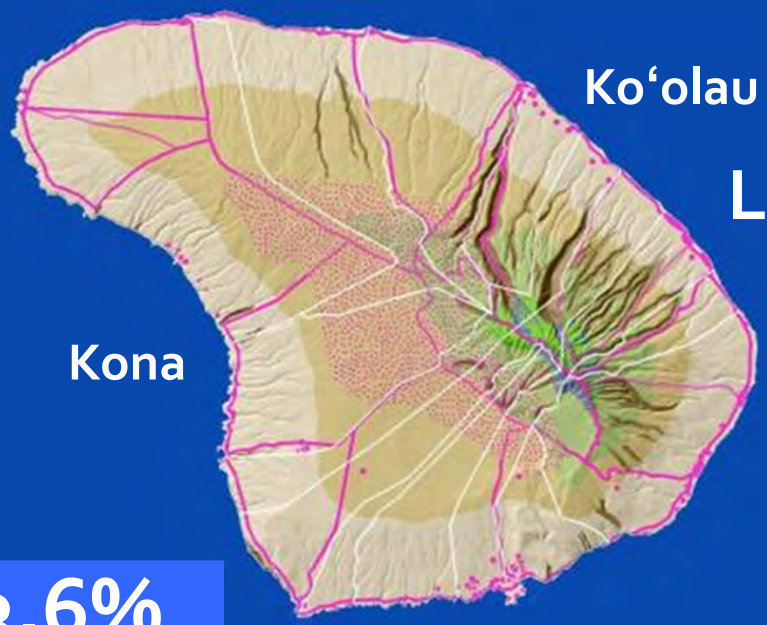
MOLOKAʻI NUI A HINA

Ka Pule Oʻo o Lanikāula

8.4%

Hawaiian Footprint

~14,000 acres



LĀNAʻI A KAʻULULĀʻAU

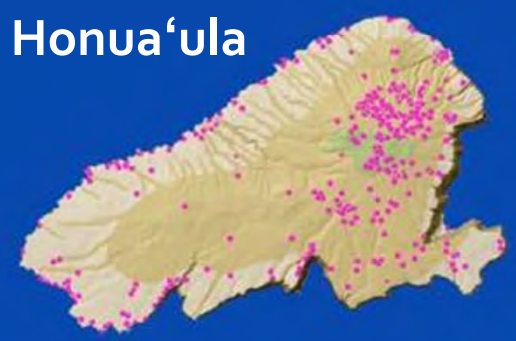
Kū i ke ʻehu o ke kai

13.6%
Hawaiian Footprint
~12,900 acres

KAHOʻOLAWE KOHEMĀLAMALAMA

Ke kino o Kanaloa

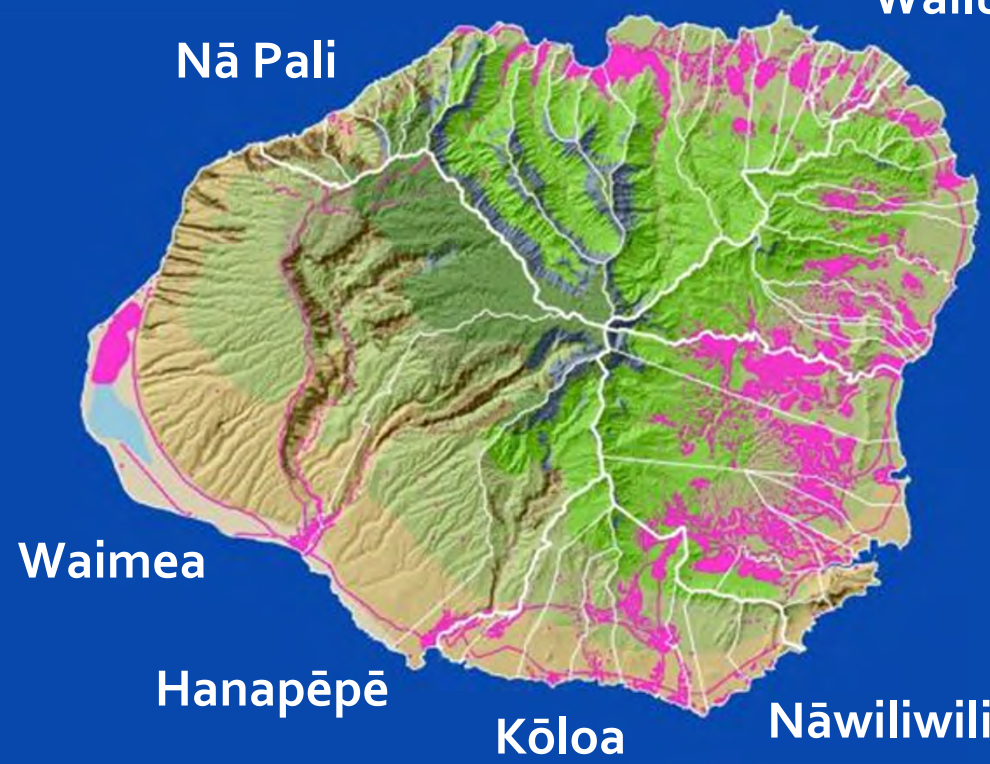
14.3%
Hawaiian Footprint
>1800 acres



KAUAʻI O MANOKALANIPŌ

Hemolele i ka mālie

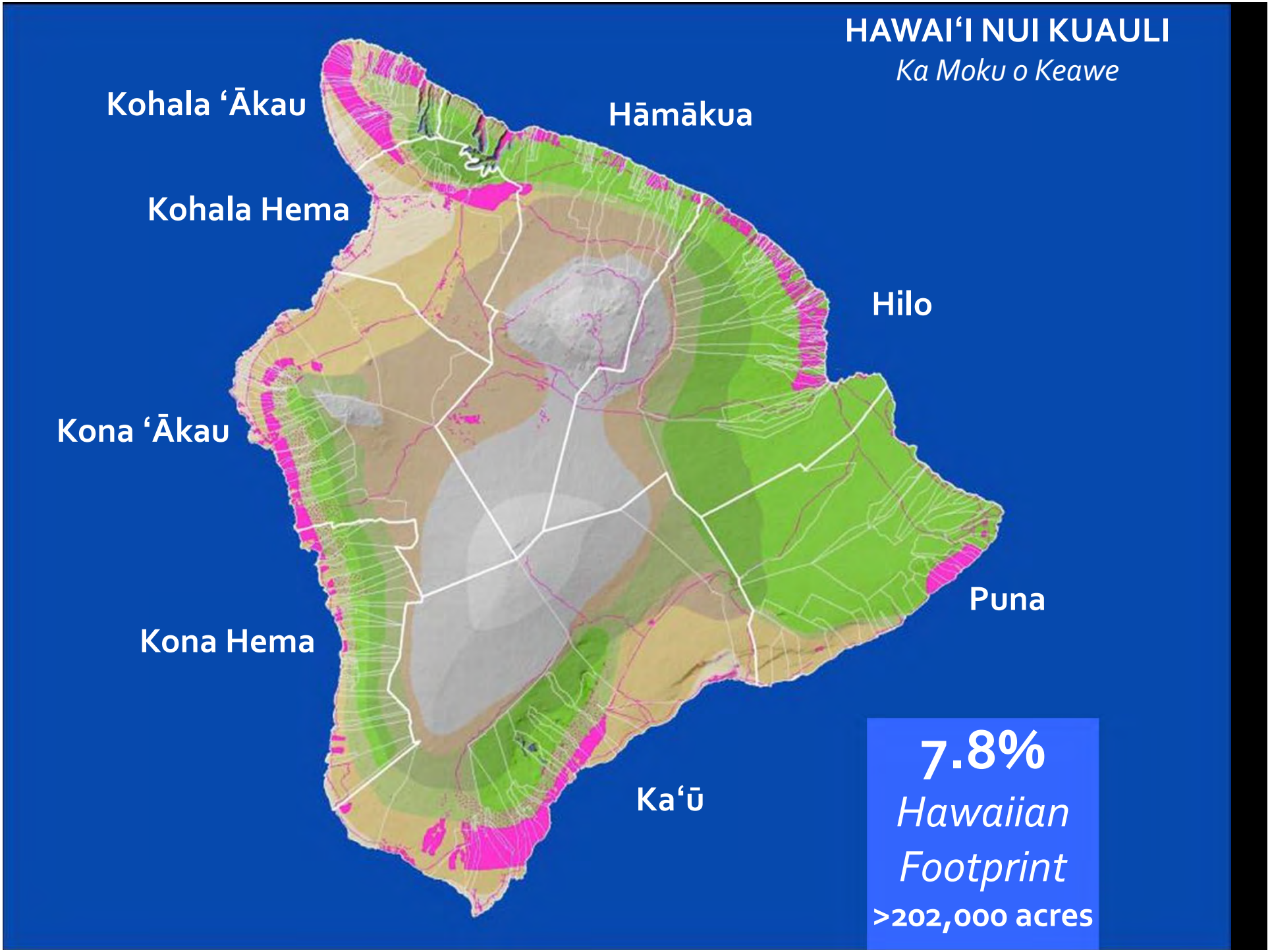
12.5%
Hawaiian Footprint
>5,800 acres



NIʻIHAU O KAHELELANI

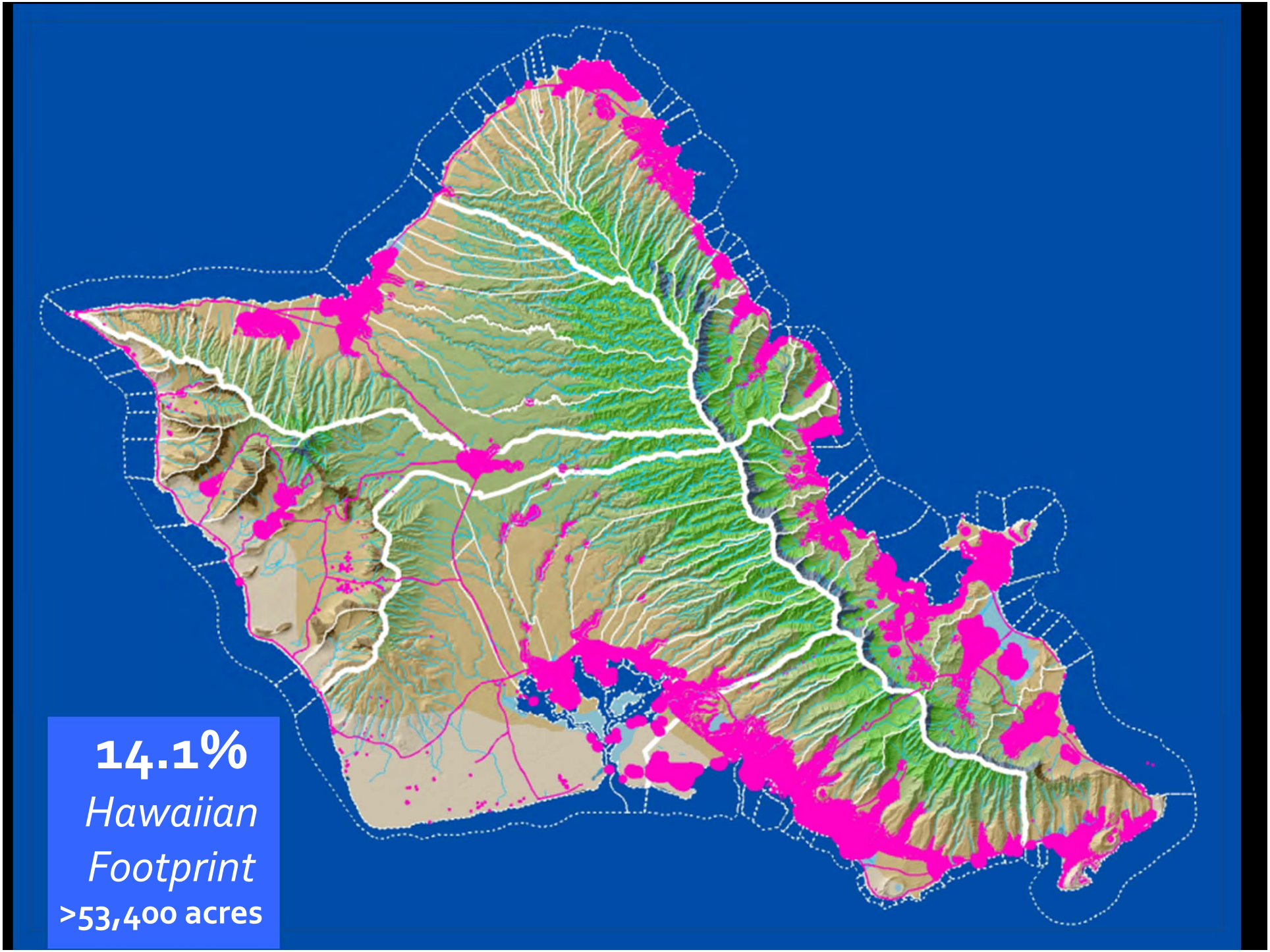
Pā i ka Inuwai

11.1%
Hawaiian Footprint
~39,400 acres


HAWAIʻI NUI KUAULI
Ka Moku o Keawe
Kohala ʻĀkau
Hāmākua
Kohala Hema
Hilo
Kona ʻĀkau
Puna
Kona Hema
Kaʻū
7.8%
Hawaiian Footprint
>202,000 acres

Nā Moku ʻEhā (The 4 Islands)

Island	Footprint (Ac)	%	Est. Population
Hawaiʻi	**202,000**	**53.0**	**265,000**
Oʻahu	**53,400**	**14.0**	**70,000**
Maui	**52,000**	**13.6**	**68,000**
Kauaʻi	**39,400**	**10.3**	**51,500**
Molokaʻi	14,000	3.7	18,500
Lānaʻi	12,900	3.4	17,000
Niʻihau	5,800	1.5	7,500
Kahoʻolawe	1,800	0.5	2,500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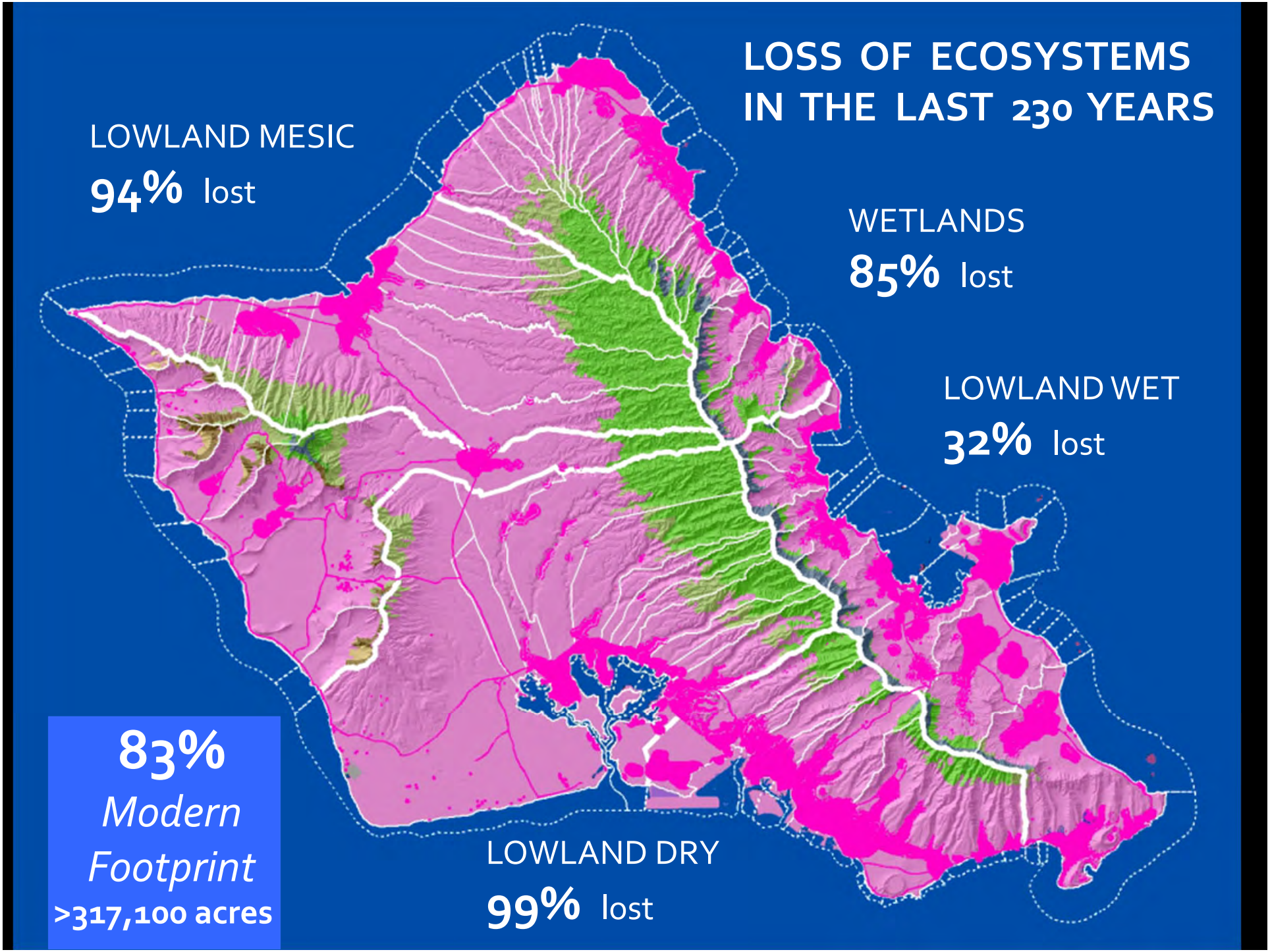
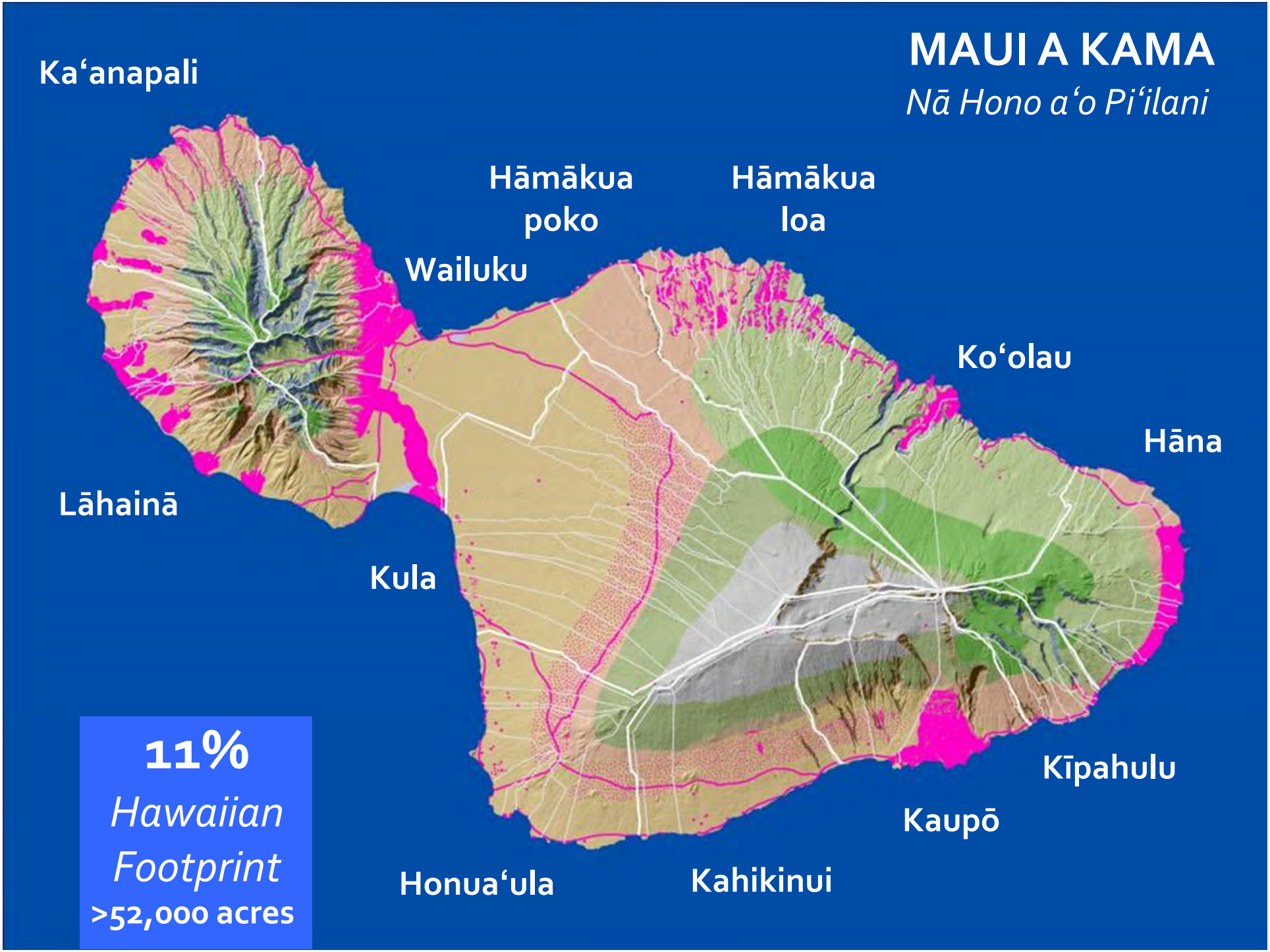

LOSS OF ECOSYSTEMS IN THE LAST 230 YEARS
LOWLAND MESIC
94% lost
WETLANDS
85% lost
LOWLAND WET
32% lost
LOWLAND DRY
99% lost
83%
Modern Footprint
>317,100 acres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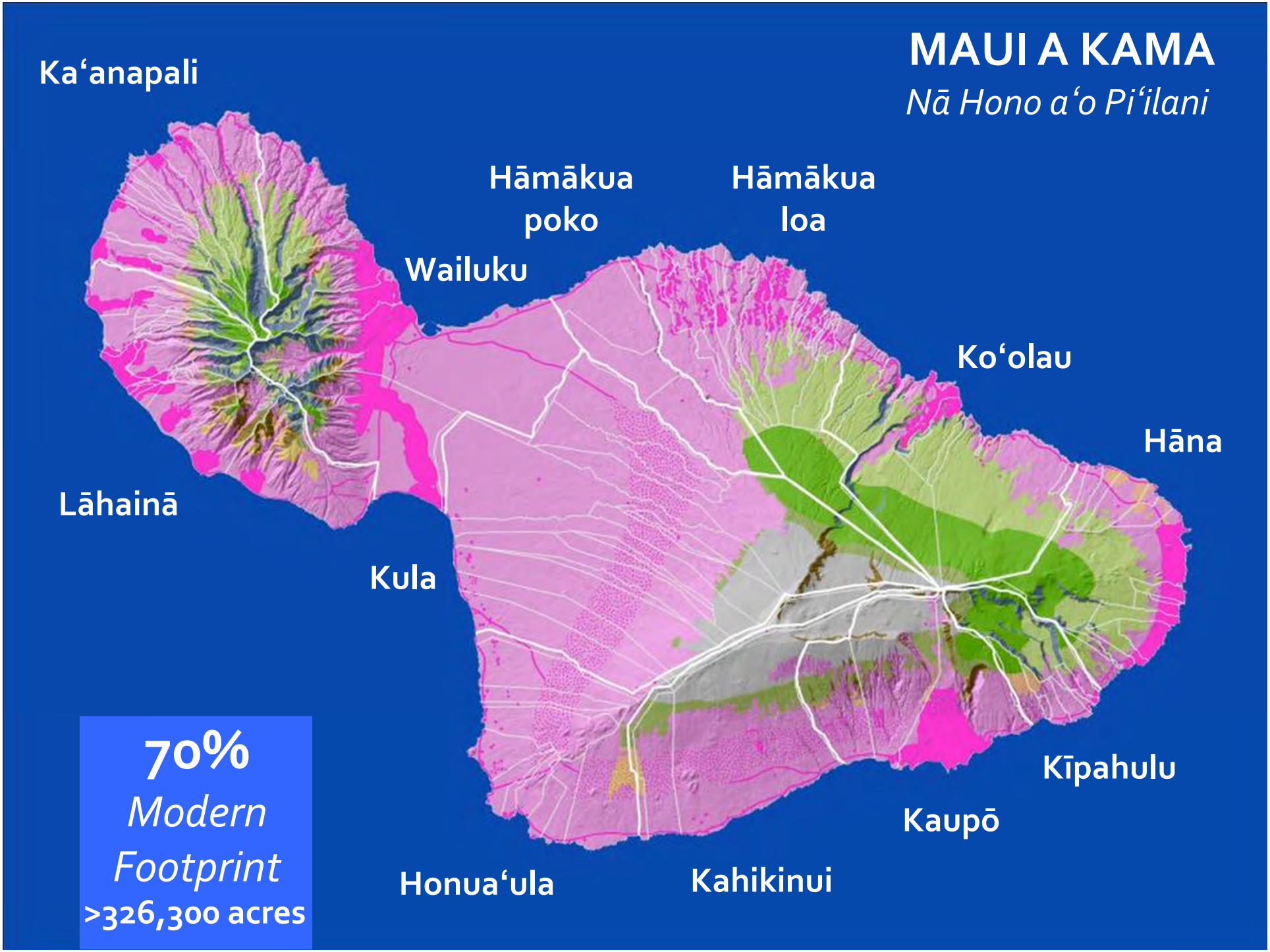
Hāmākua loa
Wailuku
Ko‘olau
Hāna
Lāhainā
Kula
Kīpahulu
Kaupō
Honua‘ula
Kahikinui
11%
Hawaiian Footprint
>52,000 acres


MAUI A KAMA
Nā Hono a‘o Pi‘ilani
Ka‘anapali
Hāmākua poko
Hāmākua loa
Wailuku
Ko‘olau
Hāna
Lāhainā
Kula
Kīpahulu
Kaupō
Honua‘ula
Kahikinui
70%
Modern Footprint
>326,300 acres

MOLOKAʻI NUI A HINA

Ka Pule Oʻo o Lanikāula

8.4%

Hawaiian Footprint

~14,000 acres

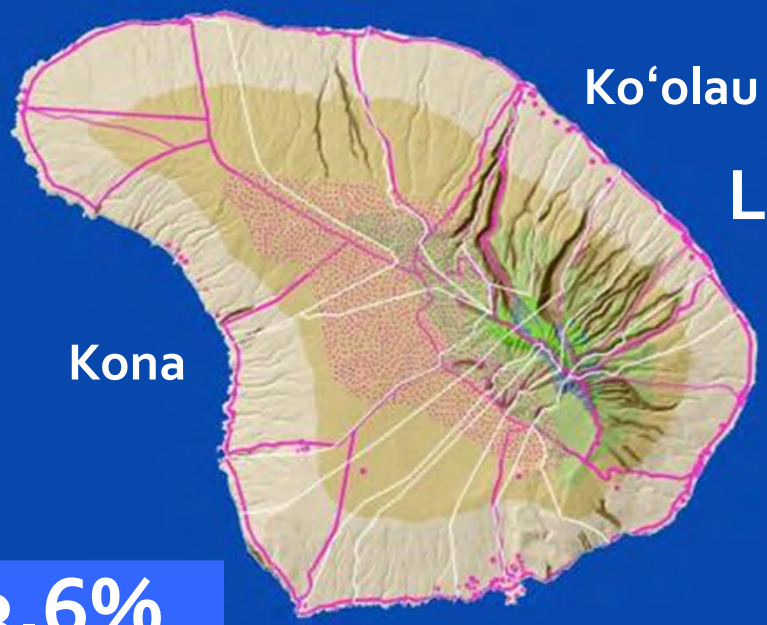
MOLOKAʻI NUI A HINA

Ka Pule Oʻo o Lanikāula

84%

Hawaiian Footprint

~139,690 acres



LĀNAʻI A KAʻULULĀʻAU

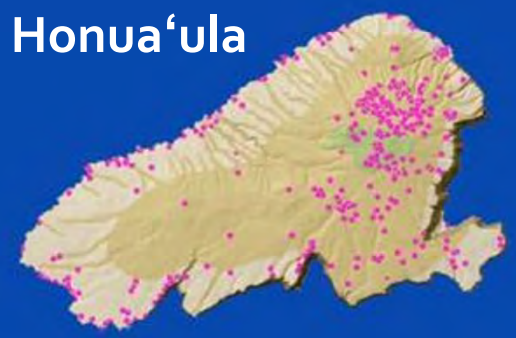
Kū i ke ʻehu o ke kai

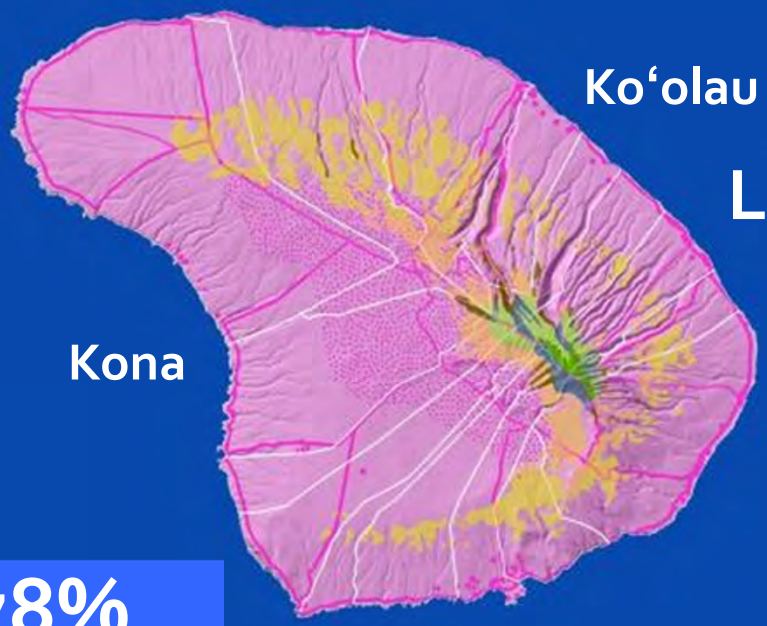
13.6%
Hawaiian Footprint
~12,900 acres

KAHOʻOLAWE KOHEMĀLAMALAMA

Ke kino o Kanaloa

14.3%
Hawaiian Footprint
>1800 acres





LĀNAʻI A KAʻULULĀʻAU

Kū i ke ʻehu o ke kai

78%
Modern Footprint
~70,850 acres

KAHOʻOLAWE KOHEMĀLAMALAMA

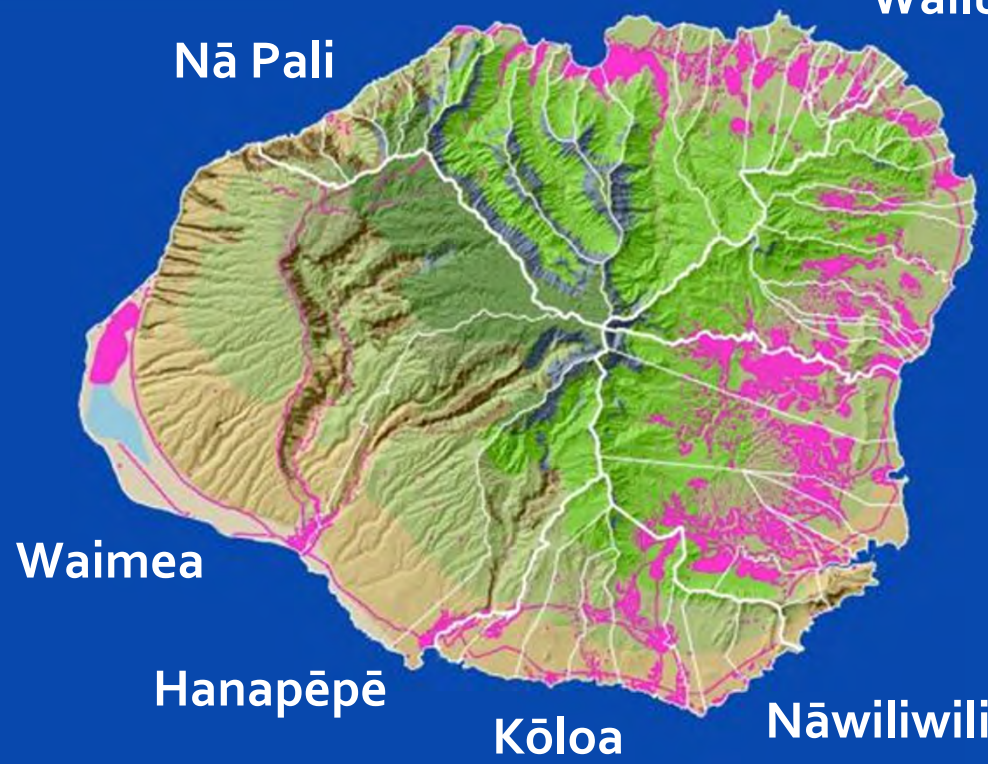
Ke kino o Kanaloa

83%
Modern Footprint
>22,300 acres

KAUAʻI O MANOKALANIPŌ

Hemolele i ka mālie

12.5%
Hawaiian Footprint
>5,800 acres



11.1%
Hawaiian Footprint
~39,400 acres

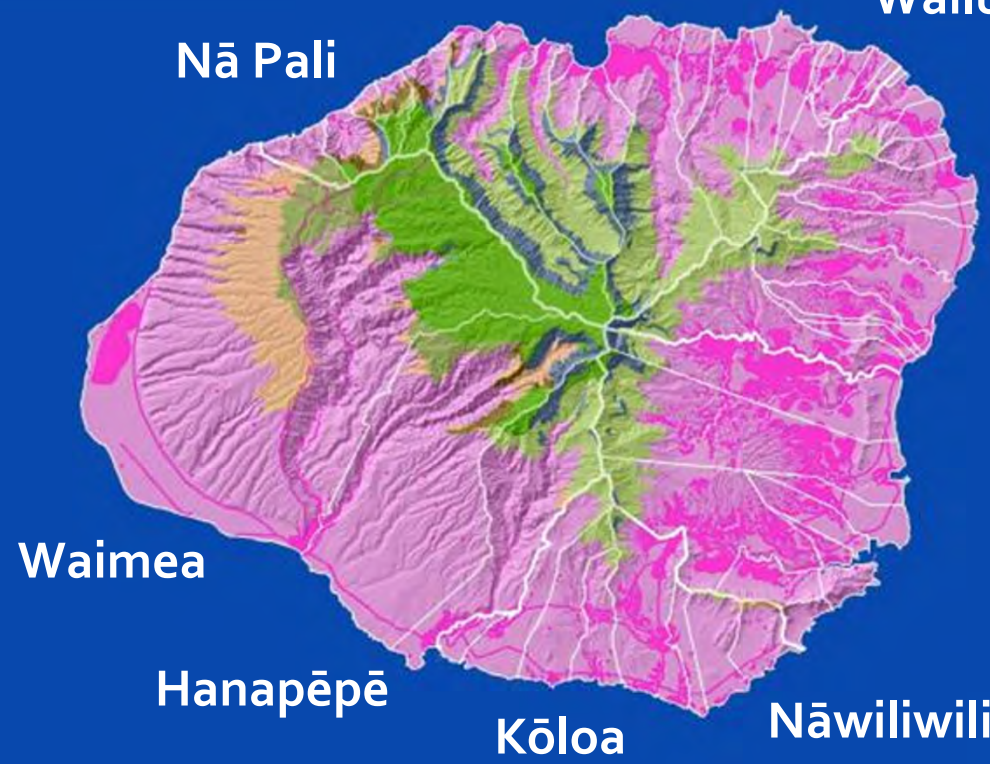
NIʻIHAU O KAHELELANI

Pā i ka Inuwai

KAUAʻI O MANOKALANIPŌ

Hemolele i ka mālie

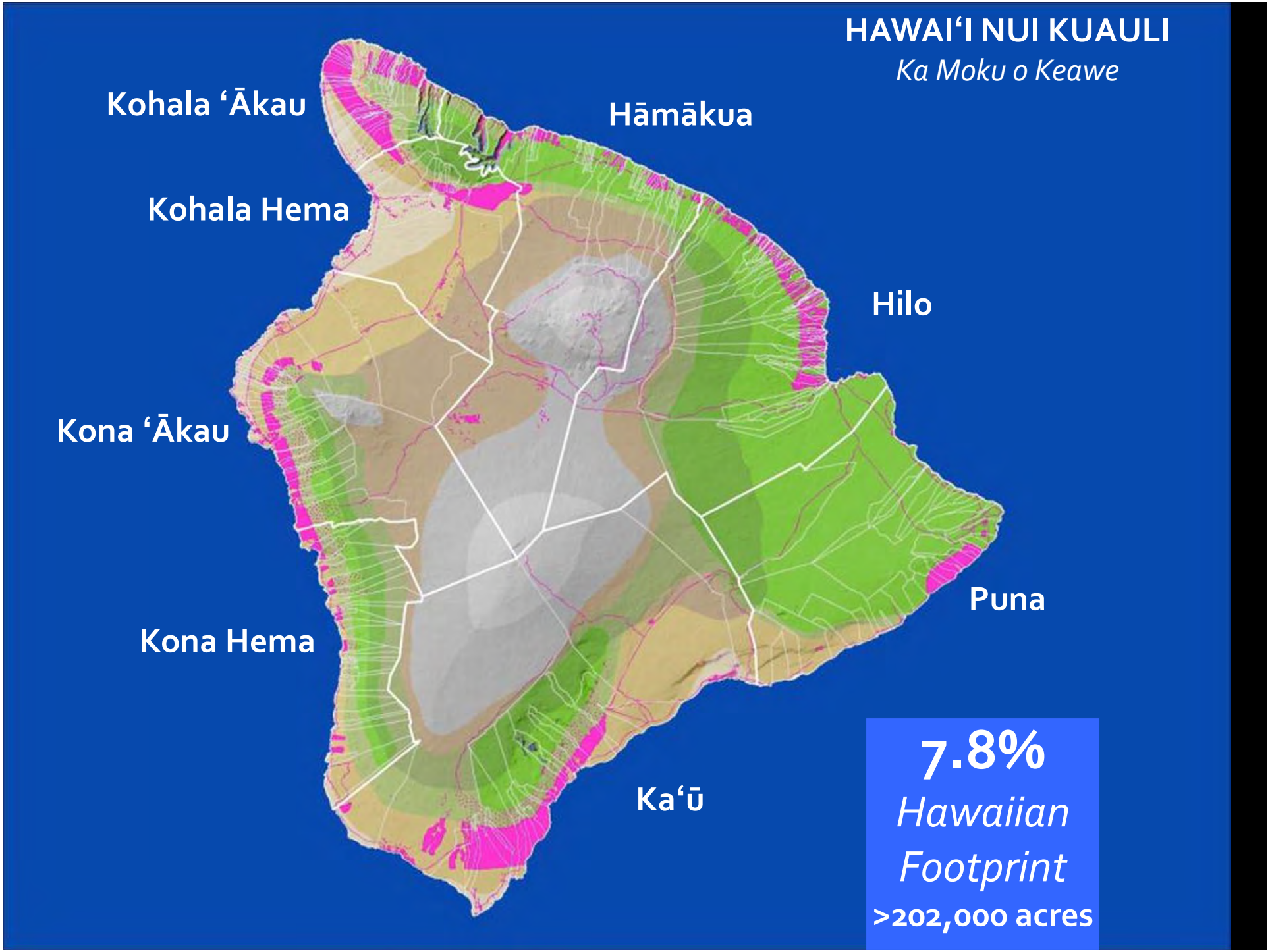
96.4%
Modern Footprint
~44,730 acres



72.1%
Modern Footprint
~243,500 acres

NIʻIHAU O KAHELELANI

Pā i ka Inuwai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Ka Moku o Keawe
Kohala ʻĀkau
Hāmākua
Kohala Hema
Hilo
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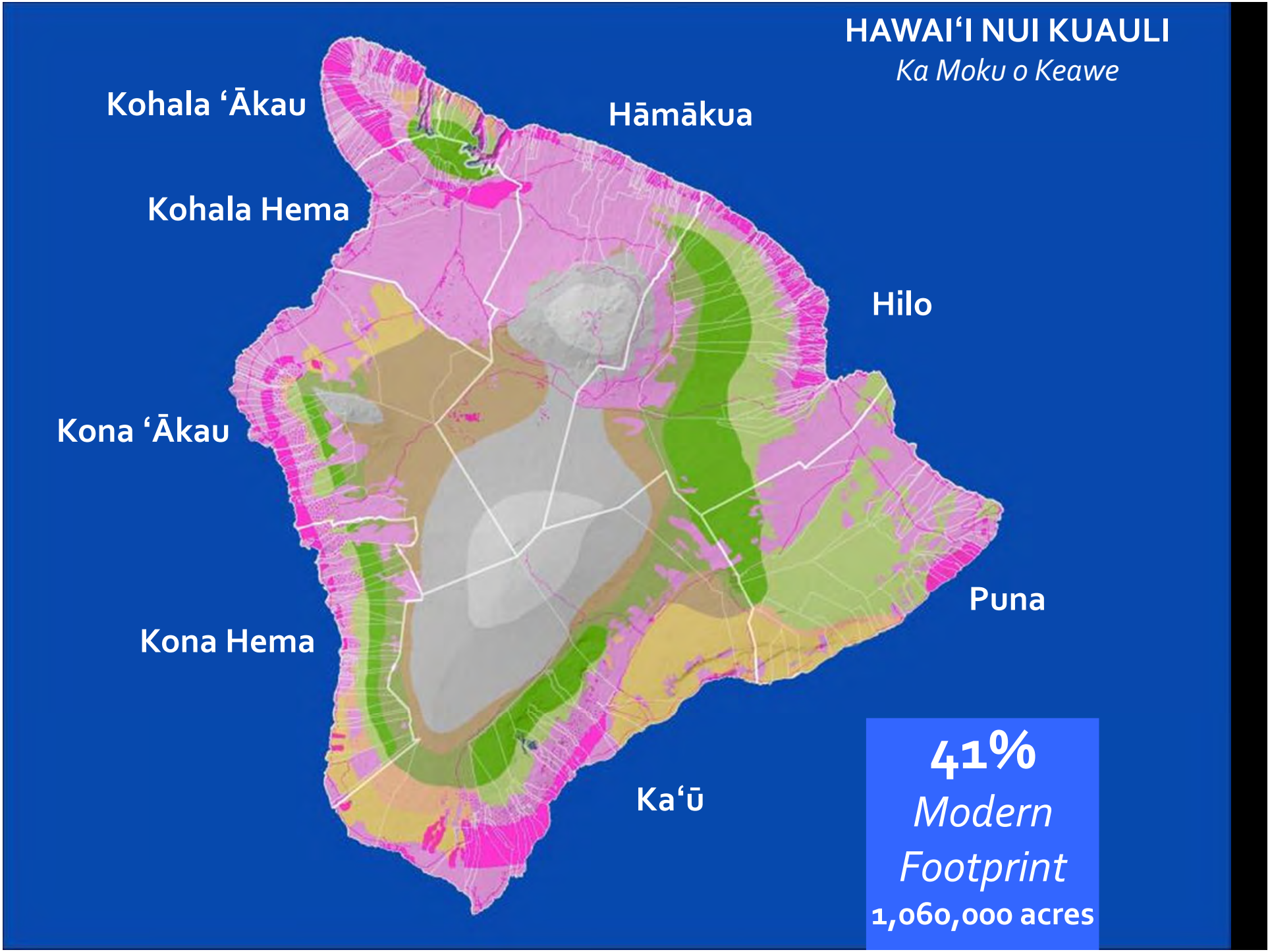
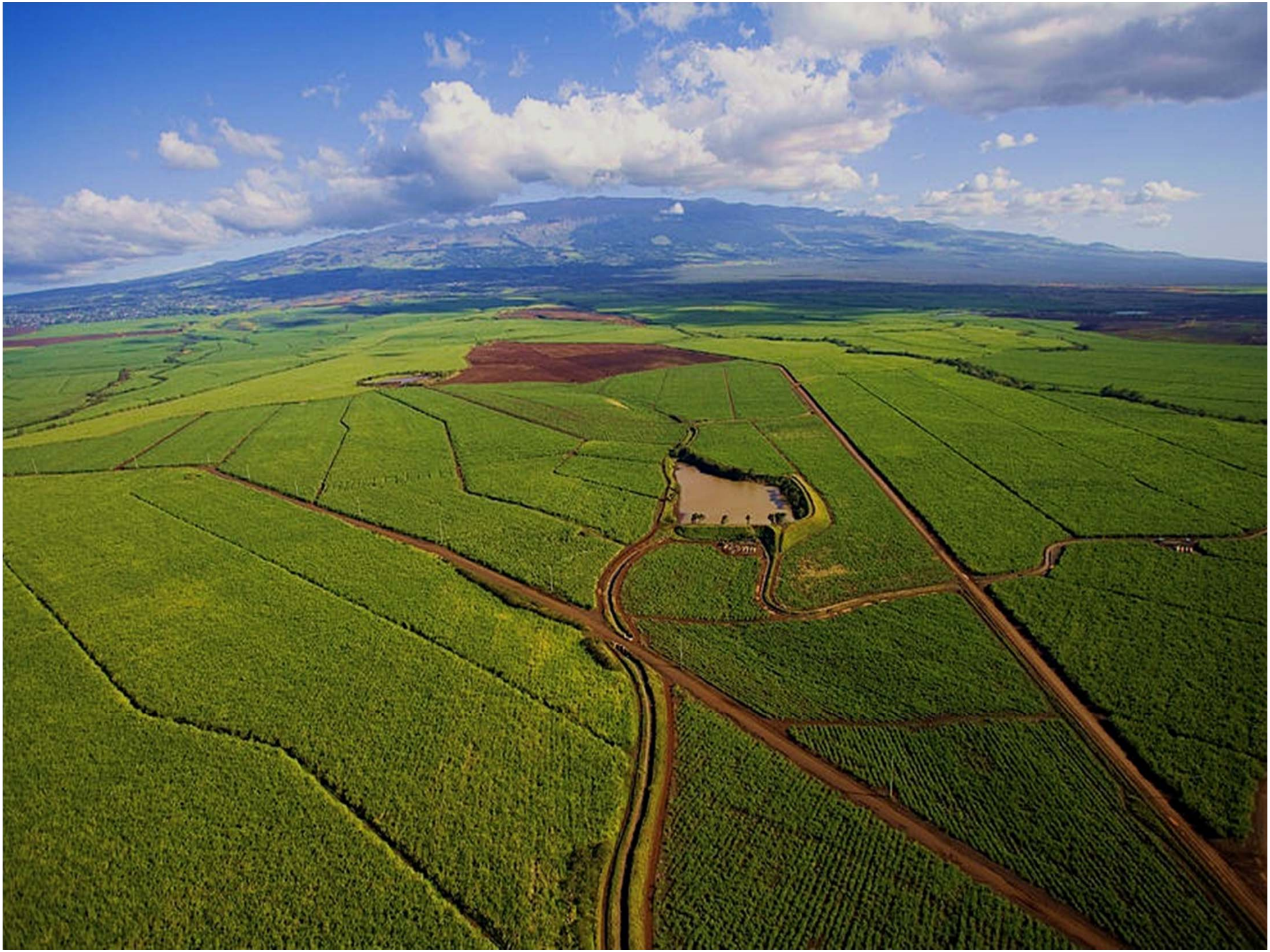
Puna
Kona Hema
Kaʻū
7.8%
Hawaiian Footprint
>202,000 acres


HAWAIʻI NUI KUAULI
Ka Moku o Keawe
Kohala ʻĀkau
Hāmākua
Kohala Hema
Hilo
Kona ʻĀkau
Puna
Kona Hema
Kaʻū
41%
Modern
Footprint
1,060,000 acres



Closing Thoughts

- < 10% Pre-contact Hawaiian Footprint
- > 50% Modern Footprint
- We must reverse this trend

- For more information:
  - Visit OHA's: kipukadatabase.com/apps/footprint
  - Email TNC: hawaii@tnc.org

Mahalo a nui!

- **Office of Hawaiian Affairs**
  - Andrew Choy, Kamoa Quitevis, Zack Smith, Kamana'opono Crabbe
- **The Nature Conservancy of Hawai'i**
  - Stephanie Tom, Sam Aruch, Dwight Matsuwaki
- **State Historic Preservation Division**
- **Hawai'i State Archives**
- **Nā ho'opa'a mo'olelo o ka wā kahiko:**
  - Davida Malo, Samuel M. Kamakau, John Papa 'I'i, Kepelino, Abraham Fornander, Thomas Thrum, Mary Kawena Pukui, George Kanahele, Ross Cordy, a me nā mea 'ē a'e, he nui.
- **Ulukau a me Ho'olaupa'i mā, mea ho'ōla nūpepa**
- **Our map reviewers:**
  - Kepā Maly, Bob Hobdy, Eric Burton, Sabra Kauka, Russell Kallstrom, Jason Jeremiah, Keala Kanaka'ole, Ka'eo Duarte, Ross Cordy, Chipper Wichman, Kāwika Winter, and many others…