Soil Carbon in Hawaiian Rangelands

NICK KRUEGER

Presentation Outline

Rationale

Context

Methods

Preliminary Results

Rationale

Growing interest in carbon

Baseline data

Identification of soil carbon drivers

Additional income source for local producers

Soil Carbon: Two Ways of Expressing

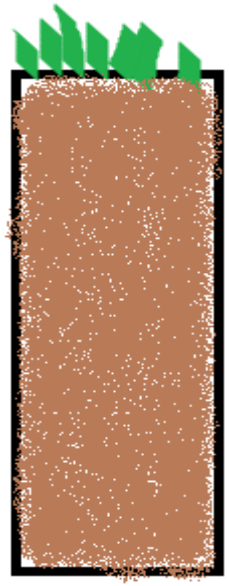
- **Agronomic: Concentration**
  - Mass carbon / Mass soil = Percent
  - Determined on a mg/kg basis by combustion analysis
- **Carbon Sequestration: Stock**
  - Mass carbon / area to given depth

$$\textbf{Carbon Stock} = \frac{\textbf{Carbon (Mg)}}{\textbf{Soil Mass (Mg)}} \times \frac{\textbf{Soil Mass (Mg)}}{\textbf{Area (ha)}}$$

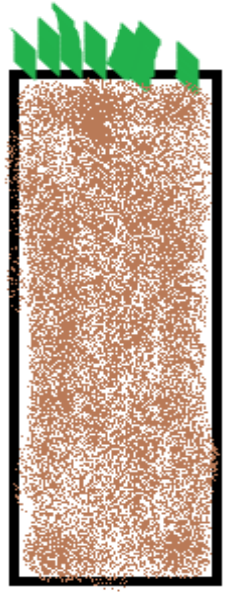
Soil mass varies greatly between soil types

Example of soil mass variation

1,570 kg soil for a grassland soil from Iowa per m^2 to 1m depth



920 kg soil for a grassland soil from Honoka'a per m^2 to 1m depth



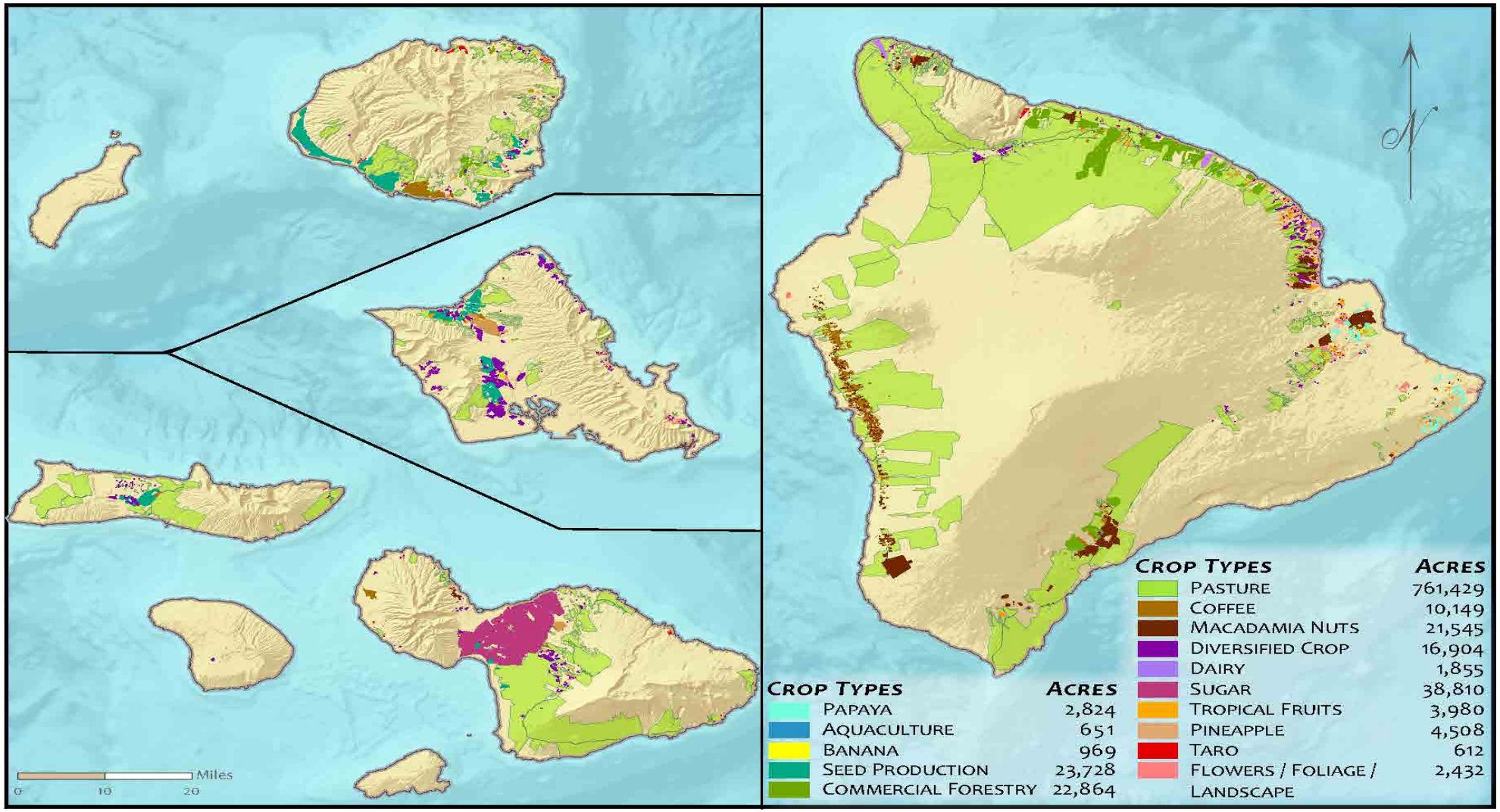
National Cooperative Soil Survey
National Cooperative Soil Survey Characterization Database
http://ncsslabdatamart.sc.egov.usda.gov/

Stocks

- Mass of carbon per area to defined depth

1,570 kg soil for a grassland soil from Iowa per m^2 to 1m depth		**2% Carbon Concentration**		**32 kg carbon stock per m^2 to 1m depth**
920 kg soil for a grassland soil from Honoka'a per m^2 to 1m depth		**8% Carbon Concentration**		**74 kg carbon stock per m^2 to 1m depth**

Rangelands in Hawaii



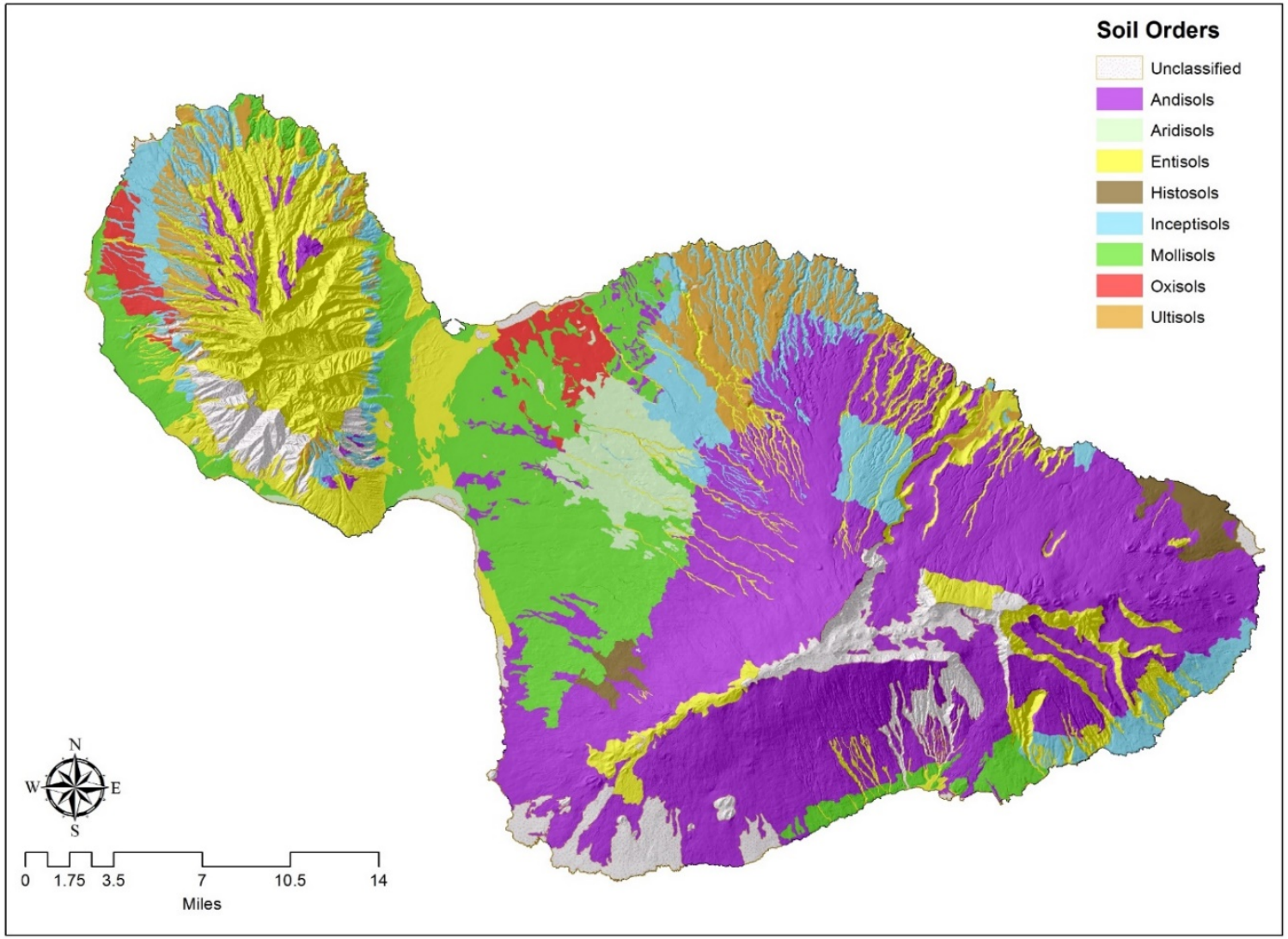
University of Hawai'i Hilo

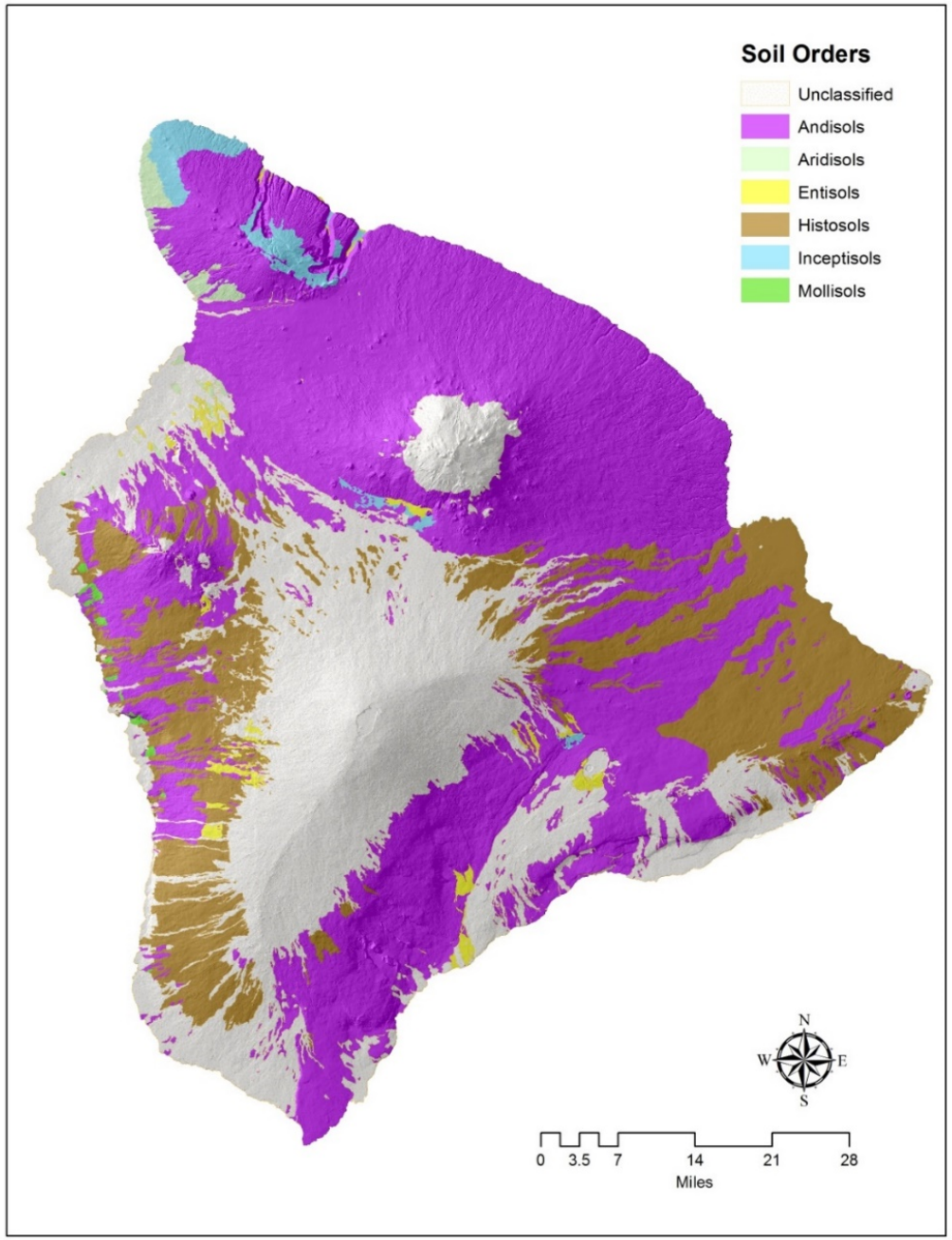
SDAV UH Hilo

Hawai'i Agricultural Land Utilization (2015)

Department of Agriculture State of Hawaii

Soil Orders throughout Maui and Hawaii Island





Andisols

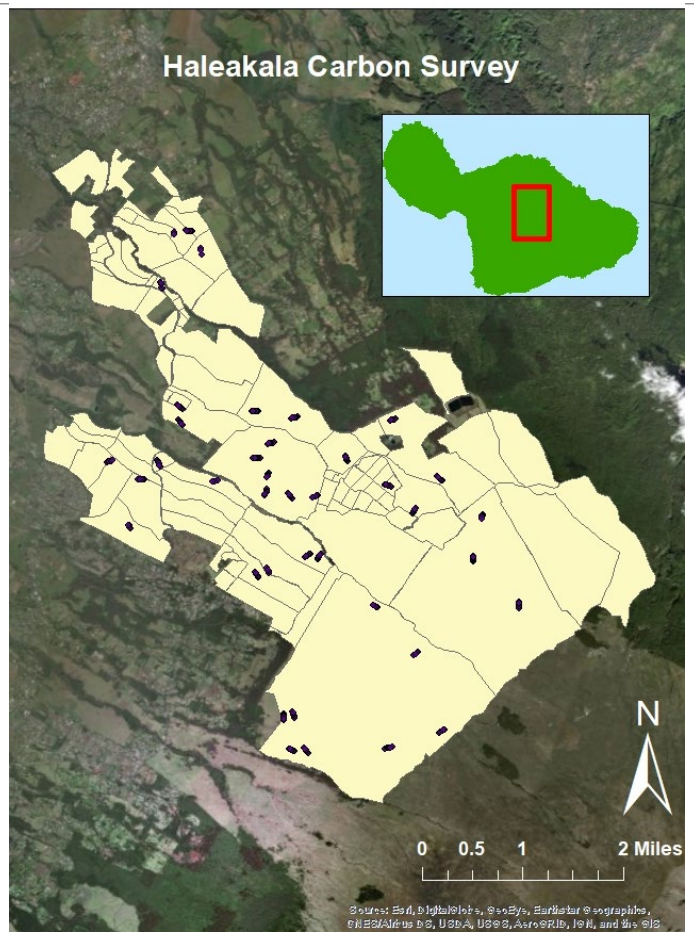
- <1% of the world's soils
- Store 1.8 – 5% of the world's soil organic carbon
- ≈39% of Hawaii's land area (818,479 acres)
- Not all Andisols are equal

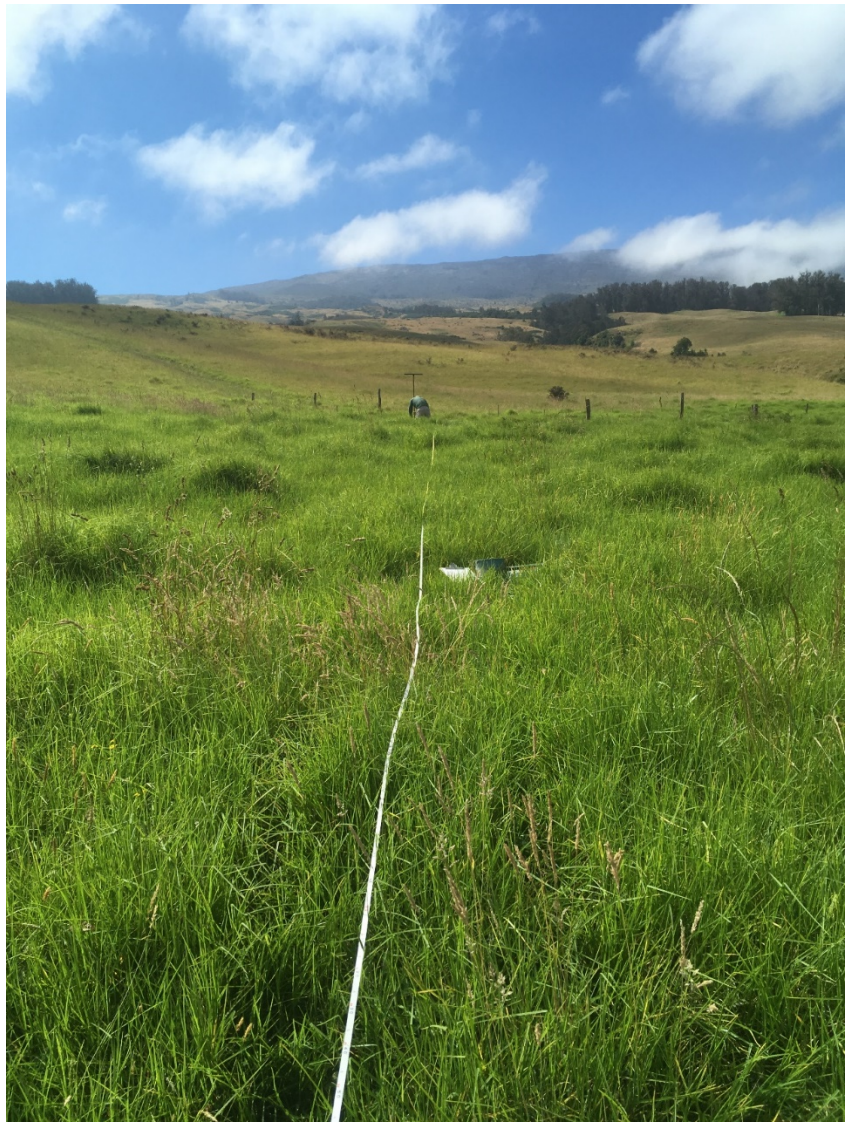
Methods

Sample collection along transects

Sampling sites were representative, actively grazed areas

Majority of ranch situated on Andisols





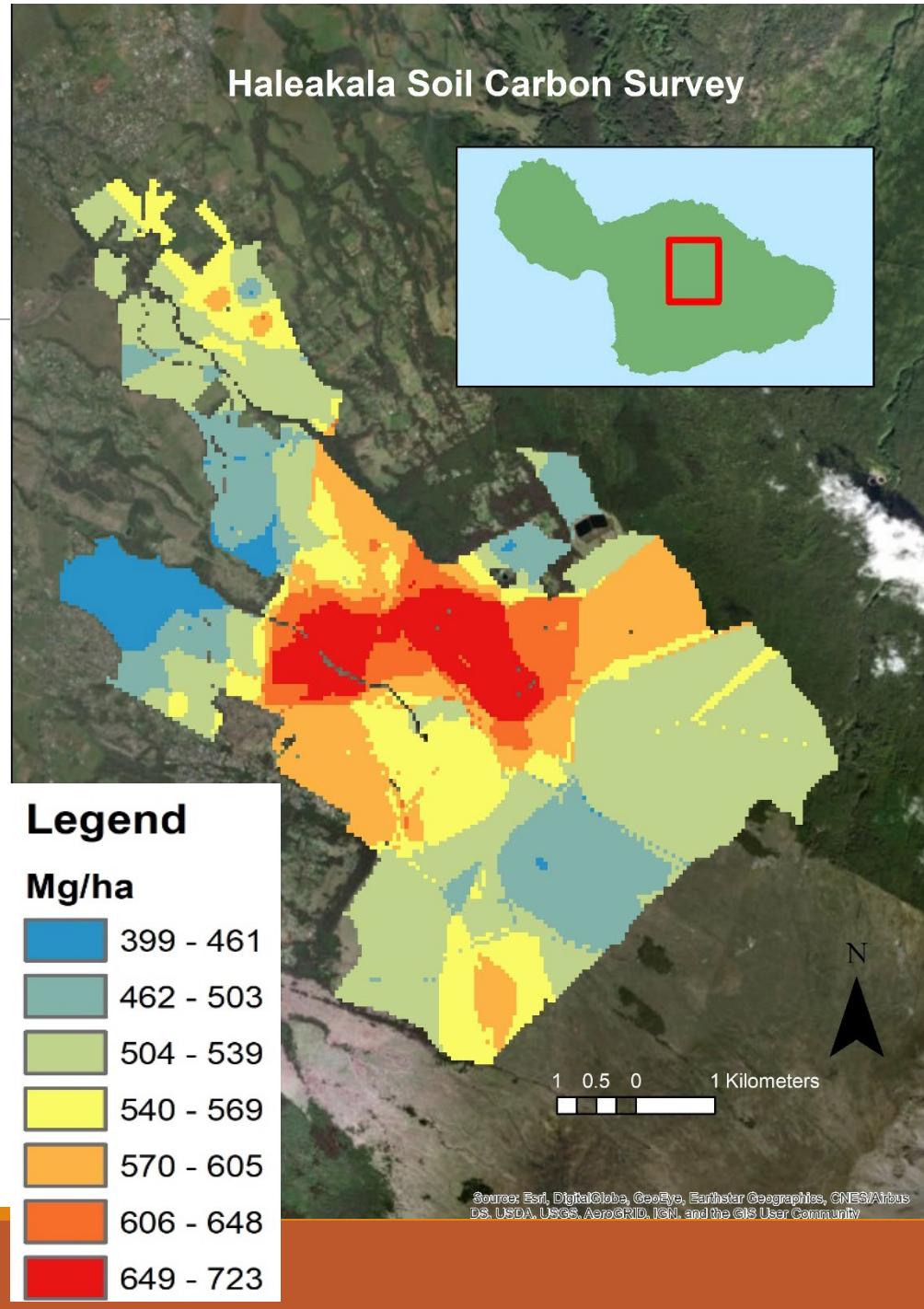
Preliminary Results

Average carbon concentration and stock across pasture systems	
System	Carbon Stock
	---Mg ha^{-1}---
Haleakalā Ranch 1m depth	552
English pasture extensively managed 1m depth (Soil type not reported)	414
Australian pasture rotationally grazed 30cm depth (Soil type not reported)	39

Chan et al., 2010. Ward et al., 2016

Spatial Distribution of Soil Carbon

- Highest carbon sequestration potential occur at mid-elevation locations
- Carbon concentration (%) increases with elevation
- Soil mass (Mg/ha) decreases with elevation



Soil carbon concentration, mass and stock between different soil types throughout Haleakalā Ranch

Series	Soil Type	Carbon Conc. (%)	Soil Mass (Mg ha^{-1})	Carbon Stock (Mg ha^{-1})
Laumaia	Andisol	10.1	5691	546
Kaipoioi	Andisol	9.9	5469	519
Kula	Andisol	9.1	6521	575
Olinda	Andisol	8.7	7046	596
Pane	Andisol	6.4	9885	553
Haliimaile	Inceptisol	4.8	11746	488

Comparison of soil carbon concentration and stock by depth increment between Haleakalā Ranch and a representative Midwestern productive soil.

Haleakalā Ranch		
Depth	**Carbon Conc.**	**Carbon Stock**
---cm---	---%---	---Mg ha^{-1}--
0-15	10.5	113
15-30	7.7	89
30-50	7.4	107
50-75	7.0	123
75-100	6.4	119

Clarion soil series Mollisol (Iowa).		
Depth	**Carbon Conc.**	**Carbon Stock**
---cm---	---%---	---Mg ha^{-1}--
0-23	1.7	64
23-33	1.3	20
33-48	0.9	21
48-70	0.5	17
70-87	0.4	11

Comparison of soil carbon stocks and aboveground carbon stocks of forest and grassland systems

Forest- Soil	Carbon Stocks (Mg/ha)
Eucalyptus Forest (Crow et al., 2016)	595
Hamakua ohia forest (Osher et al., 2003)	289
Hakalau Forest (Selmants et al., 2014)	253

Grassland- Soil	Carbon Stocks (Mg/ha)
Haleakalā Ranch	552
Hamakua pasture (Osher et al., 2003)	340
Mauna Kea Native Grassland (Kramer & Chadwick, 2016)	11 - 150

Aboveground	Carbon Stocks (Mg/ha)
Closed canopy koa and ohia forest (Hughes et al., 2018)	93
Eucalyptus Forest (Crow et al., 2016)	57
Temperate grassland (Liu et al., 2016)	2

Comparison of carbon concentrations and stock throughout Hawaii soils

Soil Series	Soil Type	Av. Soil Mass/Volume (oven-dry,g/cm^3)	Av. Carbon to 1m (%)	Av. Carbon mass to 1m (Mg/ha)
Kula	Andisol	1.10	7.9	869
Pane	Andisol	1.01	7.4	747
Honoka'a	Andisol	0.92	4.8	442
Waimea	Andisol	0.82	4.6	377
Kapa'a	Oxisol	1.23	1.4	172
Keahua	Mollisol	1.48	0.9	133
Wahiawa	Oxisol	1.50	0.8	120
Lualualei	Vertisol	1.25	0.4	50

Takeaways

Soil carbon stocks averaged 550 Mg carbon ha^{-1} to 1 meter depth: comparatively high for both regional and global contexts

Mauka portion of Haleakalā Ranch contained over 2 million Mg soil carbon across 3,700 hectares

- Currently priced at $15/Mg (California Carbon Dashboard) = **$30 million USD**

Substrate and environmental factors have large impact on soil carbon across similar management regimes

130+ years of managed grazing have resulted in high grassland productivity and permanent landcover

Mahalo’s

- Dr. Becca Ryals
- Dr. Jonathan Deenik
- Greg Friel
- Jordan Jokiel
- Haleakalā Ranch
- Nā paniolo