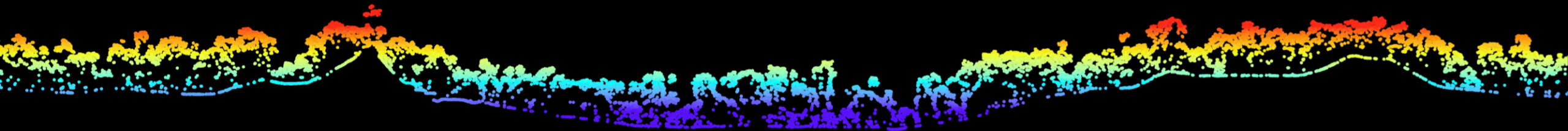# Investigating the Land Use Legacy of the Maya Civilization in the Northeastern Petén, Guatemala
through LiDAR Remote Sensing

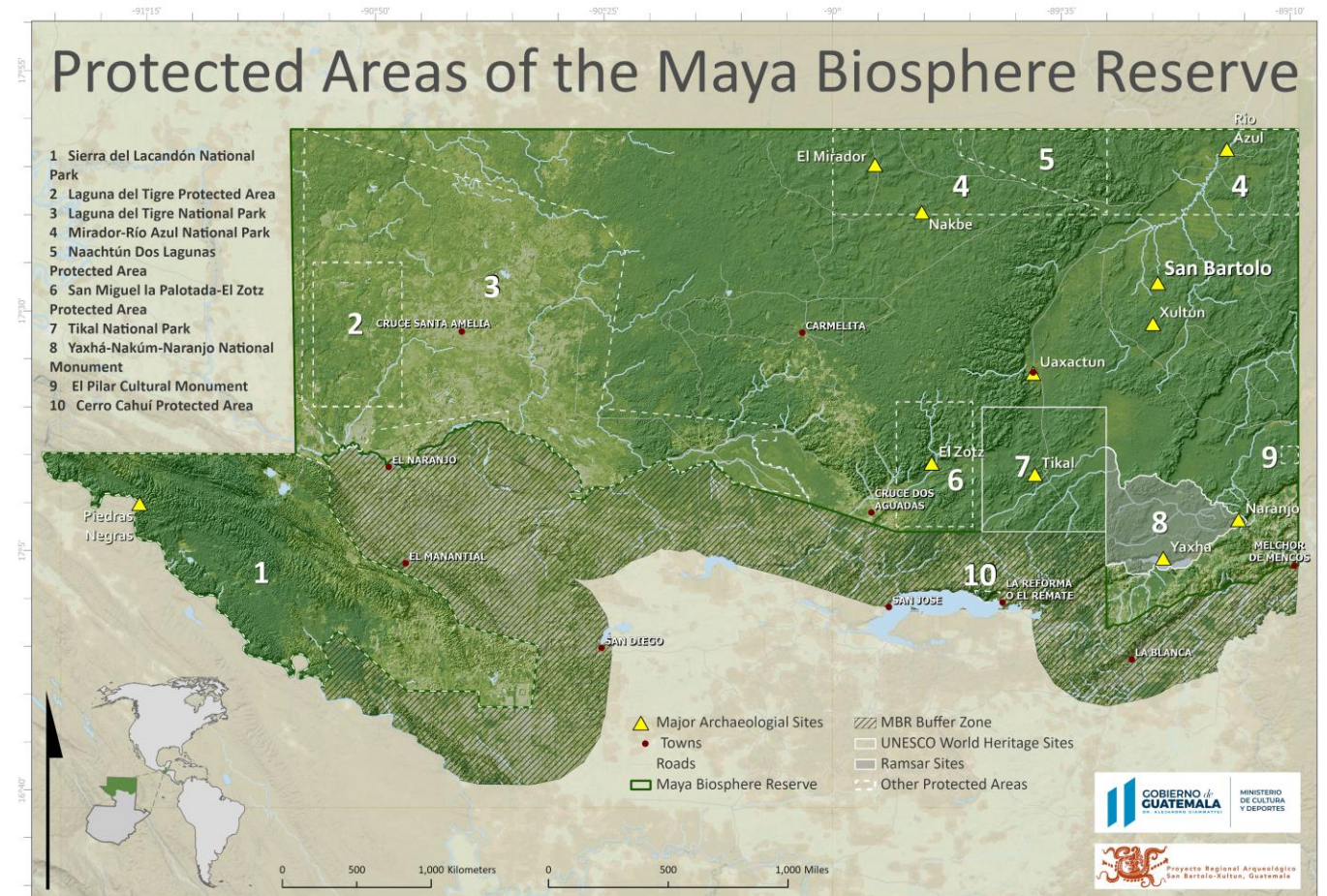Maggi Schick, Robert Griffin, Kelsey Herndon, Farnaz Bayat

University of Alabama in Huntsville

Earth System Science Center (ESSC)

Petén & Maya Biosphere Reserve (MBR)

- The Petén is the northernmost department of Guatemala
  - Includes the MBR
  - Home to numerous ancient Maya sites
- The MBR was designated in 1990 to protect one of the largest tropical forests north of the Amazon and to aid in sustainable development through conservation planning (UNESCO, 2020)
- This area is known for its rich species biodiversity, high density of archaeological sites, and popular ecotourism

Protected Areas of the Maya Biosphere Reserve

1 Sierra del Lacandón National Park
2 Laguna del Tigre Protected Area
3 Laguna del Tigre National Park
4 Mirador-Río Azul National Park
5 Naachtún Dos Lagunas Protected Area
6 San Miguel la Palotada-El Zotz Protected Area
7 Tikal National Park
8 Yaxhá-Nakúm-Naranjo National Monument
9 El Pilar Cultural Monument
10 Cerro Cahuí Protected Area

Major Archaeological Sites
Towns
Roads
Maya Biosphere Reserve
MBR Buffer Zone
UNESCO World Heritage Sites
Ramsar Sites
Other Protected Areas

Maya Society in San Bartolo & Xultun

- San Bartolo and Xultun were successful Maya cities home to rich cultures, royal elites, and religious ceremonies recorded in writing/art
  - The start of occupation at San Bartolo dates back to the early in the Middle Pre-Classic period (± 800 BC) and carried on through to the Late Classic period (900 AD). (UNESCO, 2020)
  - San Bartolo contains some of the oldest Mesoamerican murals and tombs that we know of
  - These cities included public plazas, courtyards, ball courts, stelae, and monuments (Garrison and Dunning, 2009)
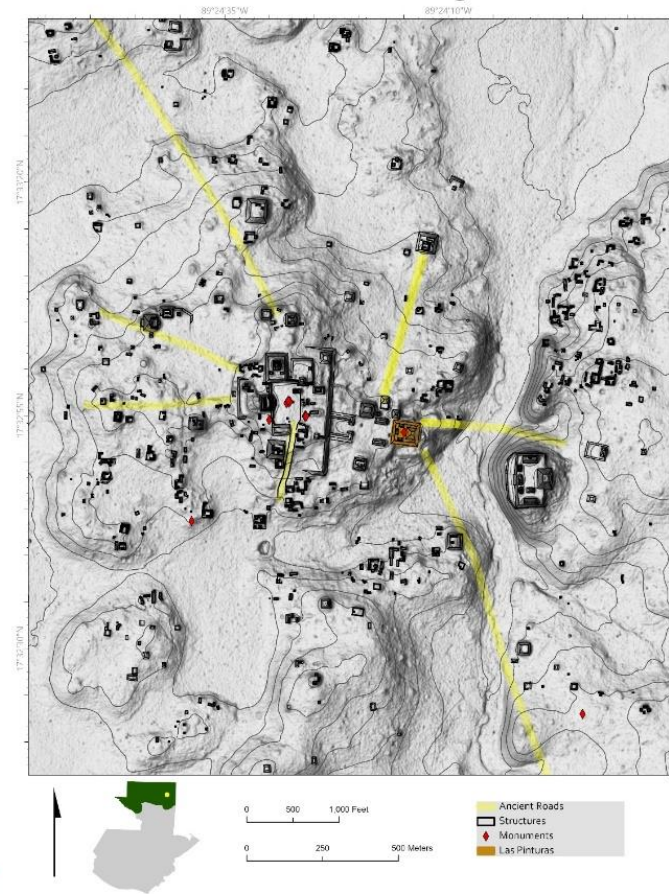

San Bartolo Archaeological Site
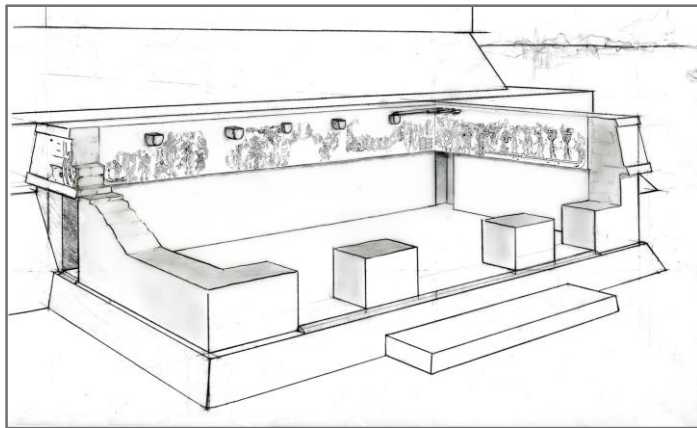
Heather Hurst, architectural reconstruction of the murals at San Bartolo, 2004

Heather Hurst, San Bartolo North Wall Mural Rendering, 2004

Land Use Legacy of the Maya

Land Use Legacy refers to the long-term impacts of human land use practices on the environment, which can include changes to soil quality, vegetation patterns, and water availability. This legacy can persist for centuries or even millennia after the cessation of land use practices. (Foster and Aber, 2004)

- The Maya had a sophisticated understanding of city planning and agricultural practices
  - Practices such as farming techniques, burning, using specific materials to construct structures, handling of waste, and water management all have the ability to change the surrounding soil and vegetation
- The region has been relatively undisturbed since the collapse of the Maya civilization
  - This provides us with a unique opportunity to evaluate the long-term effects of human alterations of a landscape
- Our thesis involves how land alterations can impact modern:
  - Vegetation health
  - Agricultural productivity
 - Forest structure
  - Biodiversity

LiDAR for Archaeology

- LiDAR has been revolutionary in the field of archaeology
  - Allows researchers to easily identify ancient sites hidden underneath dense tree canopy
  - The discovery of new sites and features have the ability to change our understanding of the Maya society, their relationship with the land, and potentially the collapse of the civilization as a whole

LiDAR for Archaeology

Ancient Agriculture

- Pacunam LiDAR Initiative
  - Efficiently process LiDAR DEMs and rapidly digitize archaeological interests to preserve Guatemala's natural and cultural heritage
  - LiDAR-based identification of the following features:
    - Structures
    - Agricultural terraces
    - Platforms
    - Defensive features
    - Monuments
    - Quarries
    - Causeways
    - Chultuns
    - Aguadas
    - Caves & sinkholes
    - Looting trenches
    - Modern paths & infrastructure


Ancient Structures
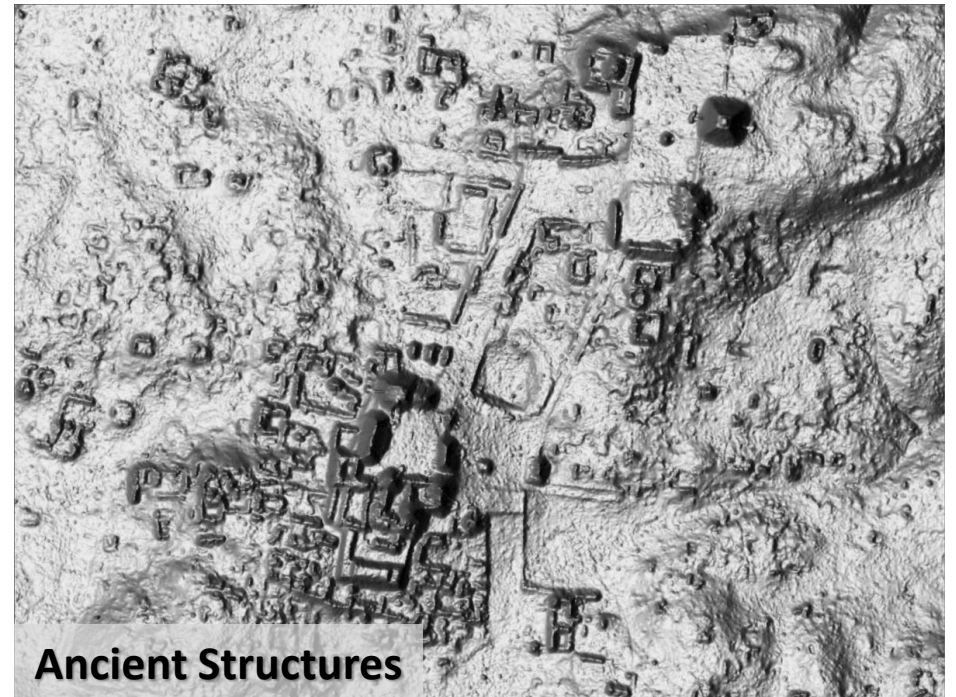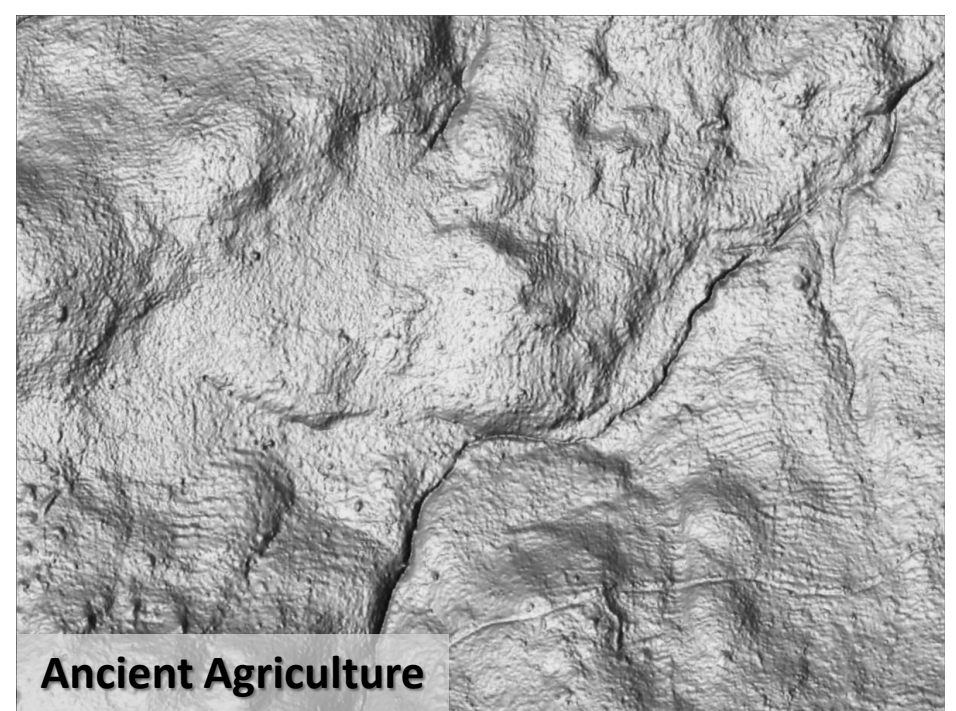
LiDAR for Archaeology

- Over 6,000 structures have been identified in the San Bartolo-Xultun region by researchers and students from Skidmore University and UAH

- Validation of all delineated features has been an ongoing process in the field for years along with excavations and scientific field surveys
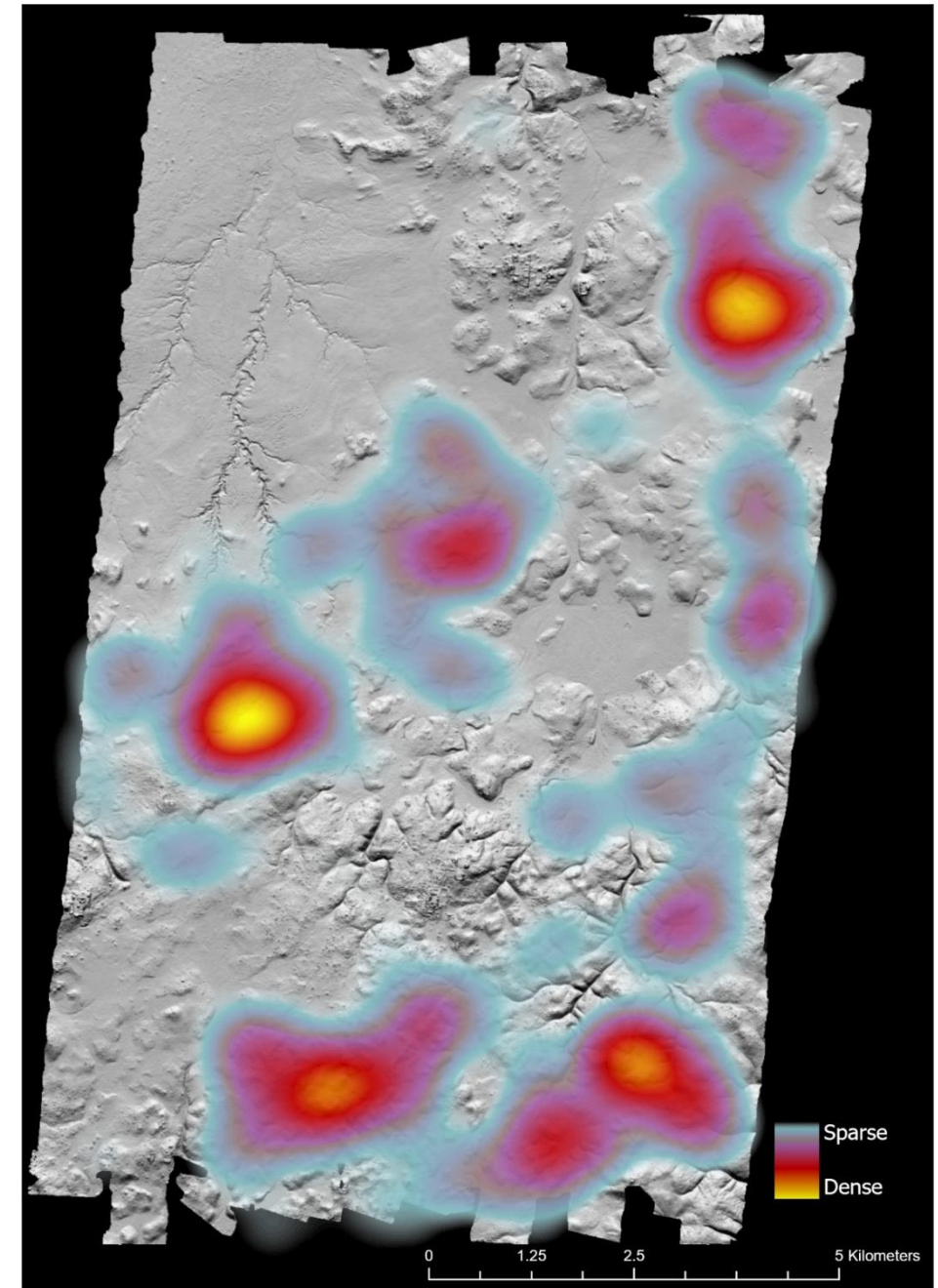
Topics of Interest – Agricultural Productivity

- ## Investigation of modern-day agriculture and length of fallow periods in the MBR
  - Along with soil samples, could provide useful information for future studies as to the agricultural productivity of ancient terraced lands vs non-terraced lands
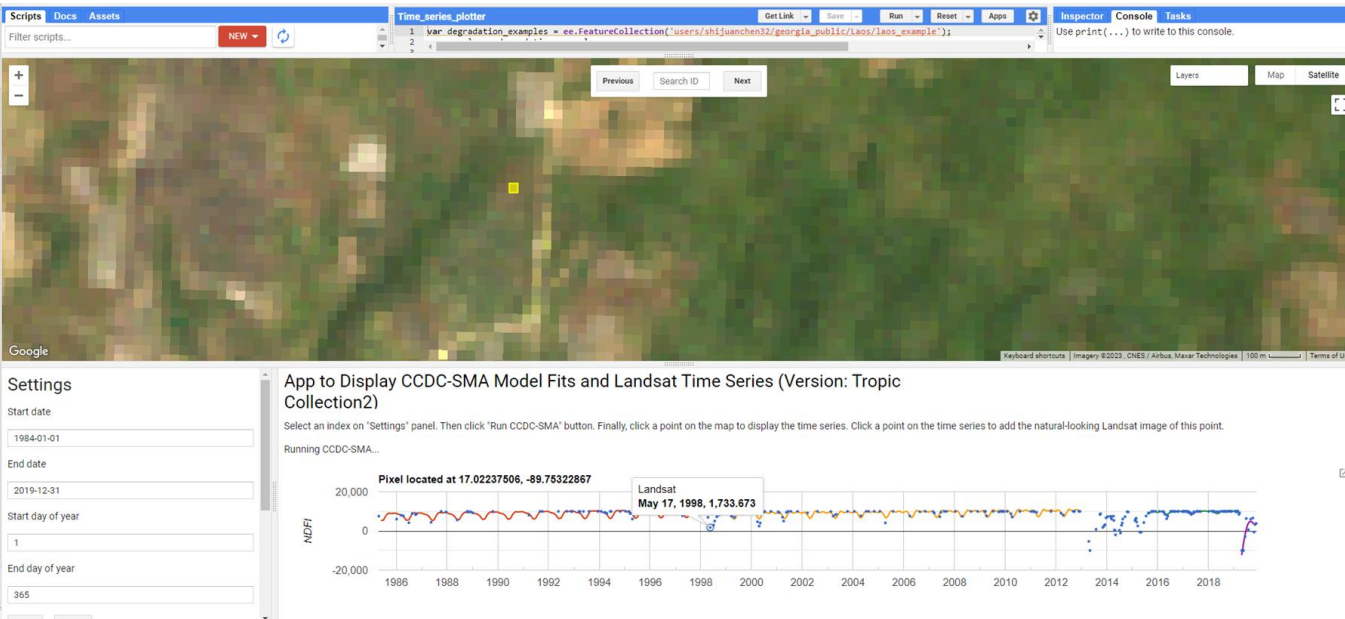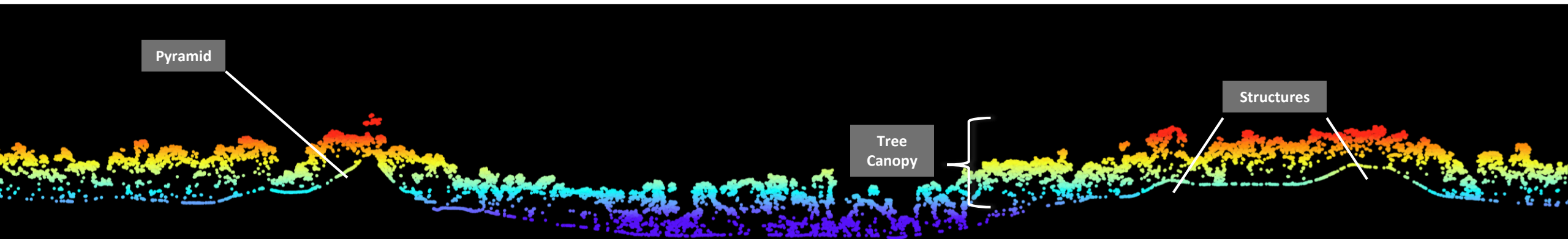

CCDC-SMA (Chen et al., 2021)

LandTrendr (Kennedy et al., 2010)

Topics of Interest – Forest Structure/Health

- Three dimensional views of archaeological remains can illustrate the scale of these sites

- LiDAR is critical to ecological research endeavors such as forest structure analysis due its ability to reconstruct canopy layers

Topics of Interest – Forest Structure/Health

- Modelling forest stand height and biomass
  - These different forest types (scrub bajo, palm forest, & upland forest) are clearly distinguishable in the LiDAR 3D point cloud
- Future work will compare forest structure metrics, like biomass and forest stand height, with areas of ancient land use
  - These metrics will serve as inputs into a clustering algorithm to classify modern forest types across the region based on the 3D structure
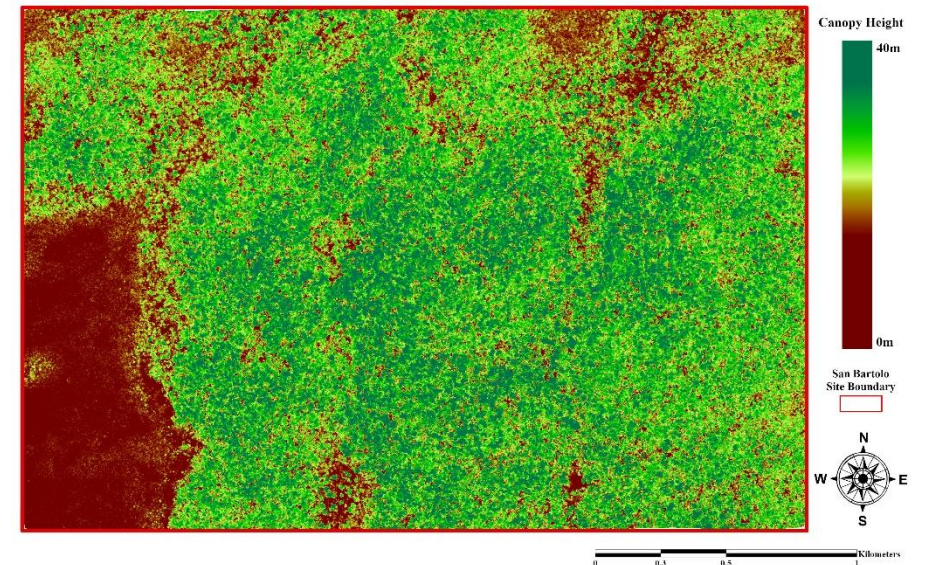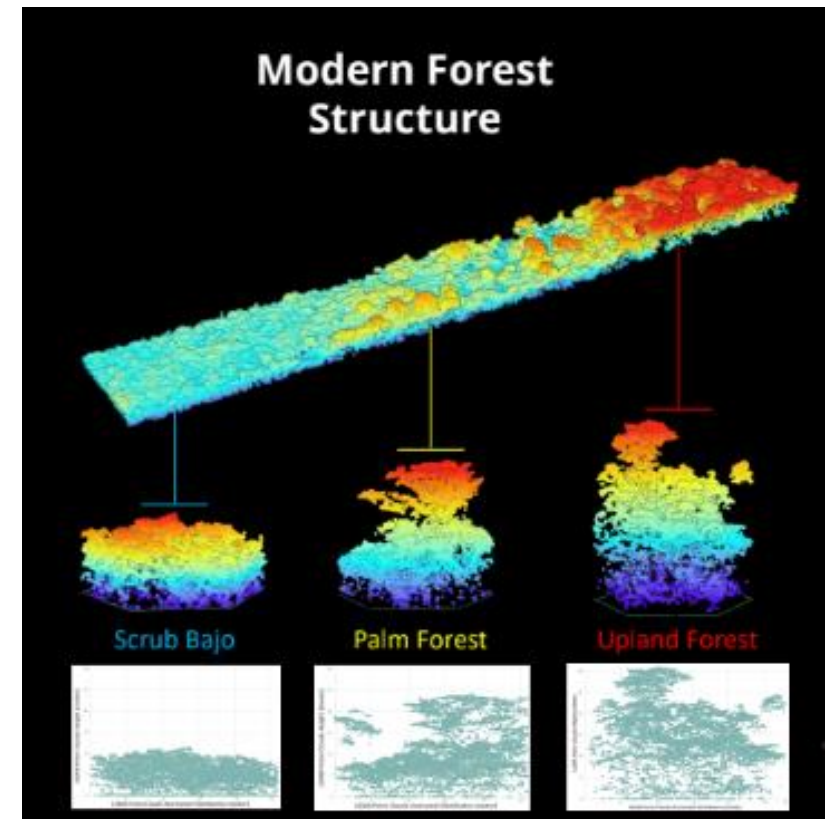
Impacts

- Maya Biosphere Reserve protected sites
  - Ecological preservation through sustainable economic development

- Forest Concessions
  - Community-led sustainable resource extraction within the region

- UNESCO World Heritage Site
  - San Bartolo currently on UNESCO's Tentative list
  - Recently moved forward on application for Nomination of World Heritage status
  - Aim is to prove an "outstanding universal value" of the site

The Painted Murals of San Bartolo
Nominated Property & Buffer Zone
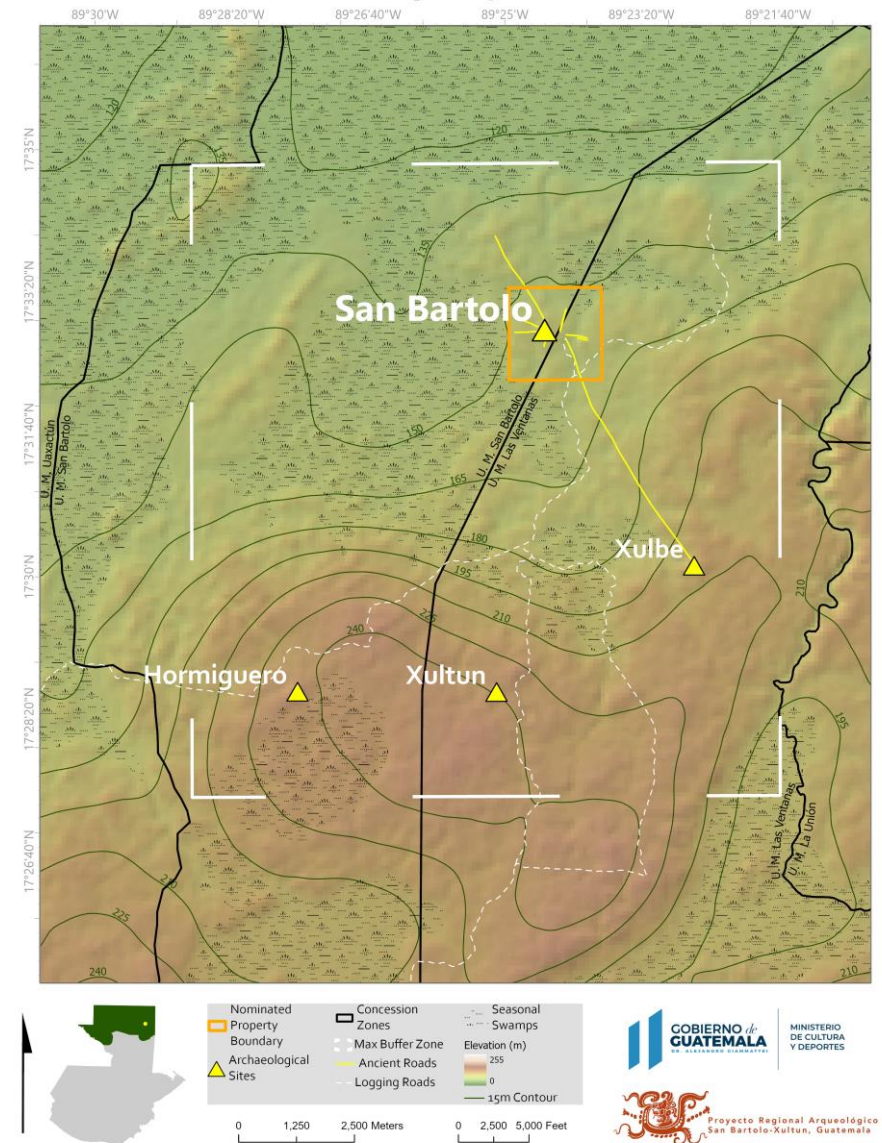
Thank You

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