

Use of Terrestrial Laser Scanning (TLS) and Unmanned Aerial Vehicles (UAV) to Investigate Rice Cultivation on the Isle of Hope, Georgia (END OF THE YEAR REPORT)

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Background

In May 2013, The Wormsloe Institute for Environmental History and The Center for Geospatial Research at UGA initiated a study aiming at investigating the possibility of rice cultivation at Wormsloe. The ultimate goal of this research is to cast some light on one of those aspects of Wormsloe's environmental history that has not yet been completely understood.

Introduction

Despite the fact that, at the moment, "*there is no concrete evidence that rice of any type was ever cultivated at Wormsloe*" (Swanson, 2012: 43), the following hints warrant further studies:

- The 1772 letter to Noble Wimberly Jones from Benjamin Franklin, who enclosed a sample of upland rice from Vietnam to suggest the experimentation of such culture at Wormsloe (Swanson, 2012: 43)
- The construction of a rice mill at Wormsloe in 1856, although it is thought it was built for processing rice coming from nearby rice plantations owned by the Jones family (Swanson, 2012: 198)
- The 1880 agricultural census – listing Wormsloe's freedmen tenants and their land use during the 1879 season – reports that one of the tenants, Peter Campbell, raised 510 pounds of rice (Swanson, 2012: 109,110)
- The fact that subsistence crops were raised at Wormsloe but were never recorded (Swanson, 2012: 46)
- The analysis of historical maps showed the presence of artesian wells onsite that could have been used to irrigate the rice fields

- Drainage ditches still present on the property could have been used to collect and provide freshwater to the rice fields (Pinckney and Smith, pers.comm.)
- The presence of dikes that may have been built to impound rice fields and protect them from salt water intrusion at high tide
- The presence at Wormsloe of poorly drained areas that are suitable to inland rice cultivation
- The presence of rice fields at the nearby Bethesda estate (across the marsh from Wormsloe) strongly encourages the possibility for rice cultivation at Wormsloe as well (Coulter, 1955: 202)

Objectives

The primary goal of this study is the investigation of the Isle of Hope through remote sensing techniques such as terrestrial laser scanning and unmanned aerial vehicles to identify archaeological evidence related to rice cultivation. In particular, specific objectives include:

1. Using terrestrial laser scanning in selected areas of the Isle of Hope to create and analyze a bare earth digital elevation model (DEM) depicting the microtopography of features that may correspond to historical rice field features such as reservoirs, ditches, embankments, and dikes
2. Collaborating with ongoing soil research performed by Wormsloe Institute for Environmental History (WIEH) Fellows to analyze soil cores and ground penetrating radar (GPR) data collected on the Isle of Hope that may indicate evidence of rice cultivation
3. Analyzing known historical rice plantations outside the Isle of Hope to improve the understanding of the current status of rice cultivation features
4. Creating a 3D geovisualization of the areas where rice cultivation is suggested by data analysis and field survey in order to improve and communicate the current understanding of Wormsloe's environmental history to cultural resource managers tasked with the preservation of coastal cultural heritage.

Literature review

Rice can be produced through three different cultivation systems: upland, inland, and tidal (Carney, 1996:13). More specifically, these three systems can be differentiated according to the method of irrigation used to grow the crop.

- Upland rice: also known as 'dry culture', the upland rice system mostly relies on rainfall for irrigating the crop, therefore it does not require the creation of canals

and embankments. Rather, this system is based on the capacity of the crop to absorb soil moisture coming from atmospheric precipitation. Since it did not produce very high yields, it was usually grown for subsistence, and we cannot exclude the possibility that it was grown at Wormsloe as well. Jones in fact could have tried the crop among other plants such as corn, potatoes, and fruits as one of his botanical experiments that characterized Wormsloe and the colony of Georgia during its first years.

- Inland rice: inland swamps – mostly cypress bottomlands – were “*drained, divided into squares separated by ditches, and surrounded with banks to prevent reinundation*” (Chaplin, 1992: 31). Freshwater collected in reservoirs would flow by gravity to the fields using canals and water control structures known as ‘rice trunks’. Early rice planters and enslaved Africans planted the crop in the lowest areas of the property (on the plantation periphery) and utilized fingers of salt marsh by building seawalls to protect the fields from tidal surges. At Wormsloe, slaves or freedmen could have cultivated subsistence rice over the years in their down time to provide their families extra food in addition to what they were already provided by the master.
- Tidal rice: similarly to the inland system, the tidal system required a complex network of canals, embankments, and sluice gates to irrigate the fields at different stages of the crop’s growth. However, this system relied on the tidal influence of bordering rivers to irrigate and drain the fields at high and low tide respectively. Given that Wormsloe is surrounded by salt water, this excludes the possibility for tidal rice at Wormsloe, since salt water is detrimental to growing rice.

Methods

Remote Sensing

For the purpose of this study, remote sensing technologies such as terrestrial laser scanning (TLS), also known as ground-based light detection and ranging (LiDAR), and unmanned aerial vehicle (UAV) will be used to perform a non-invasive on-site study of the topography, hydrology and vegetation of the study area in order to create a detailed reconstruction of conditions potentially supporting historical rice cultivation.

- TLS: with the collaboration of researchers of the Center for Geospatial Research (CGR), Department of Geography at the University of Georgia (UGA), and Dr. C.J. Jackson from Georgia Southern University and the Skidaway Institute of Oceanography (SKIO), the proposed study will employ TLS technology combined with geospatial data of the Wormsloe geodatabase served by CGR-UGA to investigate present-day microtopographic features that correspond to earthworks, ditches, and canals of an historical drainage system that may have been used for performing rice cultivation on the Isle of Hope.
- UAV: the proposed study will employ an unmanned aerial vehicle (UAV) – operated by the CGR-UGA – to collect low altitude aerial images of the area

under investigation. The collection of multiple images of the terrain from different angles also allows the employment of an emerging technique in photogrammetry known as Structure from Motion (SfM), which will allow the creation of high quality 3D virtual reality of the microtopography, hydrology and vegetation of areas of potential rice cultivation.

Soil Analysis

In addition to remote sensing techniques, this study will also benefit from ongoing soil research collected at Wormsloe by soil experts Dr. Larry Morris and Wormsloe Fellow Holly Campbell from the Warnell School of Forestry and Natural Resources at UGA with respect to the study of soil specimens by means of phytolith analysis and the flotation method.

- Phytolith analysis: this method could be used to approximate rice cultivation in the area (Morris, pers.comm.). The ability to distinguish rice from other crops is based upon the fact that rice can produce diagnostic types of phytoliths such as double-peaked, bulliform, and scooped bilobes (Zhang et al. 2010:592).
- Flotation method: this method is often used in archaeology to retrieve small material remains buried in the soil such as rice seeds that could represent archaeological evidence. Soil specimens are washed with water and lighter remains floating on the surface are screened through a sieve for manual inspection.

Field survey

Field surveys will be performed onsite to collect any evidence related to rice cultivation at Wormsloe. Features of interest will be mapped with a handheld Garmin eTrex GPS device currently available at CGR, and pictures will be taken for visual record. Furthermore, surveys to historical colonial settlements and rice plantations on the Georgia coast such as Saint Chaterine's, Skidaway, and Sapelo Islands will be performed to increase familiarity with similar historical contexts to that of Wormsloe.

Collaborations

Given the strong interdisciplinary nature of this study, which overlaps many disciplines such as archaeology, history, anthropology, geology, hydrology, archaeobotany, and geography, this study will benefit from the following collaborations and resources:

- the Wormsloe Foundation and the Wormsloe Institute for Environmental History (WIEH)
- Center for Geospatial Research (CGR) at UGA where resources such as historical maps and software will be used
- Department of Geology at UGA
- Warnell School of Forestry and Natural Resources at UGA
- Wimberley Jones DeRenne Georgia Library at Wormsloe and the Hargrett rare Book and Manuscript Library at UGA

- Ongoing research performed by current Wormsloe Fellows in the fields of Geography, Ecology, Soil Science, and Cultural Landscape
- Lowcountry and rice cultivation experts such as archaeologists Andrew Agha and Nicole Isenbarger, historian Hayden Smith, and author Roger Pinckney
- Dr. Jackson from Georgia Southern University and the Skidaway Institute of Oceanography
- Dr. da Costa from the Federal University of Viscosa (Brazil) and PhD Candidate in Anthropology at UGA Susannah Chapman for the extraction of phytolith samples from both Asian and African rice plant specimens

Preliminary results

Research conducted so far has identified three areas where rice cultivation may have occurred at Wormsloe (Fig.1). These areas are currently being considered due to the following characteristics:

- the presence of drainage ditches bringing freshwater from higher elevations to these low-lying areas (Fig.2)
- the presence of poorly-drained soils which can retain water effectively (Fig.3)
- the presence of dikes from field surveys and historical maps which could have been used to impound rice fields and protect them from salt water intrusion (Fig.4)
- marginal lands like salt marshes were often used by slaves to grow subsistence rice in the Lowcountry.

These areas will be closely investigated with the abovementioned methods to understand whether these areas have been characterized by historical rice cultivation.

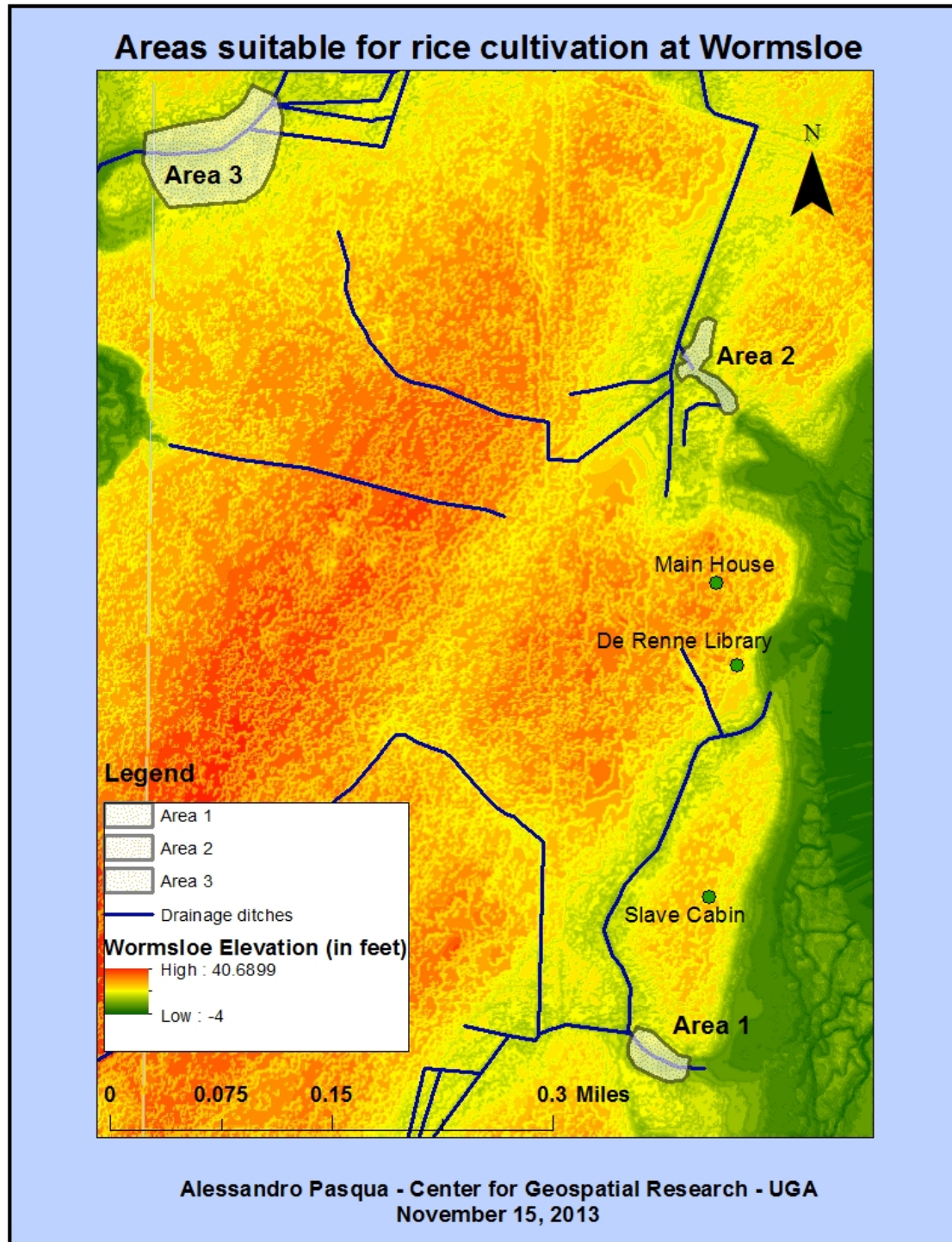


Figure 1. Lidar elevation map showing possible areas for rice cultivation at Wormsloe

Features of interest (pictures taken by the author)



Figure 2. Drainage ditch at Wormsloe



Figure 3. Poorly-drained area at Wormsloe



Figure 4. Dike at Wormsloe

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