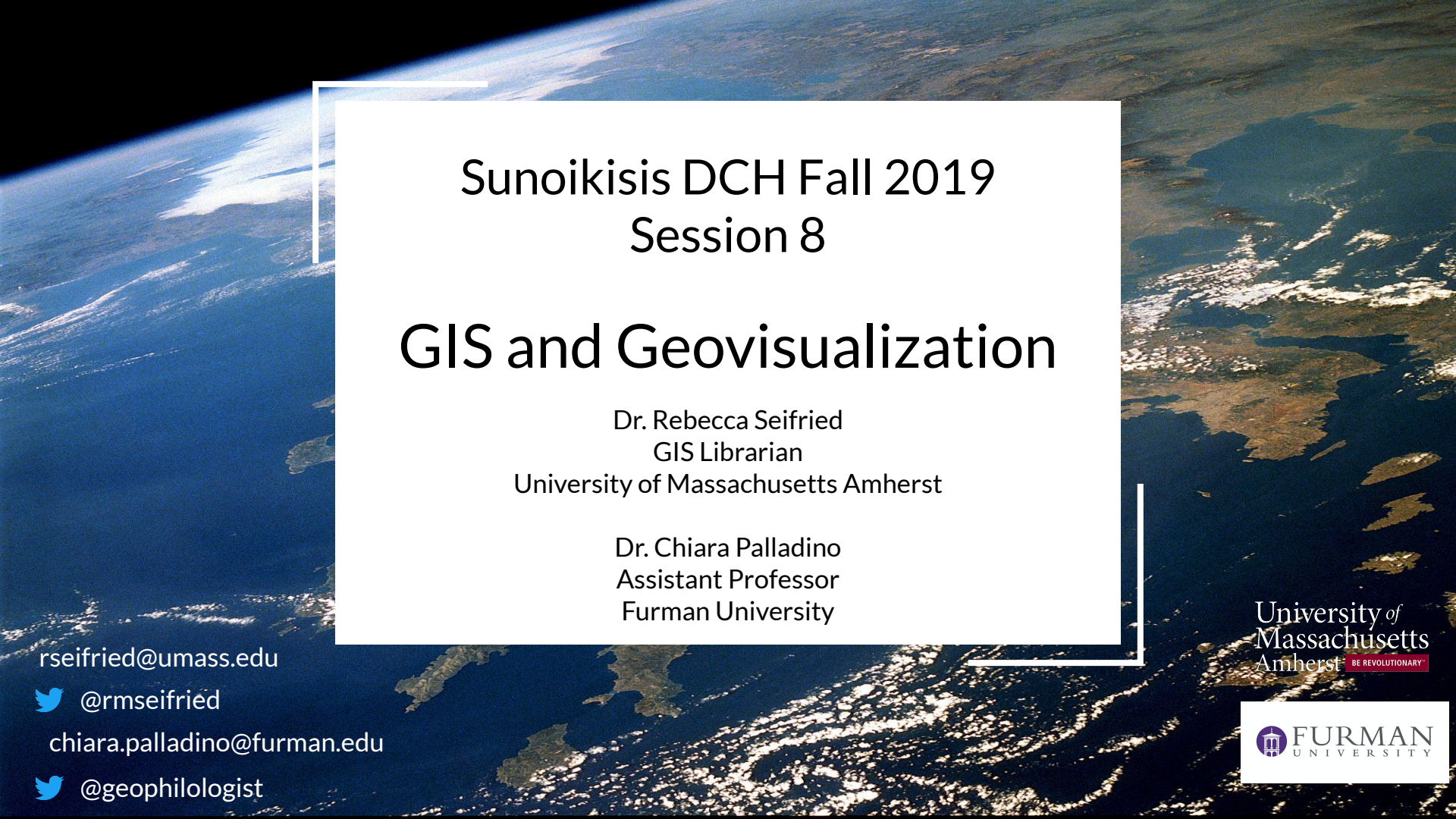

Sunoikisis DCH Fall 2019
Session 8

GIS and Geovisualization

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University of Massachusetts Amherst BE REVOLUTIONARY™

FURMAN UNIVERSITY

Session Outline

1. Introduction to GIS

- History and development
- Methods, particularly with regard to Cultural Heritage
- Spatial data formats and encodings

2. Case studies

- Site discovery
- Tracking damage to cultural heritage sites
- Phenomenological approaches to studying cultural/archaeological landscapes

3. Overview of the Exercise

Preparatory Readings

A gentle GIS introduction http://docs.qgis.org/2.14/en/docs/gentle_gis_introduction/

Getting Started with QGIS
https://docs.qgis.org/3.4/en/docs/user_manual/introduction/getting_started.html

SunoikisisDC Session 5: Gazetteers
https://github.com/SunoikisisDC/SunoikisisDC-2019-2020/wiki/DCH-Session-5-Gazetteers

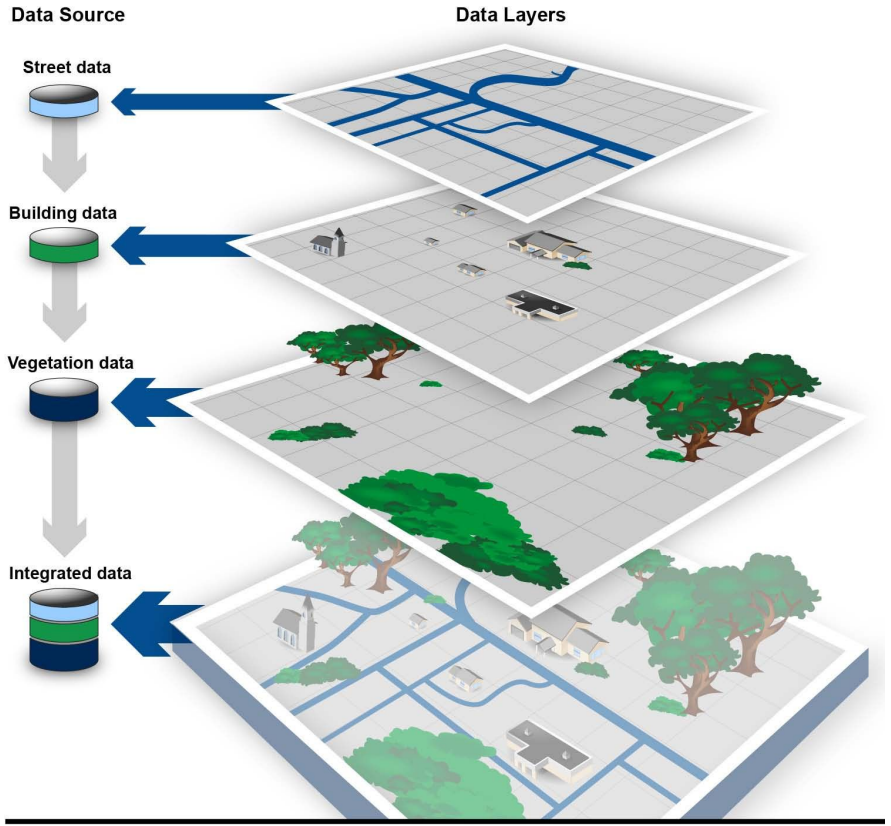
SunoikisisDC Session 3: Decolonization
https://github.com/SunoikisisDC/SunoikisisDC-2019-2020/wiki/DCH-Session-3-Decolonization

More on concepts of spatial referencing, map projections, and coordinate systems: R. Knippers, *Geometric Aspects of Mapping*, 2009 https://kartoweb.itc.nl/geometrics/index.html

A brief history of GIS

Definition(s) of GIS

- Geographic Information System
- Geographic Information Science (GIScience)
- “Lowercase” GIS and Un-GIS
- Digital Gazetteers



Mapping conventions and coordinate systems

R. Knippers, “Coordinate Systems”, in *Geometric Aspects of Mapping* (2009): https://kartoweb.itc.nl/geometrics/Coordinate%20systems/coordsys.html

Map Scale

Coordinate systems:

- 2D and 3D Geographic coordinates
- Geocentric coordinates
- Cartesian coordinates

Map projections and reference models

Mapping conventions and coordinate systems

R. Knippers, “Coordinate Systems”, in *Geometric Aspects of Mapping* (2009): https://kartoweb.itc.nl/geometrics/Coordinate%20systems/coordsys.html

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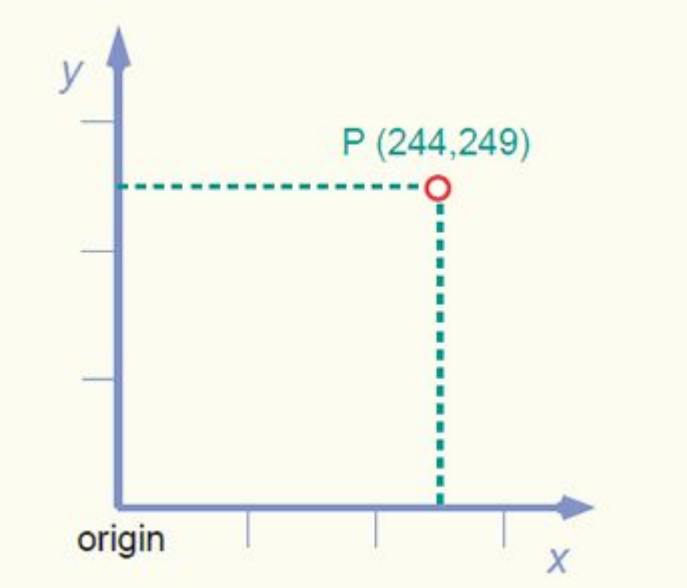
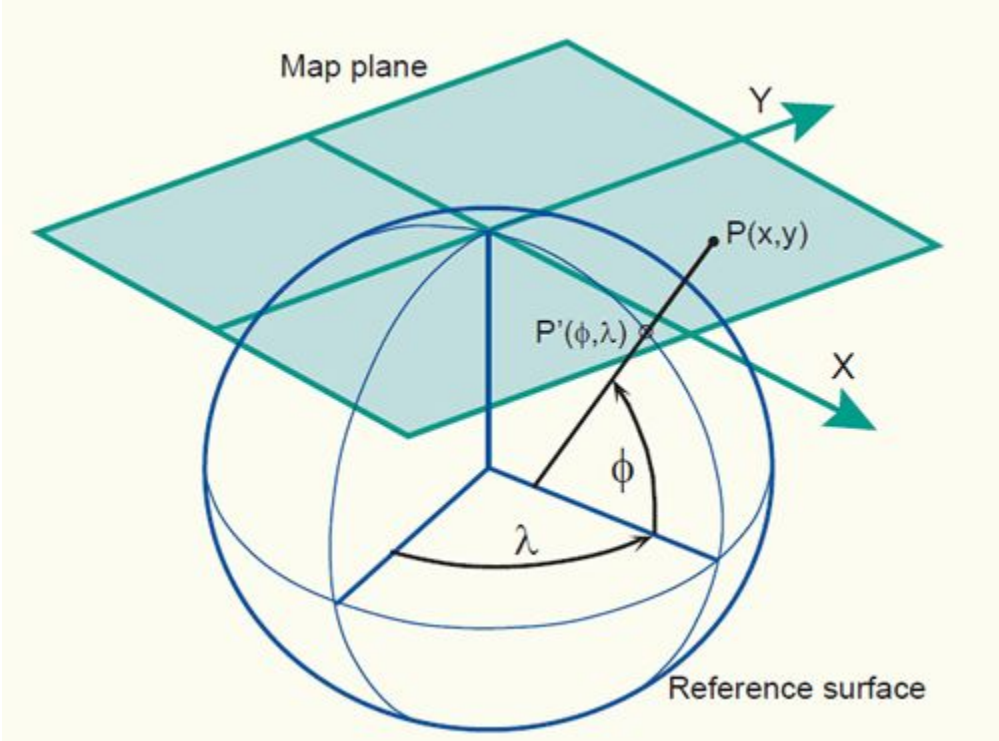


An illustration of the 2D Cartesian coordinate system.

Mapping conventions and coordinate systems

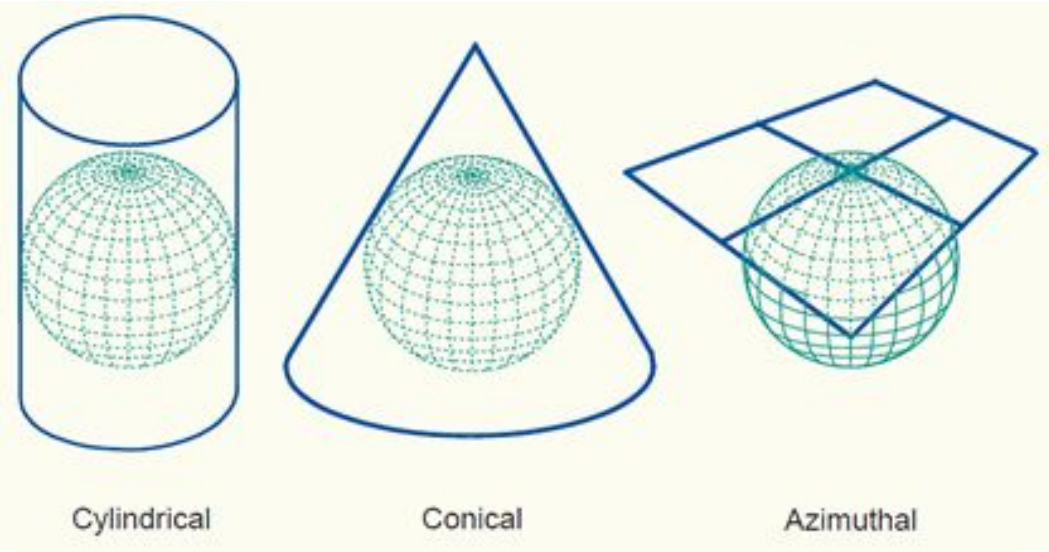
Map projections and reference models



Example of a map projection where the reference surface with geographic coordinates (f,l) is projected onto the 2D mapping plane with 2D Cartesian coordinates (x, y). © R. Knippers

Mapping conventions and coordinate systems

Map projections and reference models



The three classes of map projections: cylindrical, conical and azimuthal. The projection planes are respectively a cylinder, cone and plane. © R. Knippers.

GIS and GIS formats

- 1960s-1970s: Computational Systems for Governmental data
  - Land ownership, taxation, administration, census
  - First data formats: raster, vector
  - Tabular Data Formats

GIS and GIS formats

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  - “Desktop GIS”: expansion of GIS applications to private use, Research, Industry
  - GIS in Archaeology and History

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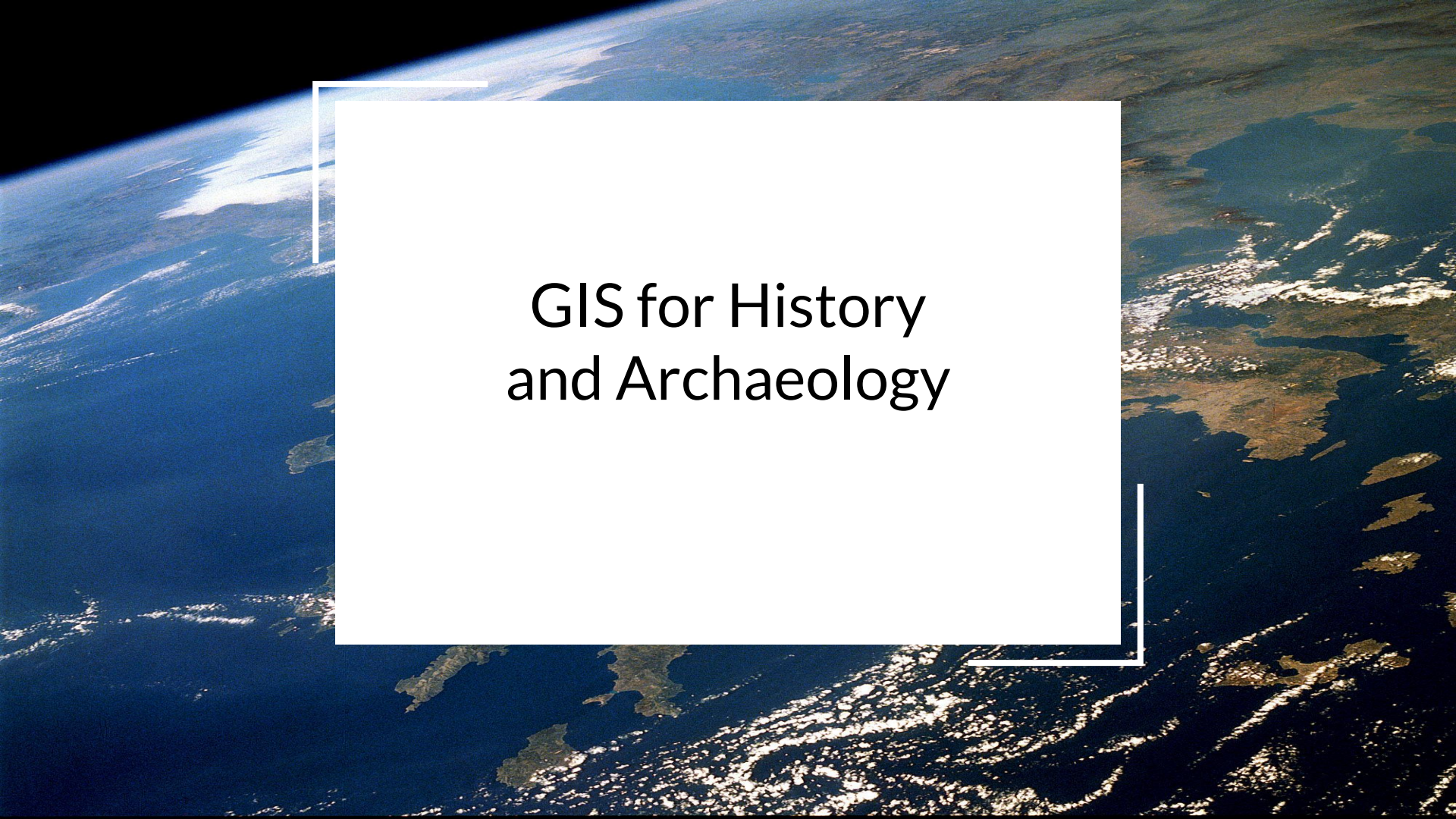
  - GIS in Archaeology and History
- 1990s onwards: the WWW and GIS
  - Web applications vs Desktop applications
  - New representational models: Google Earth, digital globes
  - Feature-oriented data formats: entities and geographic “objects”



GIS for History and Archaeology

GIS in History

- Historical data with spatial aspects
- Georeferencing (rubber-sheeting) historical maps
- Analysis of historical locations and their relations
- Interaction of spatial information with other kinds of data (people, time)

GIS Archaeology and Cultural Heritage

- For **landscape Archaeology**: storage, management, display and analysis of large spatial datasets
- For **geophysical and surface survey**
- For Field Recording
- Cultural Heritage management, monitoring, and preservation
- For database management

GIS Archaeology and Cultural Heritage

- In combination with other applications:
  - Remote sensing and viewshed analysis
  - Aerial and satellite imagery (drones, satellites)
  - Predictive and agent-based modeling: least-cost path calculation, etc.
  - 3D modelling and Virtual Reality
  - Ontologies for Cultural Heritage (CIDOC-CRM)

Limitations of GIS

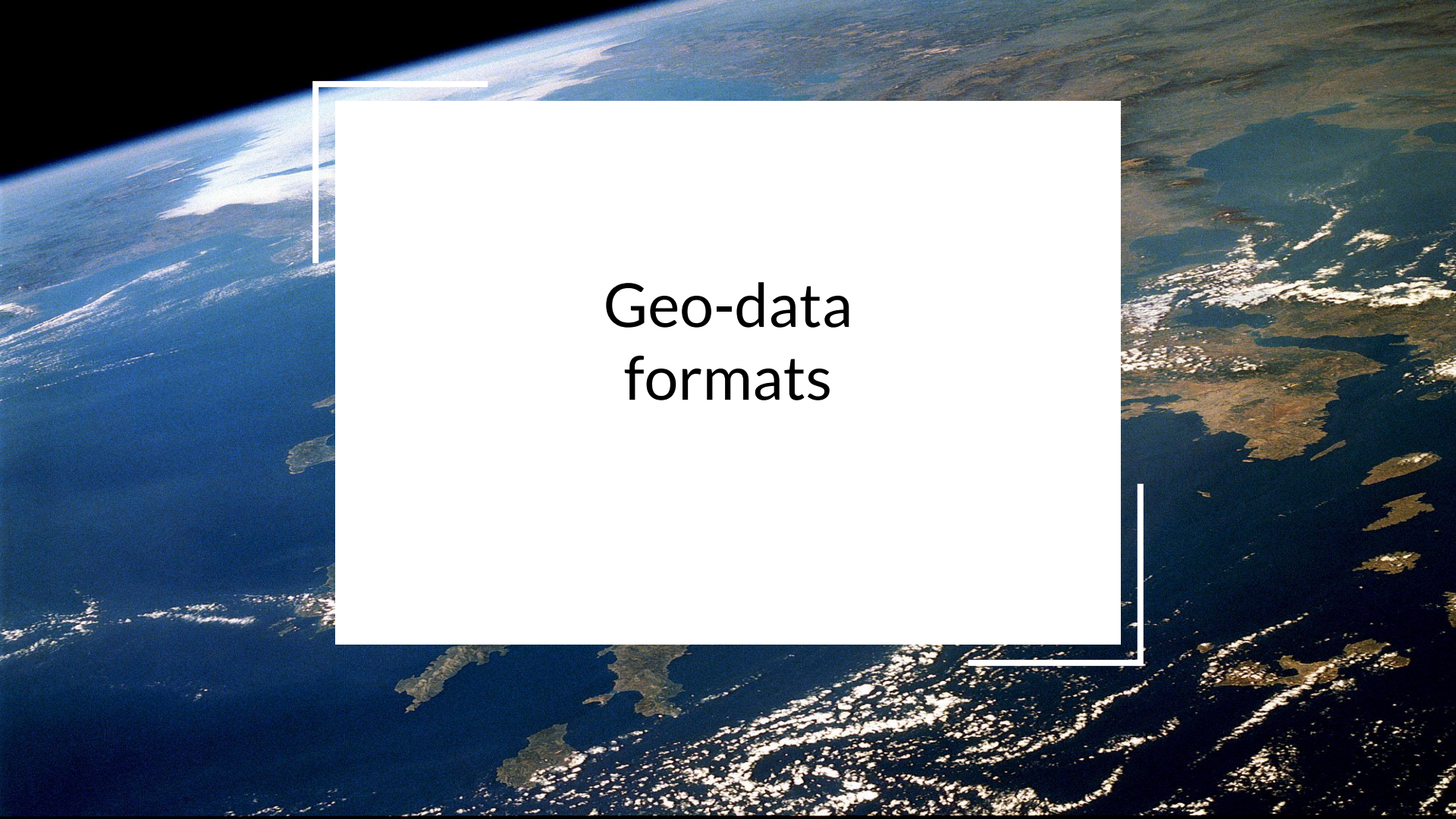
Quantitative approach vs. qualitative data

Difficulties in handling uncertainty

Historical reliability of Cartesian representations

Problems in sustainability and maintenance of the data

Sharing sensitivity and ethical obligations for the Cultural Heritage

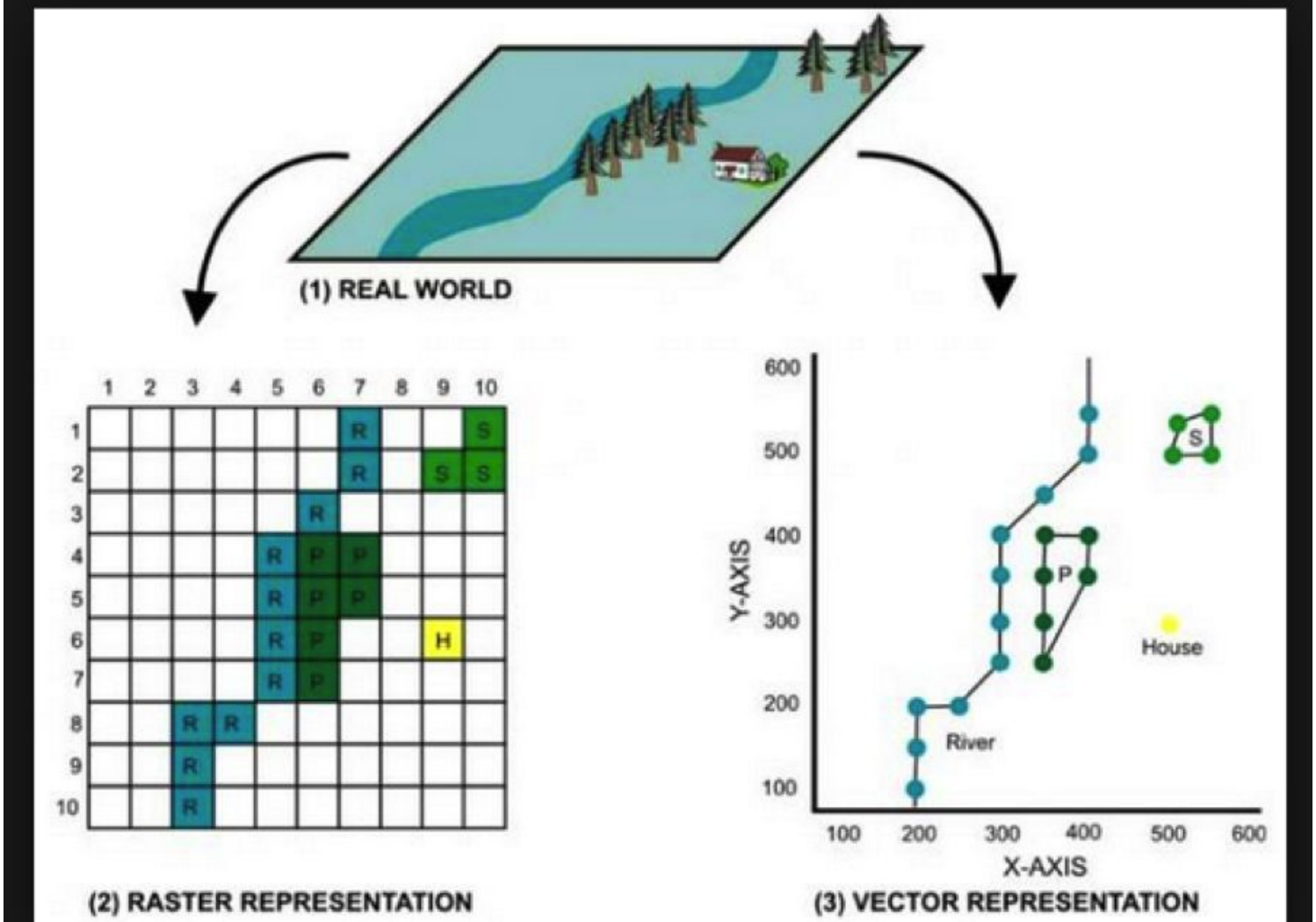


Geo-data formats

Raster and Vector

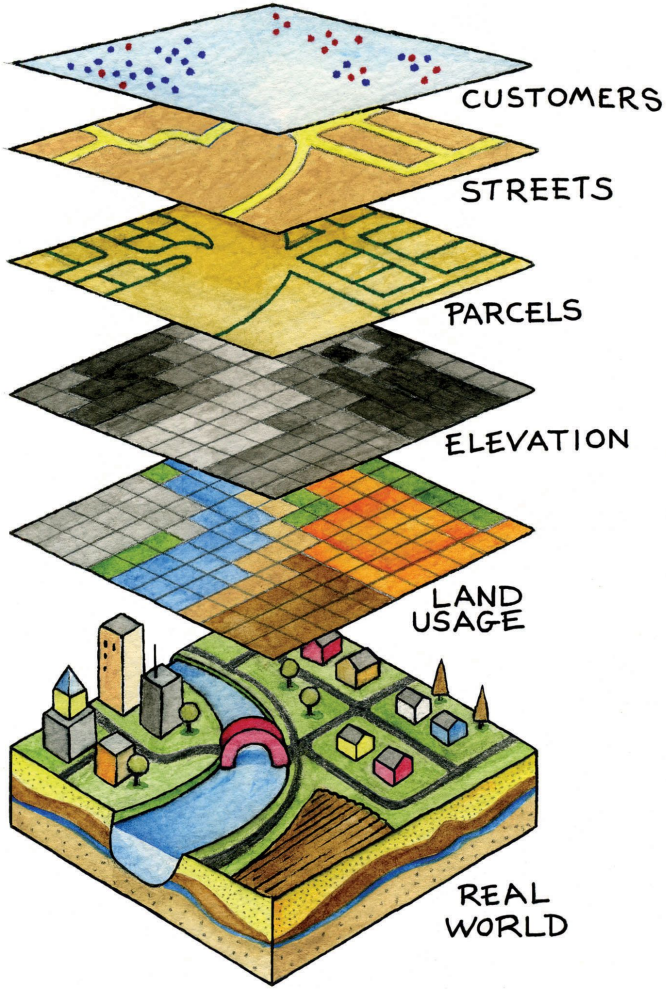
Raster: A raster in its simplest form is **an array of pixels** organized as a grid-based system. Rasters can be aerial photographs, satellite images, maps, and can represent various kinds of real-world phenomena, such as temperatures, elevation, land-use, demographics. Because they are especially flexible, raster data can be used to provide a map layer for further spatial analysis, thematic maps, surface maps of dynamic phenomena (e.g. climate changes).

Vector: Vector data represent features of a landscape in the form of geometries, and provide attributes to its components, which are indicated by numerical or textual information. A geometry is made up of one or more interconnected vertices, which describe a position in space using an **X, Y and Z axis**. Depending on the number of vertices and their connections, geometries can be referred to as **points, polylines and polygons**. The use of these geometries to represent features of a landscape depends on various factors, especially the scale of the map.


(1) REAL WORLD
1 2 3 4 5 6 7 8 9 10
1 R S
2 R S S
3 R
4 R P P
5 R P P
6 R P H
7 R P
8 R R
9 R
10 R
(2) RASTER REPRESENTATION
600
500
400
300
200
100
Y-AXIS
S
P
House
River
100 200 300 400 500 600
X-AXIS
(3) VECTOR REPRESENTATION

GIS as a layered cake

Map overlay combining information from point, line, and polygon vector layers, as well as raster layers. Campbell and Shin 2011



Raster

Advantages:

- Inexpensive and widely available
- One-attribute maps: simpler to model with quantitative/mathematical analysis
- Easy integration of different types of data (e.g. elevation)

Disadvantages:

- Resolution conditioned by the scale of the cell matrix
- Linear features (e.g. networks) are difficult to establish
- Heavy files

Vector

Advantages:

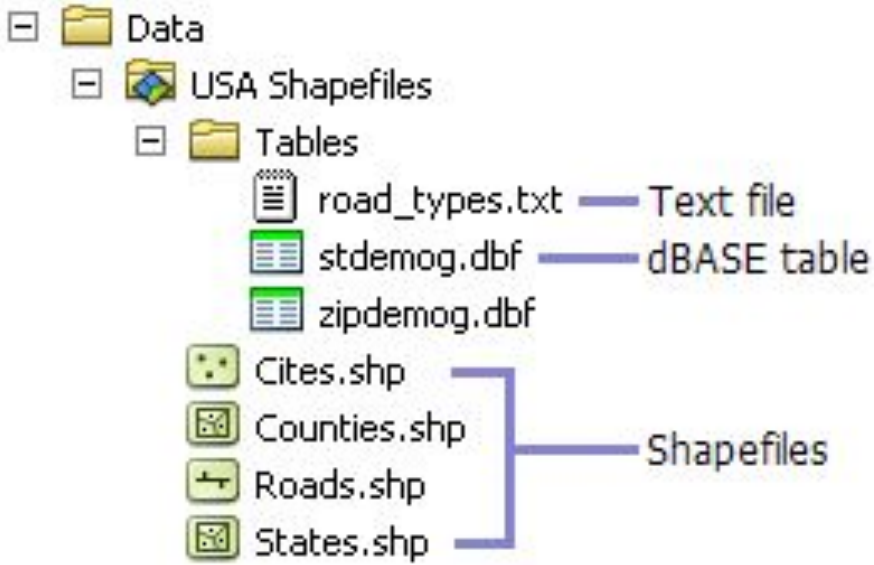
- More pleasant graphic output
- Efficient topological analysis

Disadvantages:

- The location of each vertex needs to be stored (complex data structure)
- Quantitative analysis requires processing-intensive algorithms

Vector file format: shapefile

- Nontopological files to store the geometric location and attribute information of geographic features
- Each shapefile only represents point, line or polygon
- SHP* - feature geometry
- SHX* - Index format of the feature geometry
- DBF* - feature attribute information in dBASE format



Raster file formats: 8-bit or 24-bit imagery

Tools for Geospatial visualization

- ArcGIS: https://www.arcgis.com
- Esri (ArcGIS based): https://www.esri.com or Storymaps: http://storymaps.arcgis.com/en/
- Carto (ex CartoDB): https://carto.com/
- QGIS: https://qgis.org/
- Google Fusion Tables: https://sites.google.com/site/fusiontablestalks/stories
- Google Earth: https://www.google.com/intl/en/earth/
- Leaflet: http://leafletjs.com/
- MapBox: https://www.mapbox.com/
- Neatline: http://docs.neatline.org/
- OpenStreetMap: https://www.openstreetmap.org/
- Scribble Maps: https://www.scribblemaps.com

Caveats and Definitions

Case Studies

How are GIS and geovisualization techniques being used to study and manage cultural heritage?

Site Discovery

- RS techniques are used to document the location of archaeological and historical sites and identify standing features

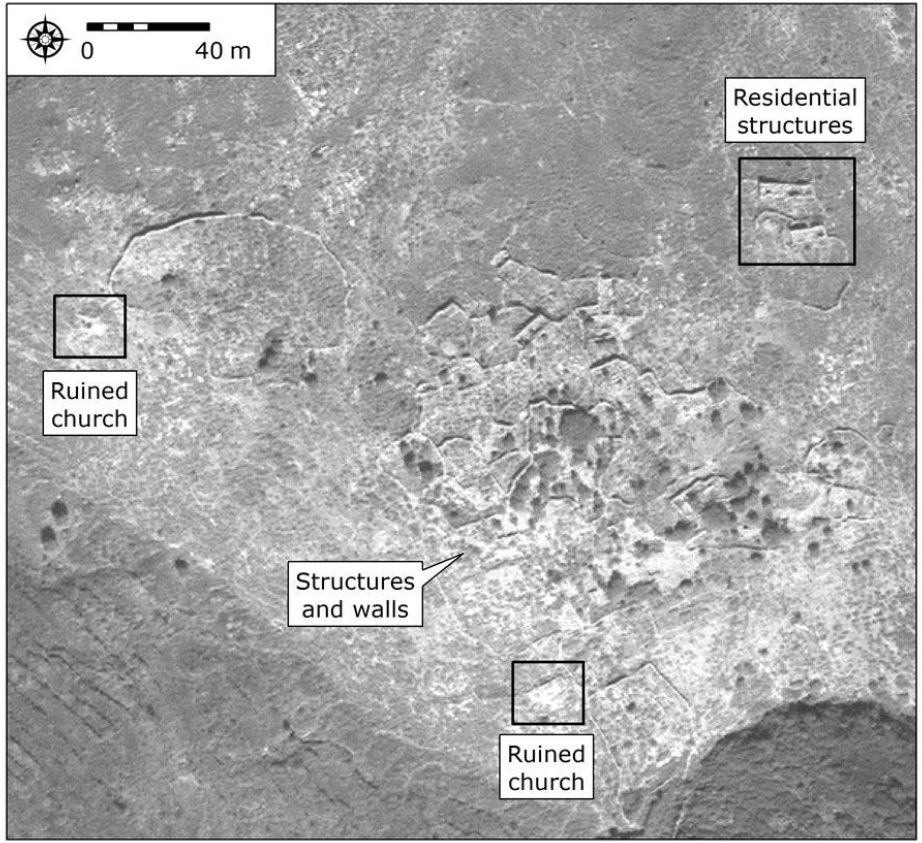
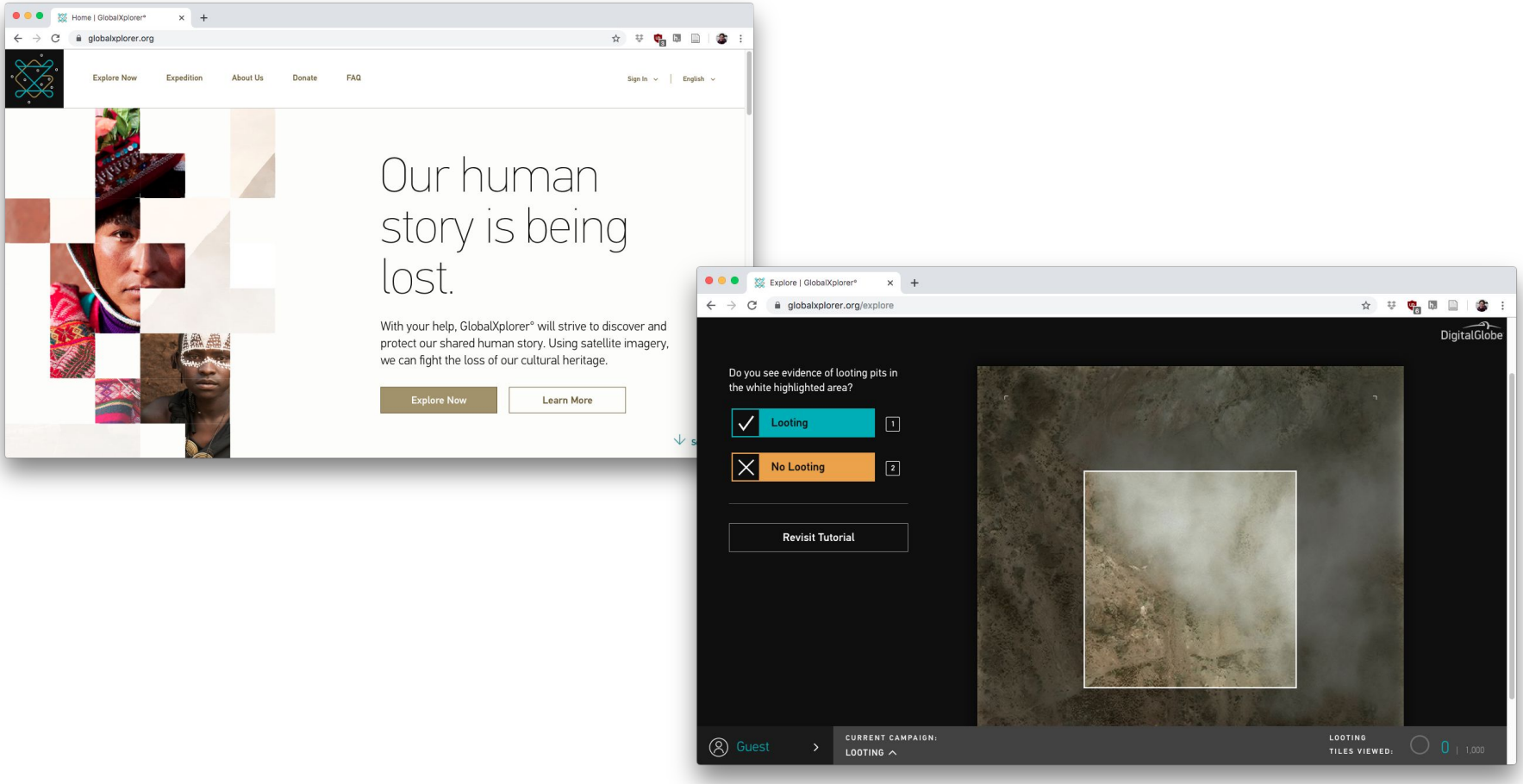


Figure 39. Site T360 (Proskephalia) identified in WorldView-2 satellite imagery.

Seifried, R.M. 2016. “Community Organization and Imperial Expansion in a Rural Landscape: The Mani Peninsula, Greece (AD 1000–1821).” Unpublished PhD dissertation. University of Illinois at Chicago. https://indigo.uic.edu/handle/10027/21274

Site Discovery

- RS techniques are used to document the location of archaeological and historical sites and identify standing features
- Crowd-sourced projects get the public involved in site detection without requiring lots of training



GlobalXplorer: https://www.globalxplorer.org/

Site Discovery

- RS techniques are used to document the location of archaeological and historical sites and identify standing features
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- Potential to cover huge areas of land quickly (particularly with automation / machine learning)

(>20% of the country of Peru)

GlobalXplorer: https://www.globalxplorer.org/

Site Discovery

- RS techniques are used to document the location of archaeological and historical sites and identify standing features
- Crowd-sourced projects get the public involved in site detection without requiring lots of training
- Potential to cover huge areas of land quickly (particularly with automation / machine learning)
- RS techniques can also detect archaeological features buried beneath the surface or otherwise obscured by modern features

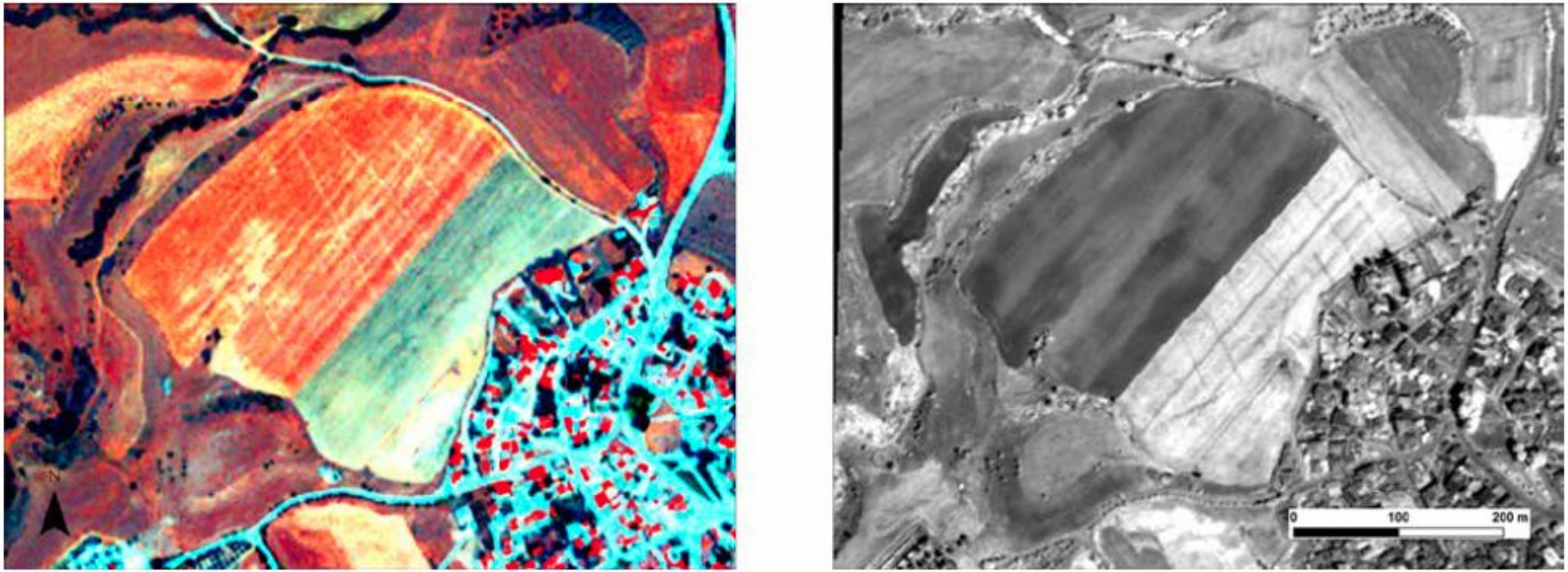


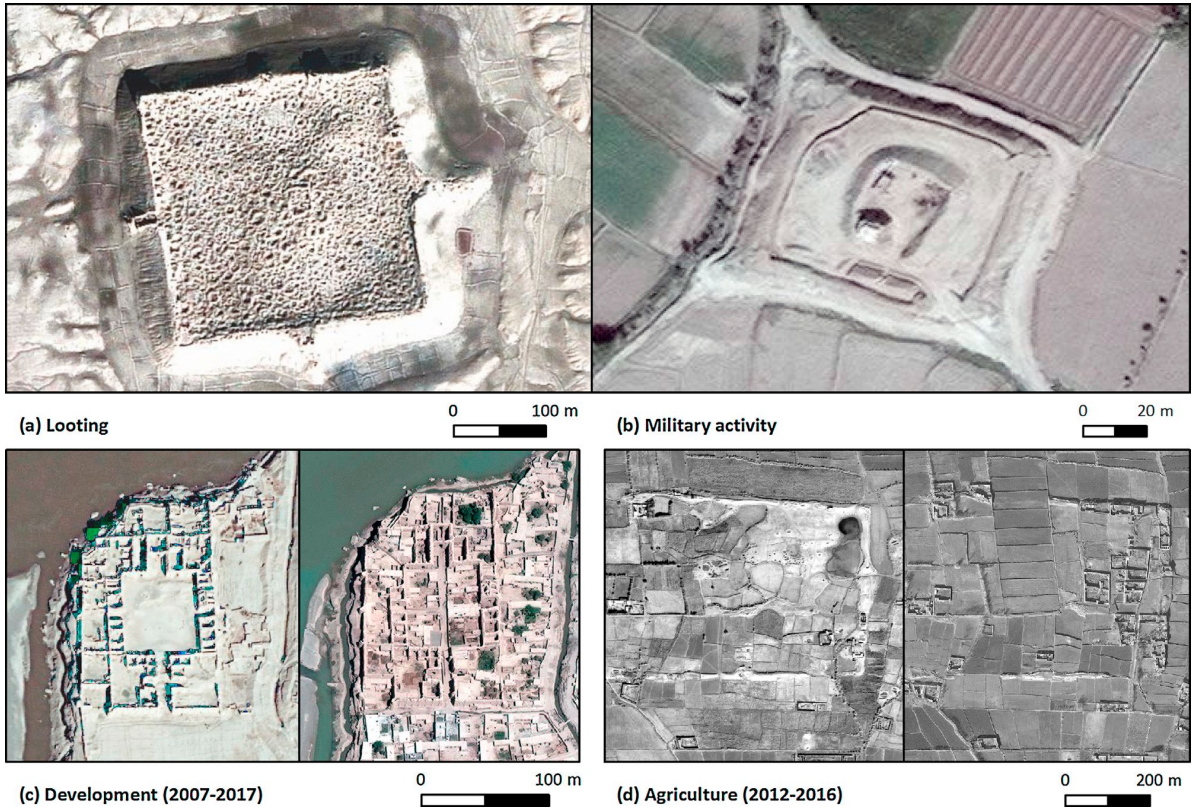
FIGURE 3. DECORRELATION STRETCH APPLIED TO QUICKBIRD, 15 JUNE 2009 (LEFT) AND MSR APPLIED TO GEOEYE-1, 4 MAY 2010 (RIGHT) SHOWING DIAGONAL SUBSURFACE STREETS AT PHERAI.

Donati, J. C. 2015. "Cities and Satellites: Discovering Ancient Urban Landscapes Through Remote Sensing Applications." In: Best Practices of GeoInformatic Technologies for the Mapping of Archaeolandscapes, edited by A. Sarris, 127–136. Oxford: Archaeopress. https://www.archaeopress.com/ArchaeopressShop/Public/displayProductDetail.asp?id={423BA2A6-E642-4BC3-B57C-9E899EE1DAAD}

Tracking Damage to Archaeological Sites

- RS techniques can be used to identify different kinds of damage (e.g. looting, urban expansion, natural disasters, etc.) and track change to sites over time

Fig. 4. Examples of each type of damage to archaeological sites as seen in DigitalGlobe imagery: a: looting at Abu Huraira in Balkh Province (Gazetteer site 8); b: military activity at Gur Tepe in Kunduz Province (Gazetteer site 400); c: development-related damage at Lashkari Bazar in Helmand Province (Gazetteer site 685); d: agricultural-related damage at Kafir Qal'a in Kunduz Province (Gazetteer site 487). Base imagery courtesy of DigitalGlobe.

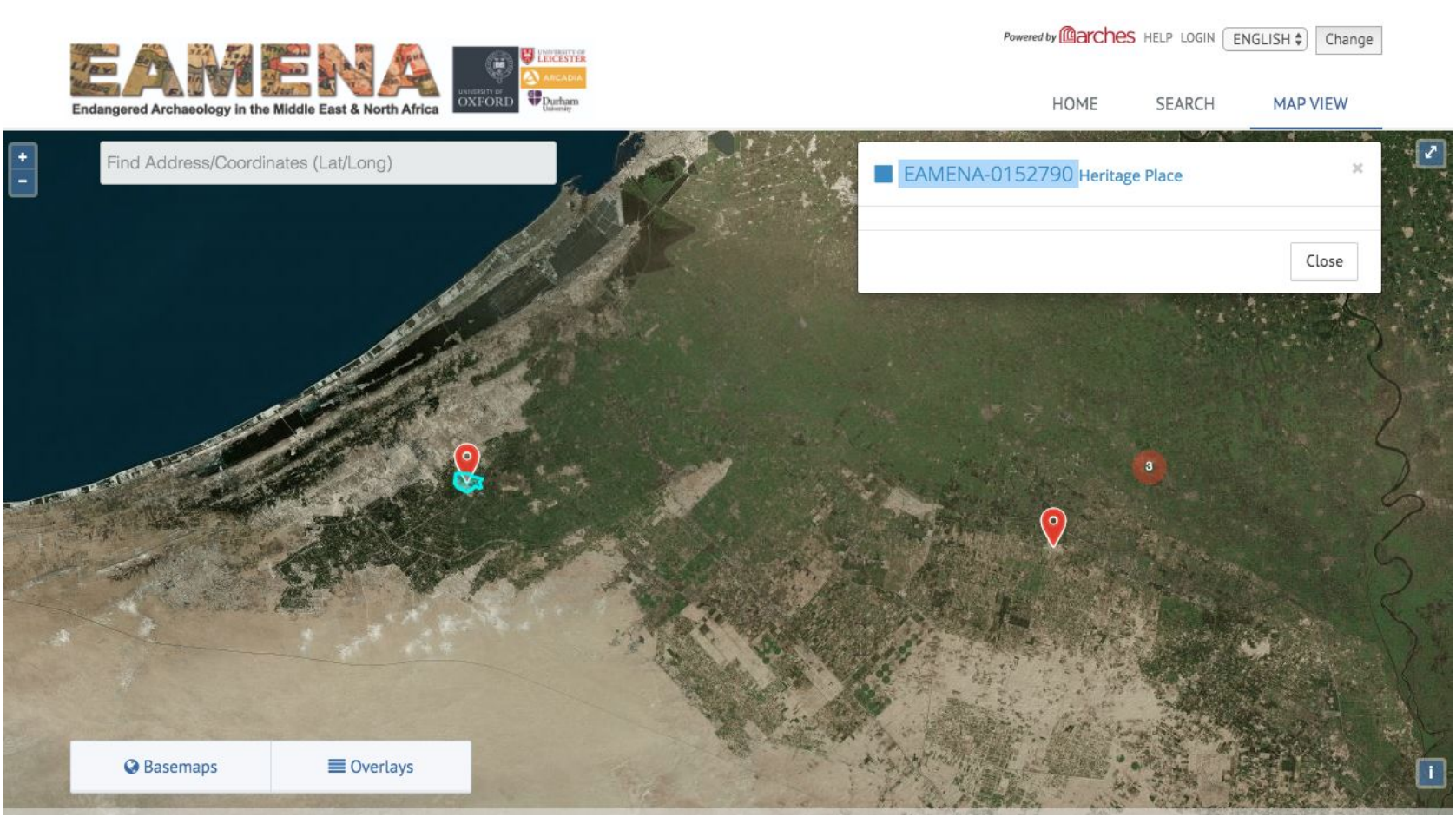


Hammer, E., R. Seifried, K. Franklin, and A. Lauricella. 2018. "Remote Assessments of the Archaeological Heritage Situation in Afghanistan." *Journal of Cultural Heritage* 33:125-144. https://doi.org/10.1016/j.culher.2017.12.008

Tracking Damage to Archaeological Sites

- RS techniques can be used to identify different kinds of damage (e.g. looting, urban expansion, natural disasters, etc.) and track change to sites over time
- Ongoing projects are using GIS/RS to monitor cultural heritage remotely and compare with targeted assessments on the ground, e.g.:
  - EAMENA database: https://database.eamena.org/
  - ASOR-CHI: http://www.asor.org/chi/about

EAMENA database: https://database.eamena.org/



EAMENA database: https://database.eamena.org/

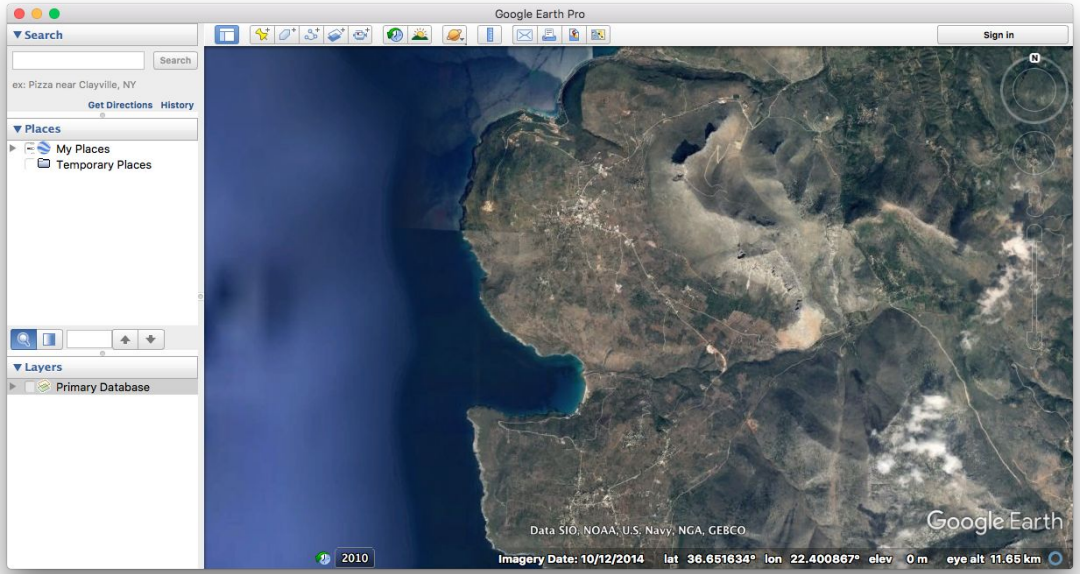
Phenomenological Approaches

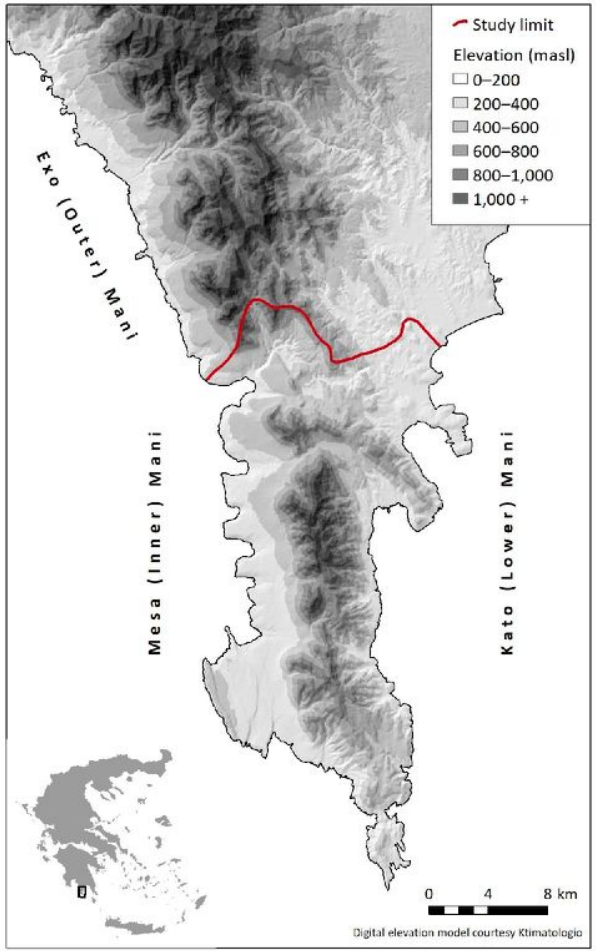
- Within this framework, GIS is conceived as a tool to help us understand different aspects of *being* in a landscape…

Photos by Rebecca M. Seifried

Phenomenological Approaches

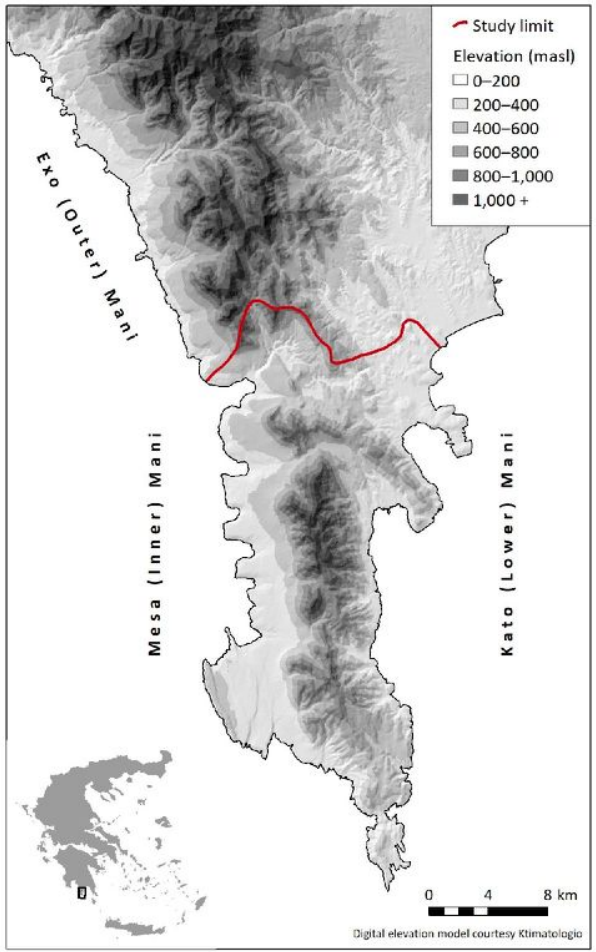
- Within this framework, GIS is conceived as a tool to help us understand different aspects of *being* in a landscape… without actually being there



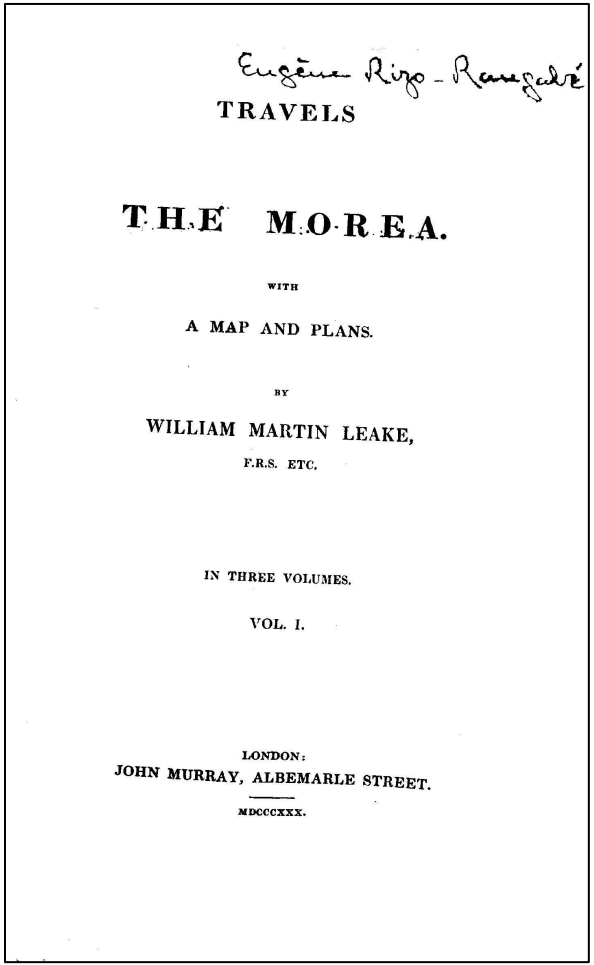


The Mani Peninsula, Greece

Images by CARTography Project: Cataloguing Ancient Routes and Travels in the Mani Peninsula (Chelsea A.M. Gardner and Rebecca M. Seifried)



Leake, W.M., 1830. *Travels in the Morea: With a Map and Plans*. John Murray, London.



Eugène Rizo-Rangabé

TRAVELS

THE MOREA.

WITH

A MAP AND PLANS.

BY

WILLIAM MARTIN LEAKE,

F.R.S. ETC.

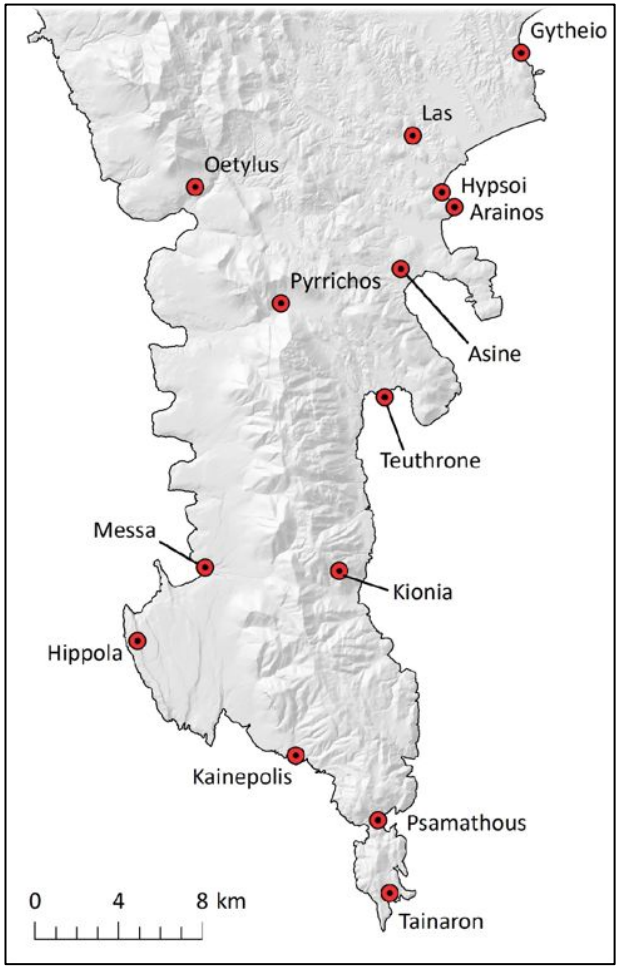
IN THREE VOLUMES.

VOL. I.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.

MDCCCXXX.

Ancient Sites in Mani



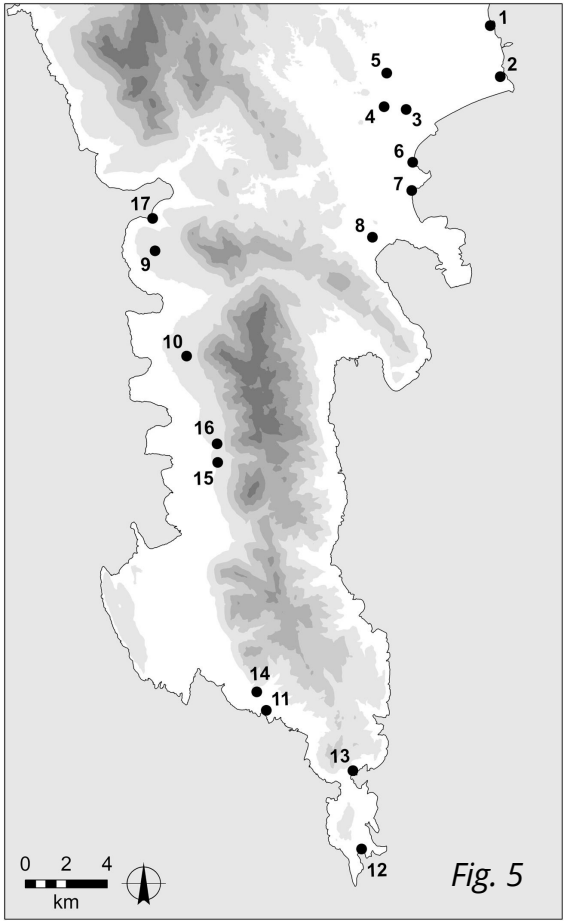


Fig. 5

Seifried, R.M. and C.A.M. Gardner. 2019. “Reconstructing Historical Journeys with Least-Cost Analysis: Colonel William Leake in the Mani Peninsula, Greece.” Journal of Archaeological Science: Reports 24: 391–411. https://doi.org/10.1016/j.jasrep.2019.01.014

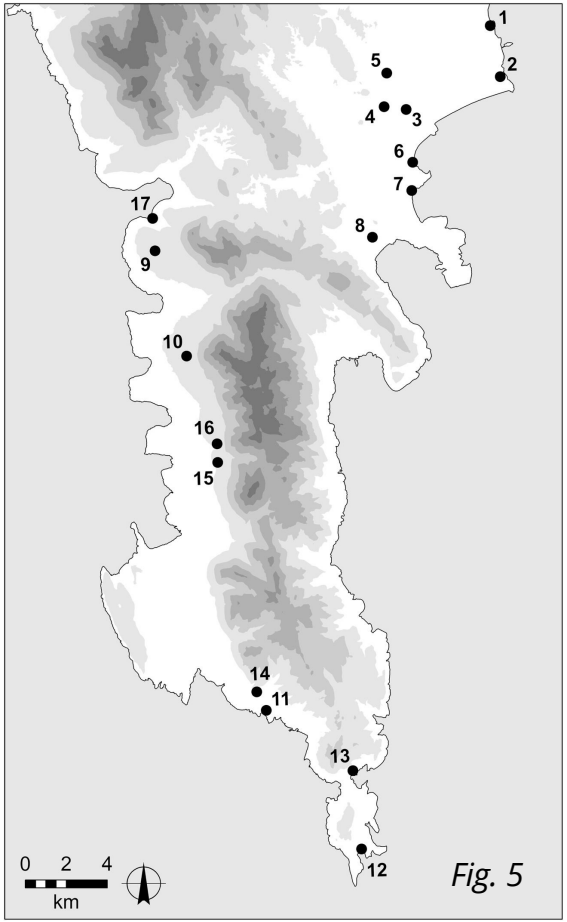


Fig. 5

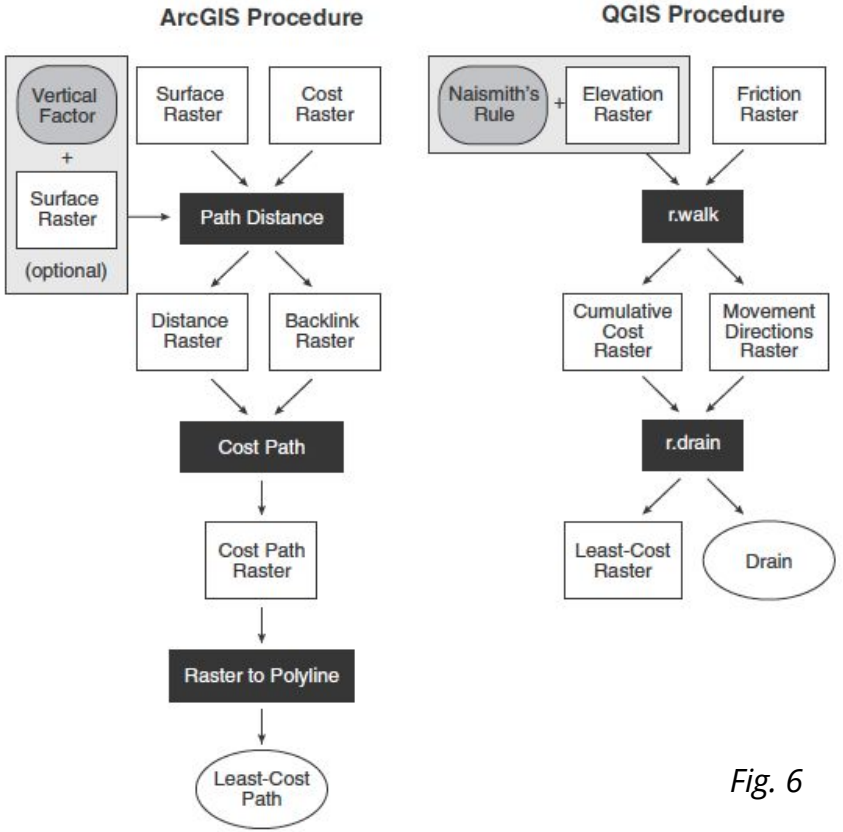


Fig. 6

Seifried, R.M. and C.A.M. Gardner. 2019. "Reconstructing Historical Journeys with Least-Cost Analysis: Colonel William Leake in the Mani Peninsula, Greece." Journal of Archaeological Science: Reports 24: 391–411. https://doi.org/10.1016/j.jasrep.2019.01.014

r.walk
https://grass.osgeo.org/grass78/manuals/r.walk.html

r.drain
https://grass.osgeo.org/grass78/manuals/r.drain.html

Overview of LCP analysis
Herzog, Irmela. 2014. "Least-Cost Paths – Some Methodological Issues." *Internet Archaeology*, no. 36. https://doi.org/10.11141/ia.36.5

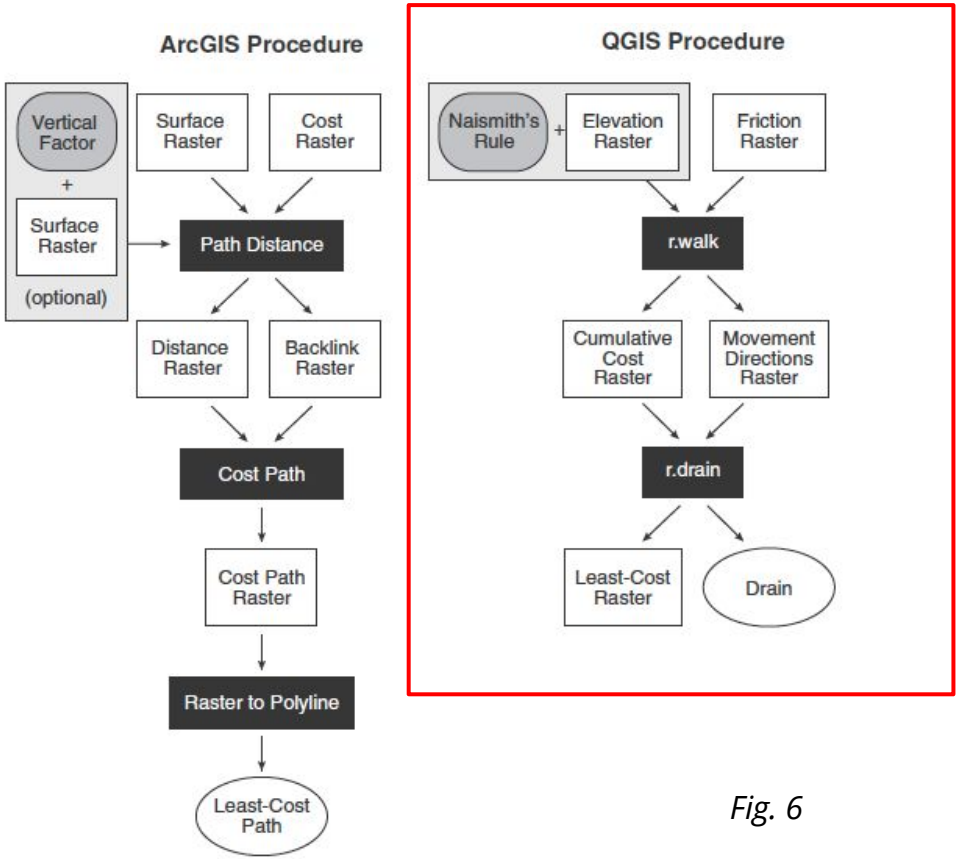


Fig. 6

r.walk in QGIS

Naismith's rule with the Aitken-Langmuir corrections:

$$T = (a \times (S)) + (b \times (H1)) + (c \times (H2)) + (d \times (H3))$$

where T is the time in seconds, Δ(S) is the horizontal distance covered, Δ(H1) is the vertical change for uphill slopes, Δ(H2) is the vertical change for moderate downhill slopes (> 5 and ≤12 degrees), and Δ(H3) is the vertical change for steep downhill slopes (> 12 degrees).

Seifried, R.M. and C.A.M. Gardner. 2019. “Reconstructing Historical Journeys with Least-Cost Analysis: Colonel William Leake in the Mani Peninsula, Greece.” Journal of Archaeological Science: Reports 24: 391–411. https://doi.org/10.1016/j.jasrep.2019.01.014 (page 400)

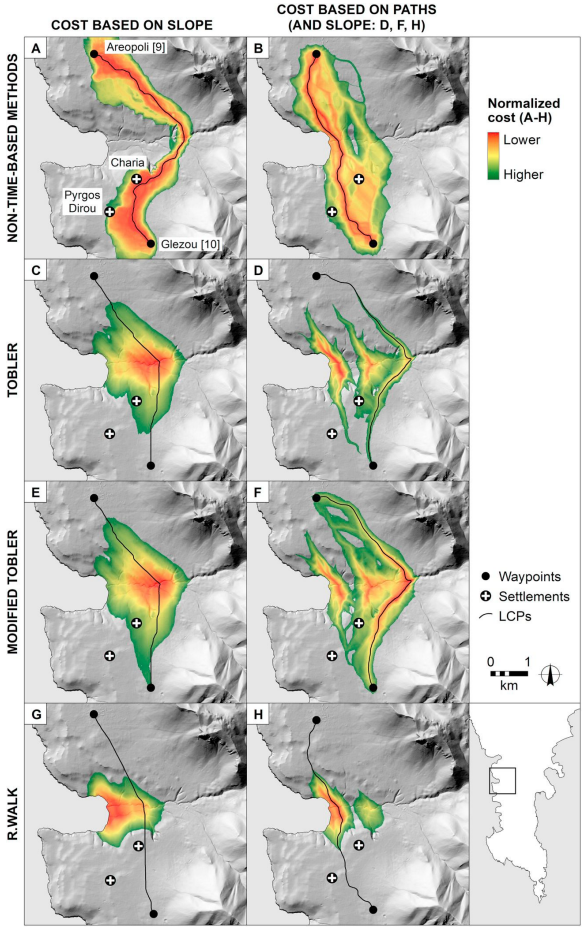


Fig. 9

Seifried, R.M. and C.A.M. Gardner. 2019. "Reconstructing Historical Journeys with Least-Cost Analysis: Colonel William Leake in the Mani Peninsula, Greece." Journal of Archaeological Science: Reports 24: 391–411. https://doi.org/10.1016/j.jasrep.2019.01.014

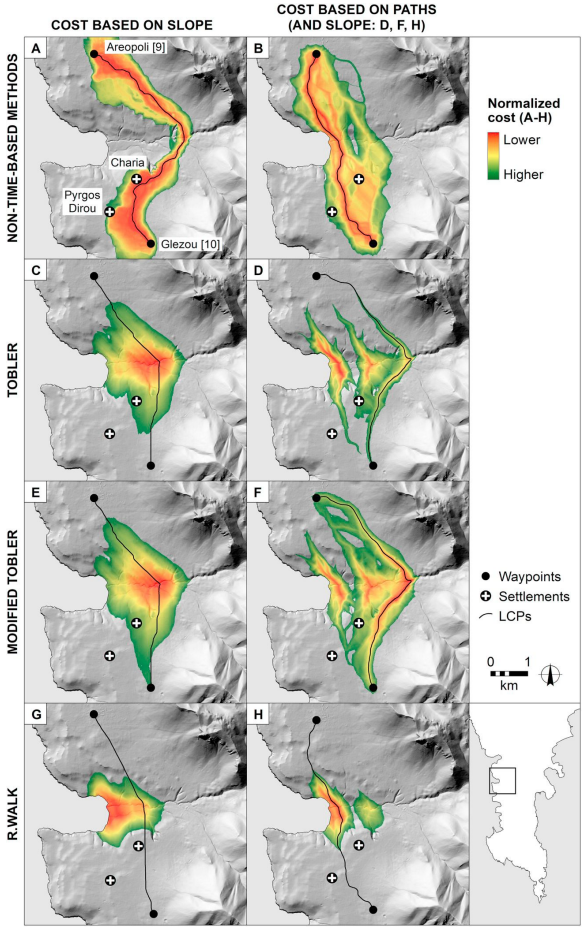


Fig. 9

Waypoints

1. Gytheio
2. Mavrovouni
3. Katziaounianika
4. Passava
5. Petrovouni
6. Vathy
7. Kamares
8. Skoutari
9. Areopoli
10. Glezou
11. Kyparissos
12. Kokkinogeia
13. Achillio Monastery
14. Alika
15. Vamvaka
16. Paliochora
17. Limeni

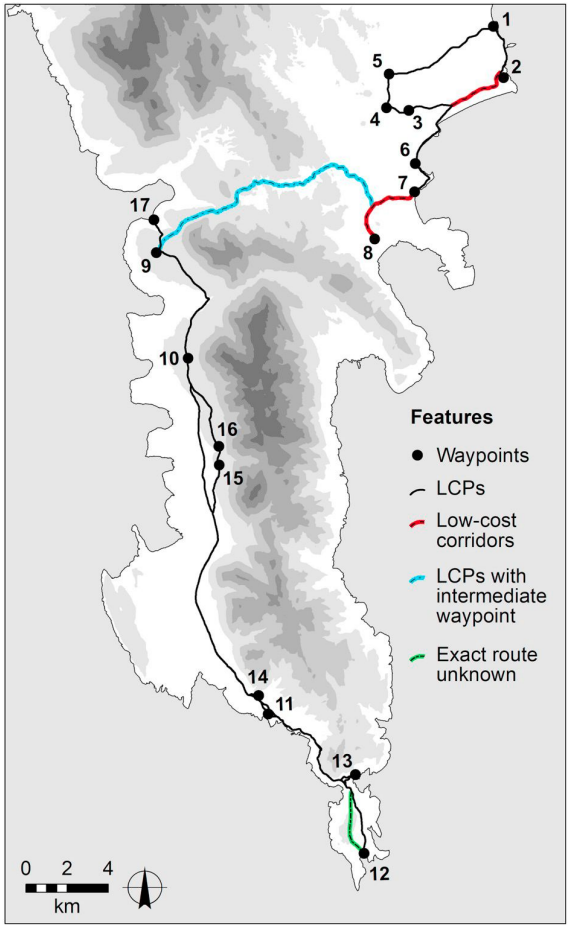


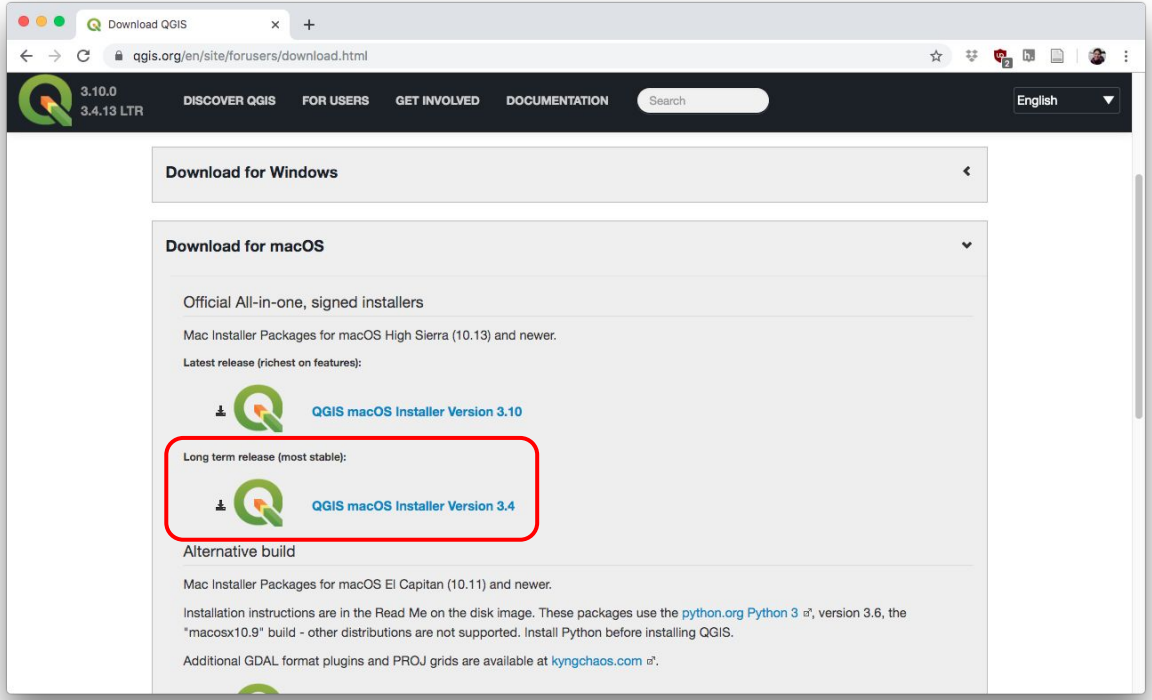
Fig. 15

Seifried, R.M. and C.A.M. Gardner. 2019. "Reconstructing Historical Journeys with Least-Cost Analysis: Colonel William Leake in the Mani Peninsula, Greece." Journal of Archaeological Science: Reports 24: 391–411. https://doi.org/10.1016/j.jasrep.2019.01.014

Overview of the Exercise

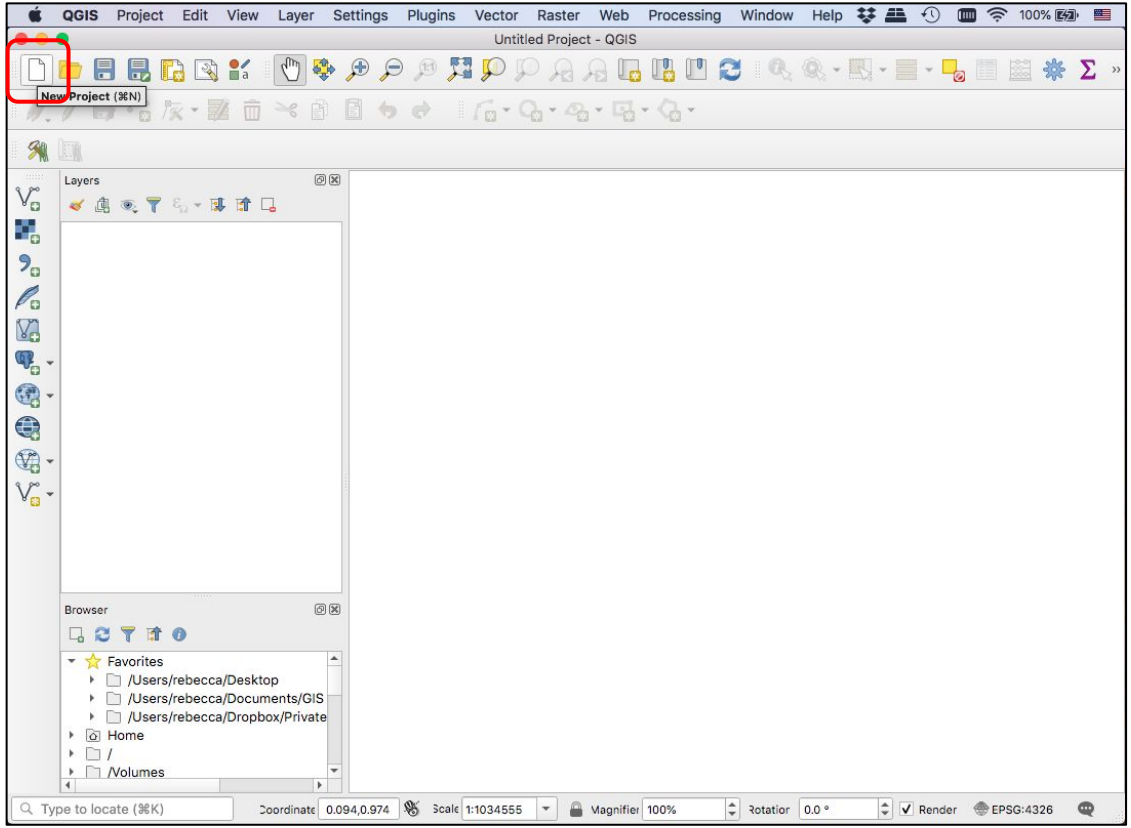
Preparation: Software Install

Download QGIS 3.4 (long-term release) https://qgis.org/en/site/forusers/download.html



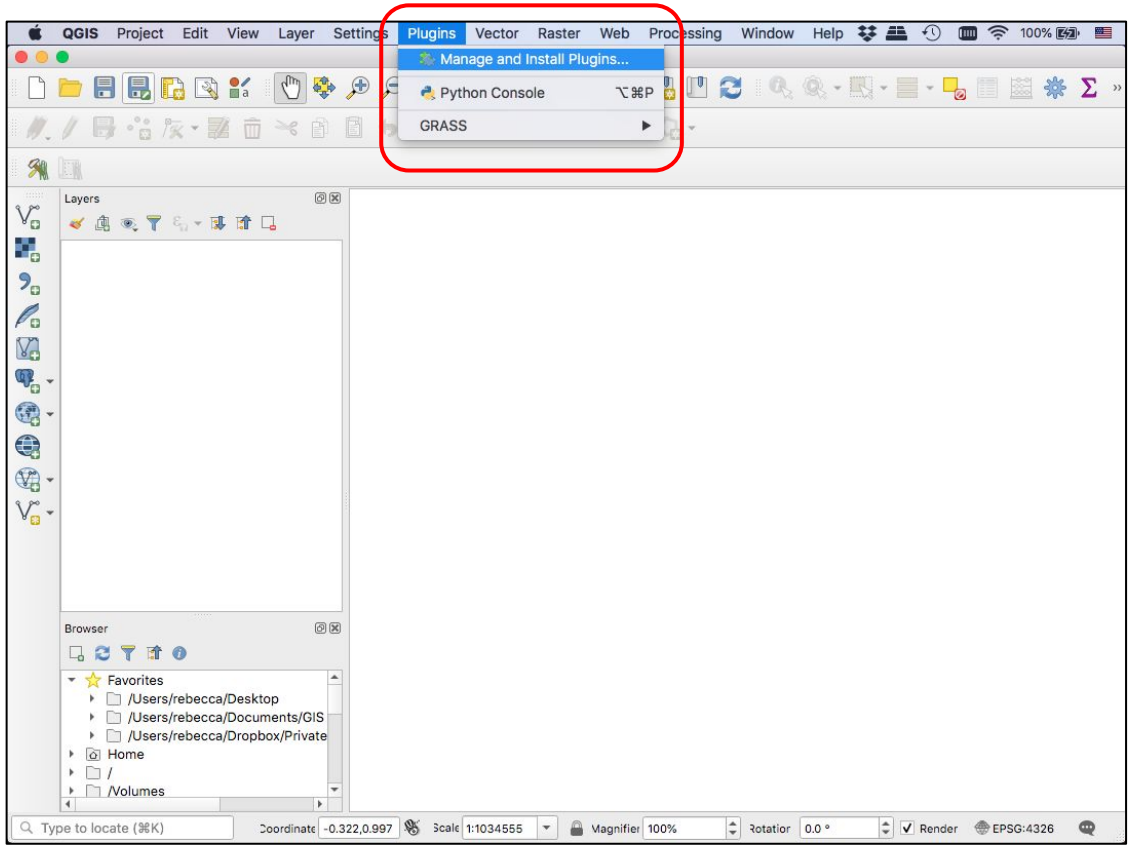
Preparation: Plugin Install

- Launch QGIS and start a new project



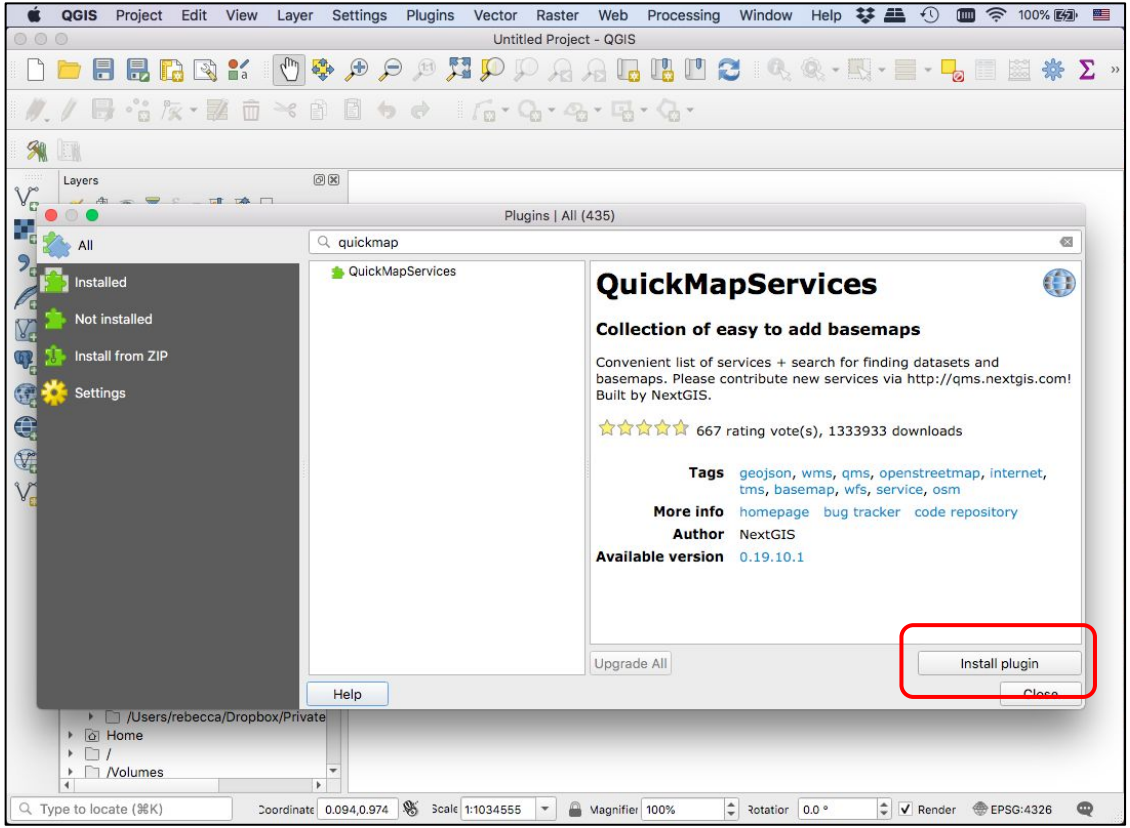
Preparation: Plugin Install

- Launch QGIS and start a new project
- Go to Plugins > Manage and Install Plugins...



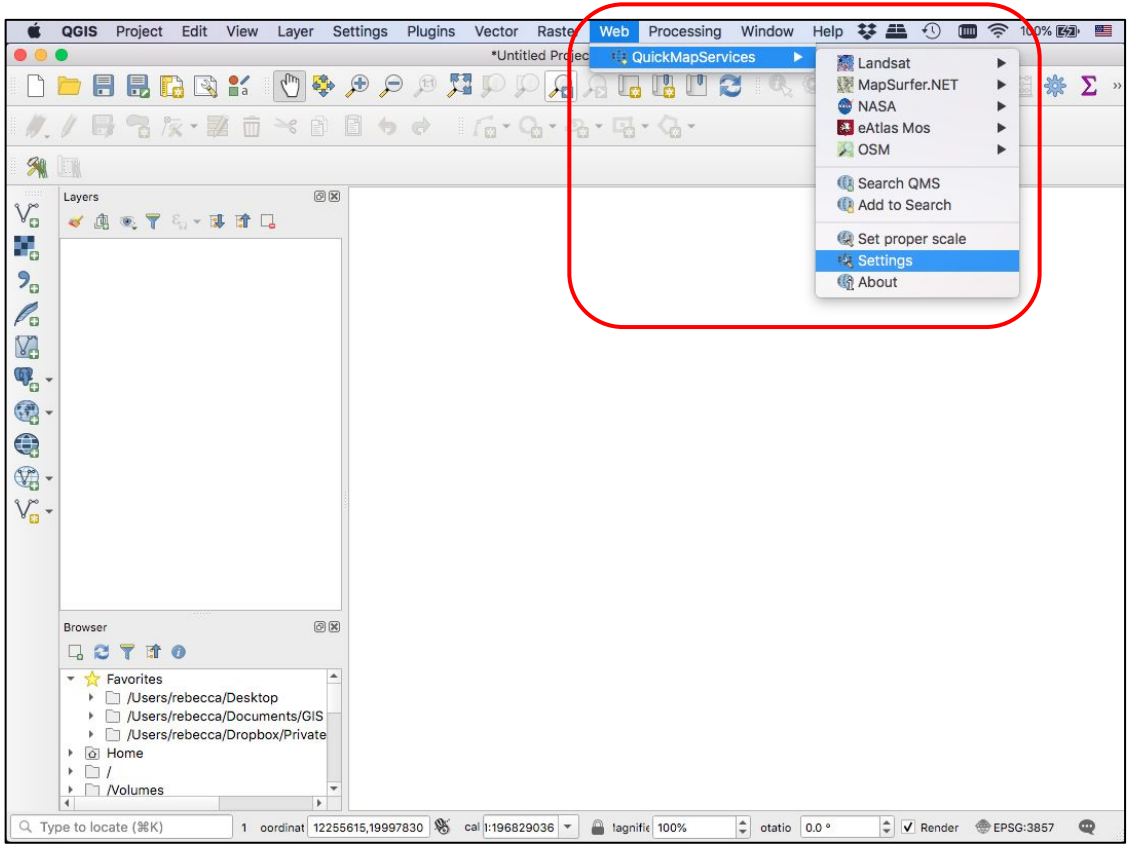
Preparation: Plugin Install

- Launch QGIS and start a new project
- Go to Plugins > Manage and Install Plugins…
- Search for QuickMapServices and click “Install plugin,” then “Close”



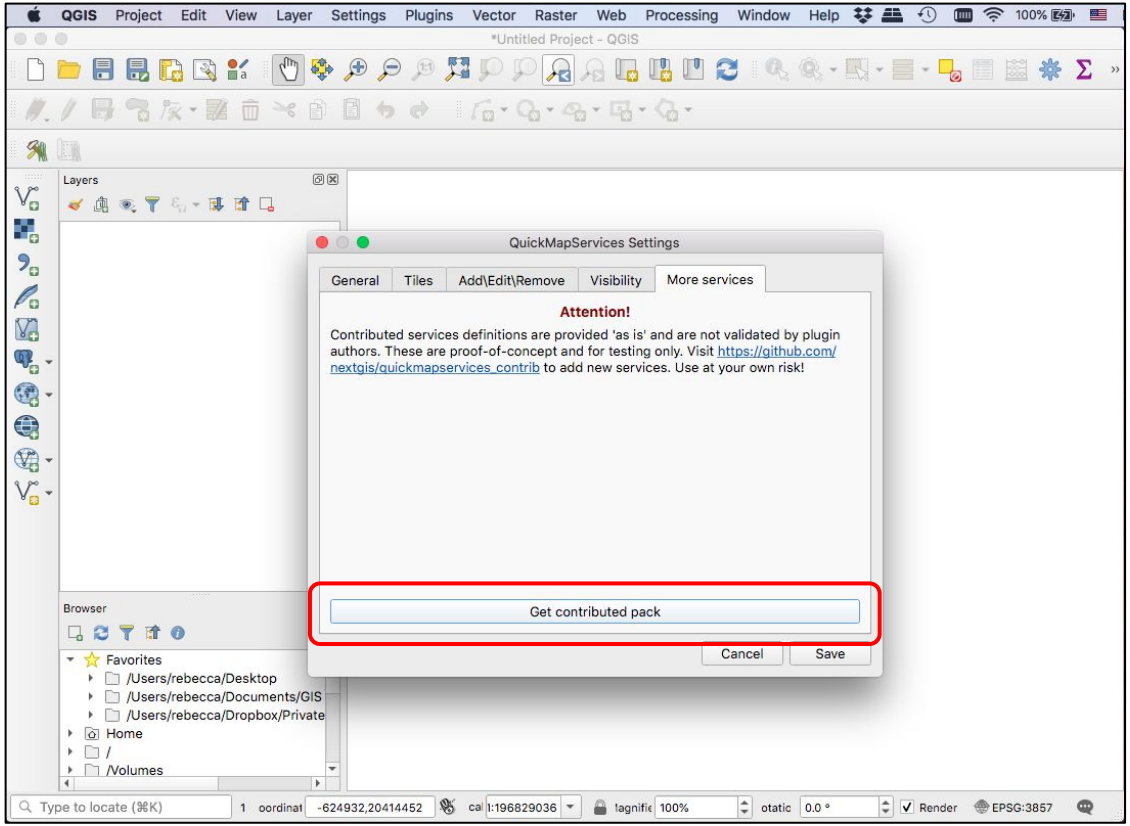
Preparation: Plugin Install

- Go to Web > QuickMapServices > Settings



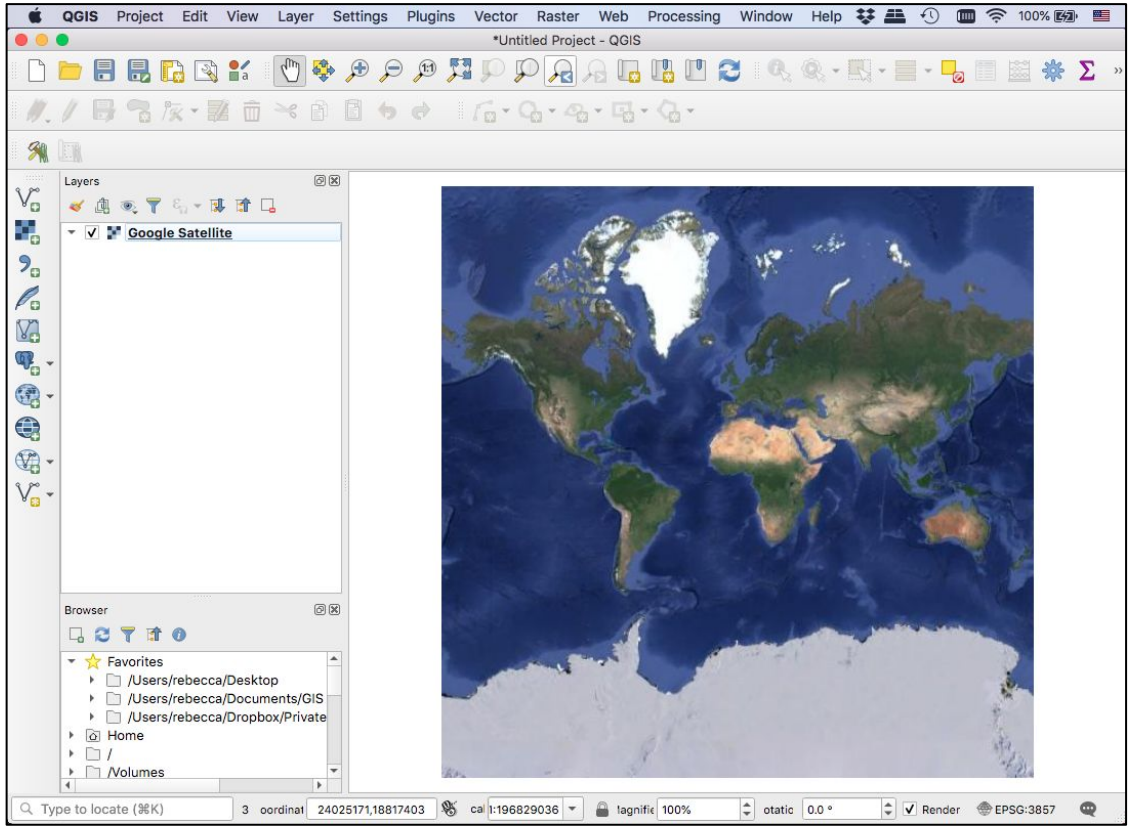
Preparation: Plugin Install

- Go to Web > QuickMapServices > Settings
- On the “More Services” tab, click “Get contributed pack” to download extra base imagery, then “Save”



Preparation: Plugin Install

- Go to Web > QuickMapServices and load Google Satellite



Preparation: Data

- Option 1 – Download the example dataset: https://github.com/SunoikisisDC/SunoikisisDC-2019-2020/blob/master/Leake_Itinerary.zip
- Option 2 – Get your own data. You will need:
  - **Places shapefile** with at least three points connected by land
  - **Elevation raster** covering the extent of the points
  - **Hillshade raster** computed from the elevation raster