# Mapping Farmstead-Sanctuary Connectivity using Least Cost Path in an Ancient Landscape

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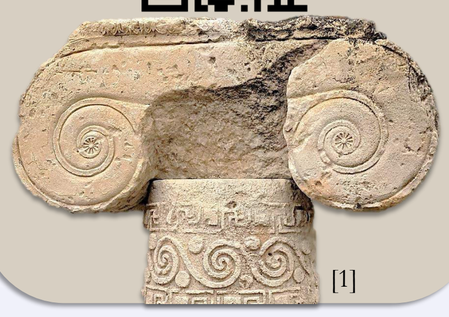
## Storymap

ACCESS TO LEGACY DATA AND MAPS



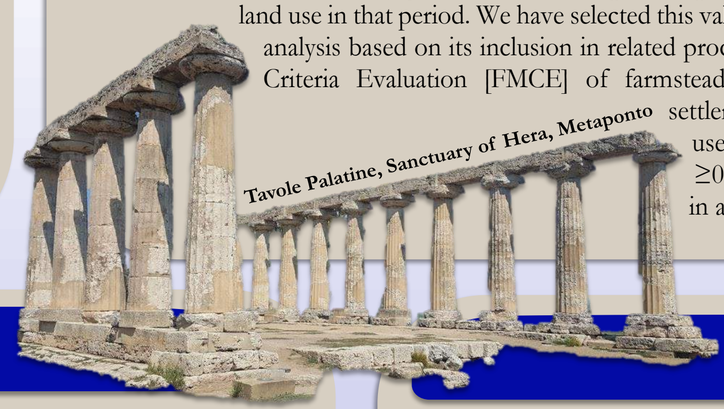
[1]

## Metaponto

Greek settlers founded the city of Metaponto in the 7th century BCE, along the Ionian Coast of southern Italy (right). A topographical 'blank canvas' granted ancient urban planners unprecedented control over the organization of not only the city, but of land division and allotment within the surrounding *chora* (countryside). Epigraphic and literary evidence suggests that the dividing of the countryside in antiquity could be deliberate and systematic (e.g. the "Black Corcyra" inscriptions regarding parceling of territory [SIG3 141]). Physical evidence of these land divisions is visible as topographic anomalies captured using aerial photography of the countryside in the 1960s.[2] Additionally, decades of cataloguing surface-level artifacts in the countryside of Metaponto under the auspices of the Institute for Classical Archaeology (ICA), and lately McMaster University, has resulted in a database which identifies the locations, typologies, and peak activity of hundreds of sites between the 7th and 1st centuries BCE. The following project reconciles the typologies of these sites, specifically farmsteads and sanctuaries, with these topographical anomalies (classified in scholarship as 'division lines'), a process which has suggested that some of these lines represent not only ancient land parceling, but routes of communication between farmsteads and extra-urban sanctuaries.

## Legacy Data of the *Chora*

The field survey (the systematic collection and identification of surface-level artifacts) in the Metapontine *chora* is one of the most extensive and comprehensive survey projects in modern landscape archaeology. Data gathered from 1979-2008 are freely available within the project Archaeological Recording Kit.[3] This includes all assemblages, typologies, and site locations (coordinate system = WGS-84 UTM Zone 33N). High-quality 'black-gloss' artifacts recovered during surface survey are dated using ceramic typology identification and related dating techniques. To account for dating uncertainty, dates are processed using a Kernel Density Evaluation (KDE), along with an Equivalent Artifact Weight (EAW) formula. The EAW values for a site represent the average number of black-gloss fragments at a site dateable within a period of 50 years. These 50-year periods are expressed as 'date bins', with a single number representing each of these date ranges (i.e. 525-474 BCE= 500). Once all dateable fragments have been evaluated, they can be compiled and the most likely date determined by multiplying the averaged EAW by the value of the 50-year period. An EAW value of 0.95 indicates that a site has the equivalent of 1 black-gloss fragment from that date bin, providing evidence of land use in that period. We have selected this value as the threshold for inclusion in the below analysis based on its inclusion in related processes by the ICA (namely the Final Multiple Criteria Evaluation [FMCE] of farmstead importance).[4] Therefore, all farmsteads, settlements, and sanctuaries whose locations are used in this analysis meet an EAW threshold of ≥0.95, eliminating all sites with minimal activity in any given period.



Tavole Palatine, Sanctuary of Hera, Metaponto

## Elevation Sources

Phantom 4 Pro, Excavations at Incoronata Greca

Elevation data was incorporated into the GIS first using the ASTER GDEM (Version 3) at a spatial resolution of 1 arc second (N40 E016). Supplemental elevation data was gathered in July of 2019 at the sanctuary of 'Incoronata Greca', which was surveyed for the purposes of creating a DEM of the plateau on which members of McMaster University (and Queens University) were performing excavation (spatial resolution of 2cm). Liminal sanctuaries have been identified in scholarship both as identifiers of *chora* extent surrounding Greek city-states, and as delineation of space.[5] Excavations at the sanctuary of Incoronata have produced a plethora of sacred materials and the site was therefore ideal for survey and inclusion in the below analysis. Additional survey of sanctuaries and of related areas of interest (including areas surrounding evidence of ancient wheel ruts) is planned for future field seasons.


DEM and Orthomosaic, Incoronata Greca

## Methodology

- curate a catalogue of sites from surface survey data which have been identified as farmstead, settlement, or sanctuary which meet a threshold of ≥0.95 EAW within a 50-year date 'bin'
- utilize ASTER elevation data (30m resolution), complemented by Metaponto Archaeological Project DEMs (e.g. Incoronata) to digitally reconstruct the *chora* within ArcGIS Pro
- test least cost path in ancient contexts by performing LCP processes between antique sites which feature archaeological evidence of a road(s) (e.g. the Athenian *lithagogia*)
- perform surface cost analysis in the Metapontine countryside (slope, hydrography) for each sanctuary within each of the 10 date bins (Pre-600 to 200 BCE)
- apply LCPs between farmsteads and sanctuaries for each date bin
- count overlapping line features to visualize routes with most activity
- investigate LCPs which interact with topographical 'division lines' to determine if these lines represent communication in the *chora*

## Testing LCP Efficacy in Ancient Route Finding

To test the accuracy of performing cost surface and least cost path analysis within ArcGIS Pro in locating ancient thoroughfares, a path was selected for which there is archaeological evidence. By comparing generated LCPs with the location of these material remains, we can test the process' efficacy, specifically at sites contemporary with Greek activity at Metaponto (7th- 3rd c. BCE).

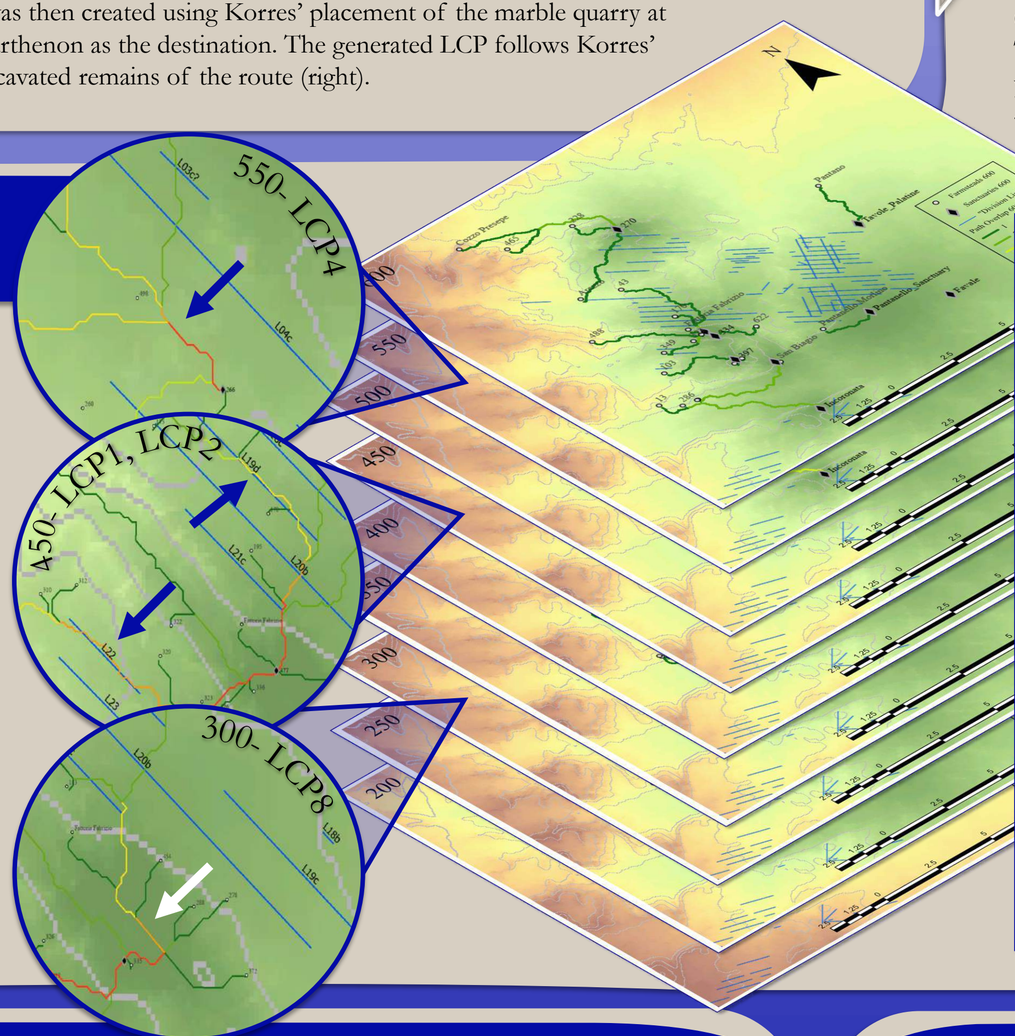
### The Lithagogia

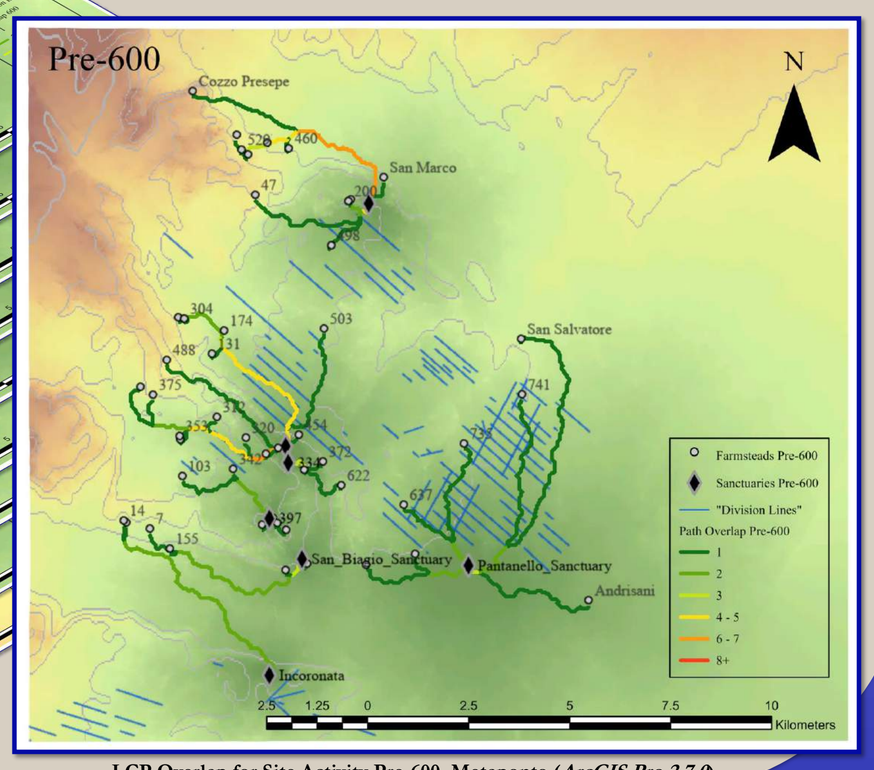
The *lithagogia* was the route used to transport marble from Mount Pentelikon to the Athenian Acropolis in the 5th century construction of the Parthenon. Monalis Korres hypothesized the location of this route in 1995, and in 2009 remains of the route were excavated, confirming Korres' hypothesis.[6] The *lithagogia* therefore provides a unique opportunity to create a least cost path to test against his (now archaeologically supported) route. From Korres' publication, two maps have been imported into ArcGIS Pro and georeferenced using spline transformation. A total of 44 ground control points were selected for Map 1 (the Acropolis), and 71 for Map 2 (Pentelikon). Hydrography was acquired from the American School of Classical Studies at Athens, from the Geofabrik/OSM (OpenStreetMap) Waterways shapefile.[7] An LCP was then created using Korres' placement of the marble quarry at Pentelikon as the source and the east face of the Parthenon as the destination. The generated LCP follows Korres' path closely, most importantly in the area of the excavated remains of the route (right).


LCP and hypothesized route from Pentelikon to Athenian Acropolis (Map 2, *ArcGIS Pro 2.7.0*)

## Diachronic Connectivity

Using the combined elevation datasets (ASTER + project gathered), we perform cost surface and least cost path analysis using the arcpy CostPathAsPolyline and CountOverlappingFeatures_analysis tools in the area of the *chora* of Metaponto. The result is a diachronic collection of 10 maps, each representative of 50 years of activity in the *chora* (Pre-600 [activity before 625], 600, 550, 500, 450, 400, 350, 300, 250, and 200. Activity in the *chora* decreased significantly around 500 BCE (the result of flooding) and later fell under Roman control during the Hellenistic period.




LCP Overlap for Site Activity Pre-600, Metaponto (*ArcGIS Pro 2.7.0*)

## Areas of Interaction with Division Lines

Counting overlapping line features for each date bin provides a visualization of LCPs which may represent high traffic. Minimum (no) overlap is represented by 1 (path), with maximum overlap at 28 (overlapping paths). We then catalogue high traffic polylines (≥4 overlap) which interact with division lines. LCP segments which interact with division lines include LCP4 with Line L05c (NW Site 266), LCP1 and LCP2 with Lines L22 and L19d respectively (W/NE Site 335), and LCP 8 with Line L21c/22b (E Site 335). LCP8 in the 300 date bin (white arrow, right), an LCP segment measuring a minimum of 400m, does not directly overlap a division line but features a geodetic angle differentiation of less than 3° with the division line system. Transversely, this LCP segment lies 720m from its nearest division line (L20b), exactly double the typical distance between division lines (260m). This LCP almost certainly reveals a continuation of the division line system.

## Applicability and Outlook

**Additional Survey:**

Results of this survey identify 52 LCP segments which significantly interact with division lines in the *chora*. This suggests that these lines could represent ancient roads and that the divisions, at least in part, could represent a system of grided communication along property delineation. They may also provide routes of access to extra-urban sanctuaries. Continued survey surrounding sacred spaces (planned for future field seasons) will provide finer resolution datasets for additional LCP modeling. These areas also align with predictive archaeological methods, suggesting that excavation could reveal evidence of roads along high-traffic LCPs.

**Expounding the Data:**

Data from this analysis will be used in the study of land use and as digital/material evidence of social interaction in the *chorai* of ancient Greek city-states. It will aid in the characterization of frequentation at extra-urban sanctuaries, a topic which relies heavily upon material evidence in the absence of ancient literary accounts of these smaller shrines and sacred spaces. Methods using GIS are quickly becoming ubiquitous in the field of landscape archaeology, and studies such as this serve as a new digital source for ancient life in the Mediterranean.

## References

[1] All visuals captured and provided by author.

[2] Adamesteanu, D., Vatin, C. (1976). L'arrière-pays de Métaponte, *Comptes rendus des séances de l'Académie des Inscriptions et Belles-Lettres, 120e année*, N. 1, 110-123.

[3] https://ica.tacc.utexas.edu/metaponto/metsur_ark/user_home.php

[4] Dana, P. (2011). Methods and Analytical Tools: GIS Methods and Considerations. In J. C. Carter and A. Prieto (Eds.) *The Chora of Metaponto 3: Archaeological Survey- Bradano to Basento Vol. 1* (pp. 93-128). Austin, TX: University of Texas Press.

[5] De Polignac, F. 1995. *Cults, Territory and the Origin of the Greek City-State.* Chicago University Press, 35-6, 56, 76.

[6] Korres, M. 1995. *From Pentelicon to the Parthenon : The Ancient Quarries and the Story of a Half-worked Column of the First Marble Parthenon.* Melissa.

[7] https://www.ascsa.edu.gr/excavations/ancient-corinth/digital-corinth/maps-gis-data-and-archaeological-data-for-corinth-and-greece