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Integrating legacy survey data into GIS-based analysis: The rediscovery of the archaeological landscapes in Grevena (Western Macedonia, Greece)

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Abstract

Surface archaeological survey has been widely established as the principal method for the regional study of Mediterranean diachronic landscapes. Before the introduction of GPS and digital, GIS-based recordings in the late 1990s, survey projects employed analogue recording strategies (e.g. personal notebooks, printed forms and cartographic materials) resulting in low-precision spatial datasets. These archives, termed here as legacy survey data, can today be visualized and analysed using computational tools. The aim of the present work is to exemplify how legacy data can be reused and reproduced to explore unknown aspects of past survey projects. It showcases a multi-source, GIS-structured workflow to manage and re-evaluate data from the region of Grevena, north-western Greece, where a largely unpublished all-period extensive survey titled the Grevena Project has pinpointed a rich, yet unavailable to the archaeological community cultural record. The publications lacked critical evaluation of the survey results and significance, such as accurate site locations, size and chronology as well as a description of the field collection strategies used. To recover and combine these data into a single geodataset, a three-step workflow was created, including the systematic recording of collected artefacts, the deployment of archival and remote-sensing resources (e.g. georeferenced cartographic and photographic materials and satellite imagery) and the development of a new extensive survey in selected areas for validation purposes. Results indicated heterogeneity in the techniques employed by the Grevena Project for site recognition. They also brought an important assemblage of Palaeolithic finds unrecorded before. Furthermore, large-scale geomorphological analysis using geomorphometric approaches demonstrated an irregularly high density of sites in elevated areas, which is considered a surveying bias. Remote sensing sources including archival aerial photographs highlighted regional landscape changes (e.g. in forest coverage) revealing architectural remains unmapped before. Finally, the new survey around Ayios Georgios showed the discovery of several new sites, emphasizing a case study of much more complex dynamics than originally considered during the Grevena Project.

KEYWORDS
archaeological survey, georeferencing, GIS-based analysis, Grevena (Greece), landscape archaeology, legacy data

1 | INTRODUCTION

Greece has been a focal region for the emergence and development of surface archaeological surveys, both extensive and intensive, for practitioners in the Mediterranean region since the 1960s (Bintliff, 2012). A surface or field survey can be generally defined as the systematic collection and study of surface remains of archaeological importance from across the landscape (Bintliff, 2014, p. 7139; Knodell et al., 2023). Early survey projects conducted mostly by foreign archaeological schools, particularly the British and the American, have shaped not only the fieldwork strategies still in use today but also the research agenda and publication format for the long-term interpretation of past cultural landscapes (Alcock et al., 1994; Alcock & Cherry, 2004; Arrington et al., 2016; Bevan & Conolly, 2013; Bintliff & Snodgrass, 1985; Cherry et al., 1991; Davis et al., 1997; Georgiadis et al., 2022; Jameson, 1976; McDonald & Rapp, 1972; Renfrew & Wagstaff, 1982). Since the 'New Wave' of the 1980s (Cherry, 1994), the continuous systematizing of fieldwork (e.g. walking in transects at defined intervals) has produced vast amounts of records, along with the collection of hundreds of thousands of artefacts that needed to be studied (Attema et al., 2020; Bintliff & Snodgrass, 1985, pp. 129–137; Cherry et al., 1991, pp. 13–35; Knodell et al., 2023; Tartaron et al., 2006; Whitelaw et al., 2007; Whitelaw, 2013; Wright et al., 1990, pp. 604–619). Such intensive surveys showed particular care to publish extensive accounts of the collected materials (mostly of pottery) as well as complete site catalogues with corresponding maps (Alcock & Cherry, 2004; Cavanagh et al., 1996, 2002; Knodell et al., 2023; Runnels et al., 1995).

In practice, as it also occurs with excavation projects, most published survey volumes and reports took several years—if not decades—to complete (e.g. Athanassopoulos, 2016; Pullen & Allen, 2011; Wright & Dabney, 2020). In a recent review of 167 completed survey projects from the Mediterranean, only 27% accomplished full publication of results (Knodell et al., 2023). Surveys are fragmentarily published through individual articles and reports, posing serious questions on the potential to reproduce or compare results between different areas of study. The unpublished material adds to the same problem and usually remains inaccessible to the archaeological community because of various reasons, including permit restrictions and personal agendas (Tsiafaki & Katsianis, 2021). The problem described is not new or local, but rather it needs to get the attention of more researchers and experts in the field. In this regard, an emerging phenomenon considers the review and management of older survey materials, which is termed here as legacy survey data. Before the introduction of digital, GIS-based recordings in the 1990s, survey projects in principle employed handwritten strategies to cover the area of interest. Legacy survey data thus consist of paper-based archives, such as personal notebooks, recording forms and point maps on printed cartographic materials that cannot be digitally explored in terms of their spatial and qualitative attributes (Allison, 2008; Witcher, 2008; Casarotto, 2017, p. 13, 2022, p. 424). Thus, these approaches aim at integrating spatial references (that is the location and extent of archaeological sites) and the statistical processing of previously recorded findings in an effort to reassess or complement existing interpretations of past human activity (Bonnier et al., 2019; Farinetti, 2011; Jazwa & Jazwa, 2017; Knodell et al., 2023; Pollard, 2023; Spencer & Bevan, 2018; Tsiolaki, 2022).

Apart from research purposes, legacy survey data are crucial today for heritage management strategies implemented by local authorities. Particularly, the rural landscapes of Greece, where most archaeological surveys are conducted, have experienced severe transformations for touristic development and agroeconomic reasons, putting the cultural record in danger (Cherry, 2003, pp. 157–158). In this direction, the introduction of digital methods in both field recording and desktop-based registers, including GPS technology, structured open-access databases,[1] GIS-based applications (Bevan & Conolly, 2004; Gillings, 2000) and multi-temporal remote sensing sources (Alexakis et al., 2009; Garcia-Molsosa et al., 2023; Orengo et al., 2015), targets at recovering and storing data no longer visible in the landscape today and, at the same time, complementing this information with new in-field results for a better understanding of the archaeological record.

Within the same framework, this paper deals with the discovery of a largely unpublished legacy survey dataset from the region of Grevena, in north-western Greece. In 2014, the newly established Ephorate of Antiquities (*EFA*) of Grevena began to compile an inventory for the heritage management of antiquities and archaeological sites that fell into its area of authority, and the high rate of local looting activities mandated immediate protection of certain zones with archaeological interest. A previous all-period extensive survey under the direction of Prof Nancy C. Wilkie from Carleton College (Minnesota, USA) and the American School of Classical Studies in Athens (*ASCSA*) between 1986 and 94 was taken as the background information for the new site index of the area. The *Grevena Project*, as it was named, employed a type of extensive, 'site-based' strategy, because fieldwalking and site reconnaissance were limited to locations

[1] https://classics.uc.edu/prap/, https://classics.uc.edu/nvap/.

mostly indicated by oral testimonies of the local inhabitants. According to Wilkie's reports, the project identified more than 300 archaeological sites within the entire Grevena region (Wilkie, 1999, p. 1345); however, the exact number of sites remains unclear in the existing publications, with estimations ranging from 318 to almost 400.[2] Moreover, very little has been published on the collection strategy the *Grevena Project* followed to recover and catalogue surface artefacts, the accurate location of the sites, their chronological periods of use and their character—despite the several published reports and articles that followed. In fact, the main source of information comes from handwritten maps or through the illustration of a few selected pottery (Wilkie, 1989, 1990, 1991, 1992, 1993, 1994, 1999; Wilkie & Savina, 1997). At present, the available data consist of boxes of the collected materials, with separate bags for each location, and a site database with point coordinates in Keyhole Markup Language (KML) format sent by the ASCSA in 2022, which included inaccuracies as it will be discussed below.

The response from the *EFA* of Grevena was to initiate the *Grevena Archaeological Project (GAP)*, an interdisciplinary research that involves extensive and intensive field survey, palaeoenvironmental and geoarchaeological studies, and excavation in selected sites. As part of the *GAP*, the general aim of this work is to propose a standardized workflow for digitizing and georeferencing archival paper records from non-invasive, ground-based archaeological surveys (the 'legacy survey data') on the example of the Grevena Project, which can also be applicable elsewhere. We introduced a multi-source model to reconstruct the techniques that the original *Grevena Project* applied in the field and at the same time retrieve as much information as possible about the located sites based on remote sensing spatial analysis and on-field investigation. Revisiting a sample of the *Grevena Project* sites 30 years after their initial survey was thus necessary (Bintliff et al., 2017, pp. 61–62; Tartaron, 2003, pp. 43–45).[3] Different case studies from the region have been included to illustrate some of the achieved results discussed below.

2 | NATURAL SETTING AND THE ARCHAEOLOGICAL BACKGROUND OF GREVENA

The modern region of Grevena is an upland, montane area of about 2300 km^2 in Western Macedonia, north-western Greece. It exhibits a remarkable topographic setting flanked by the Vourinos mountains to the east and the greater Pindus range to the west, and an elongated basin extends in between, characterized by low hillside depressions and stream incisions. This creates an alternation of small fertile plains with forested areas, all rich in water resources that drain off into the Aliakmon River and its numerous tributaries (Figure 1). The striking morphological division between upland (up to 1000 m asl) and montane (up to 2220 m asl) zones is the result of a complex geology representing the suture line of two continents that has long attracted specialists in the field. The highlands of Grevena consist of formations exposing large portions of ophiolitice rocks—fragments of the palaeo Neo-Tethyan ocean crust and upper mantle (Brunn, 1956; Rassios, 2002, 2004)—whereas the basin in the middle, also known as the Tertiary Mesohellenic Trough, was once a marine environment that was later filled with sediments up to 4 km thick (Vamvaka et al., 2006). The continuous erosive action of the Aliakmon during the Quaternary and the Holocene, enhanced by regional tectonic uplift, has left multi-period alluvial terraces and deep incisions in the landscape that break the land into small, steep valleys and catchments. This dissected topography intensified the erosion of ridges and the accumulation of colluvial and alluvial deposits in the dense network of small valleys (Doyle, 2005; Doyle & Savina, 2014, pp. 187–189; Rassios, 2004, p. 19).

Archaeological research in Grevena has not received the same attention as in the other regions of Western Macedonia, such as Kozani, Kastoria and Florina. In the past, the extensive river network of Aliakmon had emerged as a focus of palaeoanthropological research attesting human presence in the area as early as the Middle Palaeolithic period, c. 100 000–30 000 BCE (Galanidou & Efstratiou, 2014; Harvati et al., 2008; Panagopoulou et al., 2004). Furthermore, in the highland regions and alpine peaks of north-easter Pindus around Samarina, a pioneer international survey has been revealing evidence of Palaeolithic hunter–gatherer groups and the possible routes they followed across the mountains (Biagi et al., 2017, 2022; Efstratiou, 2008; Efstratiou et al., 2006; Efstratiou & Biagi, 2013). Beyond a period-specific spectrum, the extensive survey carried out by the *Grevena Project* team was the first serious attempt, although unpublished, to study the diachronic landscapes of Grevena from the Neolithic to the modern periods (Wilkie, 1993; Wilkie & Savina, 1997). Excavation projects, on the other hand, are limited and usually related to rescue excavations as part of large public works, such as the opening of the Egnatia Highway and the construction of the Ilarion Dam in the 2000s (Karamitrou-Mentesidi, 2004, 2005, 2006, 2007, 2009, 2011, 2016; Karamitrou-Mentesidi & Theodorou, 2011, 2013). To date, the only systematic excavation has been carried out at the site of Kastri Alatopetras-Polyneriou under the auspices of the Aristotle University of Thessaloniki, revealing the fortified acropolis of an ancient city (4th–2nd centuries BCE) that was seemingly part of the Macedonian Kingdom (Drougou, 2015). Overall, the picture at Grevena remains significantly unexplored, and thus, the reassessment of the old unpublished datasets combined with new fieldwork maintains a high potential for a comprehensive understanding of its archaeological landscapes. Although the *Grevena Project* was developed in most parts of the province of Grevena, it did not cover the same study area as the Samarina survey for example, and, therefore, we cannot merge the data of both projects in this paper but rather compare and discuss their results as points of reference.

[2]The total number of sites appears to be 390 according to Wilkie (1992, p. 238); nearly 400 of which 318 catalogued according to Wilkie (1999, p. 1345) and Rosser (1999, p. 975); 339 according to the geolocation of Wilkie's material we conducted; and finally, 319 based on the ASCSA map (see below).

[3]https://www.iihsa.ie/projects/the-kea-archaeological-research-survey-kars-project (last accessed: 21/05/2023)

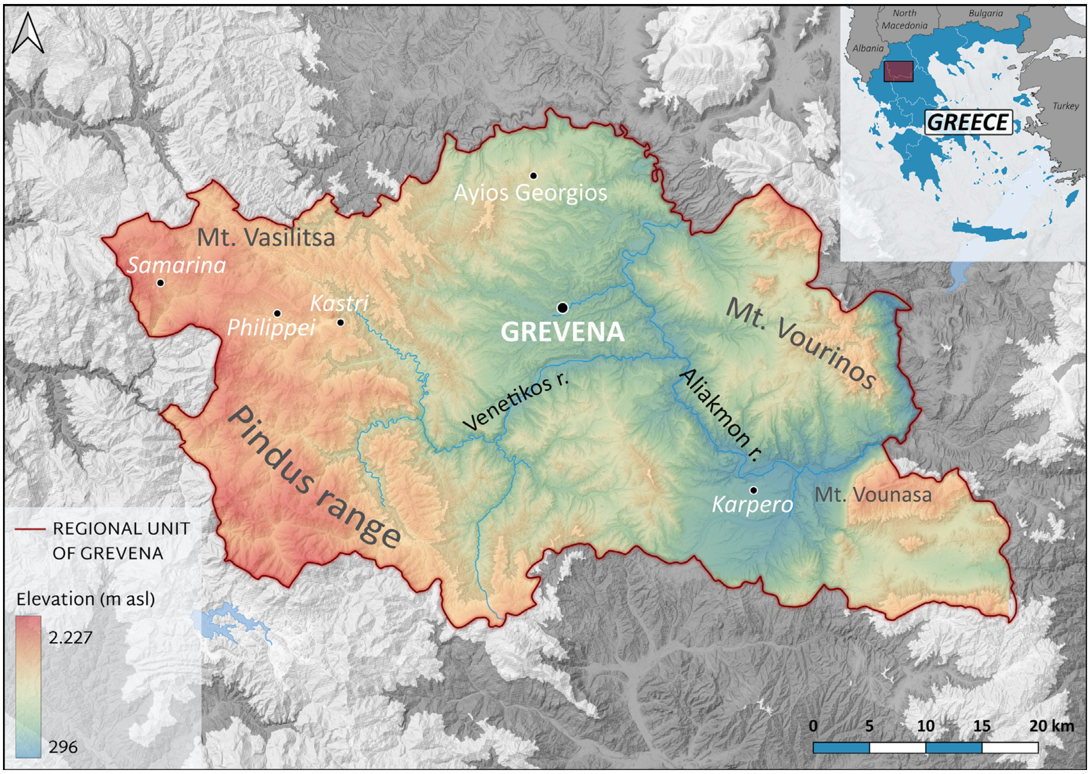

FIGURE 1 Topographic map of Grevena with main locations mentioned in the text. [Colour figure can be viewed at wileyonlinelibrary.com]

3 | MATERIALS AND METHODS

To approach the main objectives set in the introduction, we developed an integrated multi-scalar framework divided into three stages: (1) the qualitative and quantitative study of the old surface finds, (2) the collection and analysis of multi-source archival materials (mainly photographic and cartographic) and (3) the systematic revisiting of selected sites. A structured geodatabase file was created within a Geographic Information System (GIS) software, in our case QGIS Desktop 3.22.3 (QGIS Development Team, 2023), to introduce and manage all acquired data. This integration enables to perform layer-by-layer evaluation of different materials in conjunction with the archaeological sites of the area (e.g. by overlapping site location with georeferenced maps and aerial photographs) that would otherwise require much more time to process manually. For the needs of the fieldwork, the QGIS database was synchronized with QField, an open-access cloud software that can operate on portable devices (mobile phones or tablets) for real-time spatial recordings (Figure 2).

Using the term 'site' to interpret surface artefact recovery needs further attention here. In the surface archaeology of Greece, site definition varies from project to project. For example in regions like Boeotia, Laconia and Keos, sites were designated as bounded areas with a high concentration of observed artefacts in comparison with the overall surface assemblage (Bintliff et al., 1999, p. 141; Cavanagh et al., 2002, pp. 34–40; Cherry et al., 1991, p. 22; Forbes, 2013); for other projects, such as the Berbati-Limnes in the Argolid, where overall surface materials appeared scarce, terms such as 'findspot' were preferred in order to shift the focus towards smaller areas with less conspicuous artefact recovery (Wells & Runnels, 1996, p. 18). Such variation in site characterization is still an ongoing issue and stems from decision-making on how an archaeological site should be manifested in terms of recognizable cultural remains (Attema et al., 2020; Bintliff, 2000, p. 200; Gallant, 1986, p. 417). Given that a definition of what constituted a site was absent from any published work of the *Grevena Project* (e.g. Wilkie, 1999, p. 1345), we conventionally kept the term 'site' to catalogue all previous material and avoid discrepancies. After the end of the cataloguing process, more information on the interpretation of the *Grevena Project* sites was provided through comparative statistics (see Section 4).

3.1 | Study of previous survey finds

The initial step of our study included cataloguing all available surface finds from the *Grevena Project*. A team of five specialists with experience in pottery studies spent a month to complete this process. The finds had been stored in bags within 169 boxes labelled with the name of the modern settlement the sites belonged to and the toponym of the locations where they were collected. Thus, each site was georeferenced by assigning coordinates based on the toponym reference that was later reviewed during fieldwork. A vector point layer was created to include both qualitative and quantitative variables. Site information and other handwritten notes were digitized and stored in the layer. Artefacts were quantified according to the most frequently

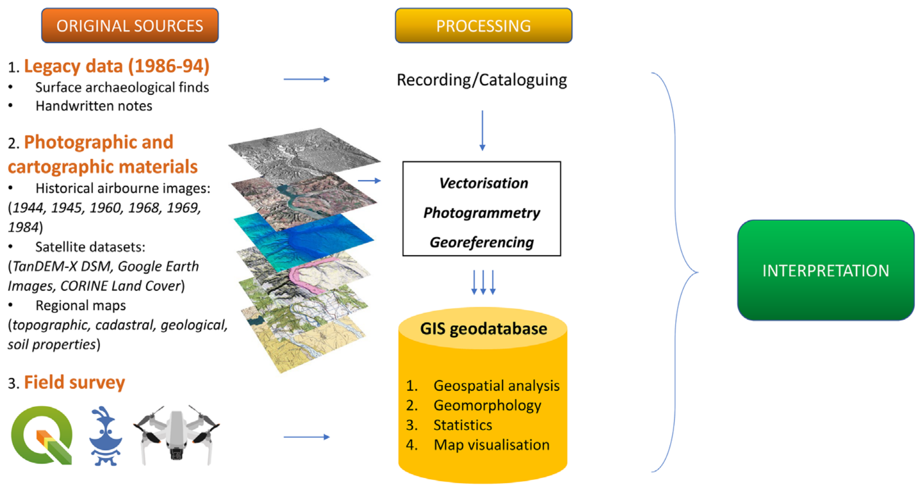

FIGURE 2 General workflow followed in this article. [Colour figure can be viewed at wileyonlinelibrary.com]

encountered categories (e.g. pottery, tiles and lithics). Pottery received further attention and was divided into sub-categories based on predefined parameters (rims, bodies, handles, bases, decorated and pithos). Finally, personal comments, photographs and bibliographical references were added to complement the site index.

While counting the material, chronologies indicated by datable finds were established. Period division was based on broader cultural periods used to describe the prehistory (Palaeolithic to Bronze Age) and the historical times (Early Iron Age to Modern) in Northern Greece, and it highly depended on studied pottery typology or, in some cases, on the presence of stone tools and other diagnostic finds (e.g. building mortars, tiles, coins and metal ornaments). In all cases where the date of the finds remained uncertain, they were labelled as prehistoric unknown or historical unknown accordingly.

3.2 | Digitization and georeferencing of archival materials

For the second stage of our work, we focused on the problem of the accurate digitization and georeferencing of paper records, that is archival aerial imagery and topographic maps from the first available sources from the 1940s to the present day. The aim was to visually identify the location of each site and assess surrounding topography, geomorphology and terrain changes by producing multi-temporal georeferenced orthomosaics of the study area through the photogrammetric processing of the aerial photographs (Orengo et al., 2015). Similar studies dealing with the georeferencing and locating archaeological sites throughout the world have also illustrated the advantages of using light detection and ranging (LiDAR) sensors instead of RGB imagery, particularly in forested areas (Affek et al., 2021; Chase et al., 2012; Grammer et al., 2017). Given that in Greece, such datasets can be currently obtained exclusively by private companies at an extraordinary cost, the implementation of this technique fell outside the budget of the project and was thus not available to us.

Historical aerial photographs, nevertheless, have the potential to reveal archaeological imprints nowadays covered by vegetation or destroyed due to land flattening and reclamation processes that took place in Greece between the 1970s and 1990s (Agapiou et al., 2022; Alexakis et al., 2009; Donati & Sarris, 2016; Orengo et al., 2015; Stoker, 2010). In the case of Grevena, the aerial imagery we used included three single-band greyscale datasets, the British Royal Airforce (RAF) series acquired in 1944 and 1945, the 1960 US Air Force (USAF) series and the 1984 series made by the Hellenic Military Geographical Service (HMGS). Apart from the BSA archives that were provided freely for research purposes, the rest of the datasets were supplied at a cost by the HMGS.

All archival imagery was received as scans of photographic prints in a resolution between 600 and 1600 dots per inch (dpi). For the orthorectification and the georeferencing of these materials, we used the photogrammetric software Agrisoft Metashape Professional 1.8.5®. During the initial image treatment, white balance between the frames was calibrated to reduce sharp colour contrast in the final orthomosaic. During the image-based modelling, a mask was applied to all images to exclude the photographic frame. Furthermore, at least three ground control points (GCPs) per image were introduced to facilitate georeferencing. GCPs were extracted from two different sets of information: visible remains across the landscape common to all datasets, of which coordinates were extracted using Google Earth Pro (e.g. standing architectural features, crossroads and field limits) and fixed coordinates provided by the triangulation stations of the HMGS. The total root-mean-square error (RMSE) of the GCPs ranged between 0.109 and 4.728 mm, and the achieved ground resolution of the orthomosaics was between 28.2 and 71.8 cm per pixel. Every dataset had an approximate 65%–70% overlap between the images (Table 1). Besides archival photography, georeferenced topographic maps of the HMGS at various scales (1:5000, 1:25000, 1:50000) were obtained through the EFA of Grevena and were also included in the integrated geodatabase. These maps assisted in the identification of site locations because many of them were named after local toponyms illustrated on the maps. Yet, they did not include any direct reference to archaeological remains, and therefore, no attempt at automated data extraction (Berganzo-Besga et al., 2023; Garcia-Molsosa et al., 2021) was pursued but they were rather used for topographic, toponymic and navigation guidance.

TABLE 1 Details of the historical aerial imagery used in this study.

Source	Number of images	Flight height (ft)	Focal length (mm)	Scanning resolution (horizontal × vertical dpi)	GCPs total error (mm)	Orthomosaic ground resolution (cm/pix)
British Royal Airforce (RAF)	78	20 000 to 26 000	152.4–609.9	600 × 600	4728	40.8
British Royal Airforce (RAF)	16	42 000	152.4	1600 × 1600	0.109	58.9 to 71.8
U.S. Air Force (USAF)	18	30 000	151.683	1600 × 1600	1689	50.6 to 60.9
Hellenic Military Geographical Service (HMGS)	41	15 000 to 20 000	152.45	1600 × 1600	2301	28.2 to 42.5

After the georeferencing of the *Grevena Project* sites, local topography was digitally visualized with the help of the TanDEM-X Digital Surface Models (DSMs), granted by the German Aerospace Centre (DLR).[4] The TanDEM-X has a ground resolution of 12 m per pixel (Krieger et al., 2007), facilitating a high-resolution performance in basic and advanced spatial GIS-based analyses, such as the topographic position index, the multiple-direction hillshade and the multiscale relief model (Orengo & Petrie, 2017). In our case, we further processed the TanDEM-X with *Geomorphons*, a pattern recognition, pixel-based GIS tool designed for morphometric classification and mapping of landforms (Coll Moritan et al., 2023; Jasiewicz & Stepinski, 2013; Sărăşan et al., 2020). A buffer of 50 m around each site was created as a sample area for conducting the geomorphometric analysis by comparing all pixel values within the buffering zone and then extracting the dominant class.

3.3 | Field survey

Groundtruthing constituted the central part of our workflow and was designed as a validation method for the larger database of located sites. We employed a site-targeted strategy following the previous *Grevena Project* records and oral testimonies. All field recordings were directly introduced into a geodatabase via the QFieldCloud, a QGIS plug-in application. QFieldCloud is a GIS mobile app synchronized with the desktop project. Our designed QField geodatabase allows the systematic mapping of the landscape performed by individual surveyors or a small team of two to four people. Once the site was located, surveyors attempted to define its extent based on artefact scatters and topographic characteristics (Cherry et al., 1991, p. 22; Cavanagh et al., 2002, pp. 34–40).

Artefact density was mapped through separate GPS coordinates for a better understanding of the size and activity of the site (Bevan & Conolly, 2013, p. 14; Bonnier et al., 2013, p. 232; Fachard et al., 2015; pp. 180–181; Georgiadis et al., 2022, p. 6), allowing the collection of information that was missing completely before we started the project. Larger features, such as kiln parts and (stone) architectural remains, obtained individual coordinates. Further comments about ground visibility conditions and local geomorphology were also recorded during fieldwalking.

During the re-survey of Wilkie's sites, a sample of the surface artefacts was collected, typically including diagnostic potsherd categories, a selection of tiles and building materials and all small finds. These sample collections helped to re-assess not only the chronological spectrum of use for each site but also the type of human activity in the area (e.g. habitation, workshop and cemetery). All new survey artefacts were catalogued in the same database format we used for the study of the old materials (see Section 3.1) to use as a matter of comparison between the two datasets.

4 | FIRST RESULTS

4.1 | Study of surface materials and examination of the Grevena Project field techniques

The studied materials from the *Grevena Project* included pottery (89.5%), tiles (6.8%), stone tools (2.3%), clay objects (0.8%), metal objects (0.3%), glass objects (0.2%), mortar fragments (0.1%) and metal slags (0.1%) in a total assemblage of 24,571 finds, dating from the Palaeolithic to the Modern periods. There were 339 sites catalogued in total. Based on proposed chronologies, most sites (280 or 82%) are multi-period, that is including artefacts that belong to more than one cultural periods. Single-period sites, 59 in total, account for 18% of the sum. The number of sites indicated a priori that two major periods are the most represented in the archaeological record, the first being between the Late Bronze Age and the Early Iron Age (c. 1500–600 BCE), and the second from the Hellenistic period onwards to the end of the Late Roman (c. 300 BCE–500 CE). More than half of the single-period sites were dated to the Late Roman period (c. 3rd–5th centuries CE), showing a pattern that has not been explored before in the local archaeology. This evidence will contribute to the consensus developed for other parts of the Greek mainland and the islands, where an explosion of (rural) site numbers in the Late Roman times is typically taken to represent the establishment of a new economic regime (Bintliff, 2012, pp. 357–358; Farinetti, 2021; Pettegrew, 2007).

Furthermore, quantitative overview illustrated that 46.8% of the *Grevena Project* sites include less than 30 collected artefacts (Table 2). Conversely, only 14 sites (4.1%) yielded more than 300 collected finds.

[4]Application DEM_OTHER3598 (Project *MoundArch: Testing large-scale detection of mounded archaeological features and geomorphological signatures in the cultural landscapes of Northern Greece.*), German Space Agency (DLR).

Based on registered pottery, there also seems to be a variation in the methodology that the *Grevena Project* followed to sample between diagnostic and non-diagnostic potsherds. For example, undecorated body parts fall below 20% of the individual site assemblage balancing well with the rest of the diagnostic categories—especially when the total number of sampled artefacts does not exceed 30 pieces. On the contrary, when it comes to large collections, there was an apparent intention to keep as many body parts as possible, reaching more than 70% in total. Therefore, in the first case, the high percentage of diagnostic finds can be interpreted as selective collection, whereas in the second, a total collection strategy was probably employed.

4.2 | Location and large-scale topographic analysis of sites

Since the beginning of the project in August 2021, we have been able to accurately spot 319 of the 339 (94.1%) registered sites from the *Grevena Project*. The ASCSA site map submitted to the Grevena EFA was at first useful to visualize site location but later proved to include inaccuracies, with sites being placed in the wrong peaks or ridges, dozens or even hundreds of meters away from their validated location.

At first glance, the results of the site locating process highlighted a clear density of sites in areas with an elevation approximately between 600 and 1100 m asl, which coincides with the geographical limits of the middle Grevena basins and the Hellenic Trough (Rosser, 1999, pp. 983–984; Wilkie, 1999, pp. 1355–1357) (Figure 3). There were only 20 sites (6.3% of the total) documented in elevations more than 1100 m, with the highest being the fortified site of Profitis Ilias Prosvoro in Eastern Pindus, situated at a peak of 1400 m asl. Yet the mountainous survey of Efstratiou and Biagi, again in parts of Pindus, has published a significant number of sites dating from the Late Neolithic to the Byzantine period in altitudes between 1500 and almost 2000 m asl, for example the remains of a Roman smelting kiln at 1939 m asl (Biagi et al., 2022; Efstratiou, 2008, pp. 53–59). This sharp topographical difference in site recovery indicates a much more complex site distribution than the data of the *Grevena Project* suggests.

Furthermore, the side-by-side review of the TanDEM-X DSM with the projected geomorphons map facilitated preliminary comments on topography and geomorphology based on morphometric statistics. For instance, we attempted to illustrate computationally the relation between the number of sites from the *Grevena Project* and their location at distinct geomorphological classes. Given the highly irregular topography of the region, this approach was carried out to highlight potential site distributions at certain terrain classes. To secure reliable results, the information of only the 318 accurately located sites was considered. Hypothetical 'normalized' values in equal class division showed a clear preference for high visibility locations with sites in peaks, ridges and shoulders being overrepresented, whereas no conclusive pattern could be drawn for the rest of the classes (Figure 4).

TABLE 2 Numbers of recovered artefacts in relation to identified sites in the Grevena Project.

n of artefacts	*n* of sites	% of sites
<10	70	20.6
<30	158	46.8
<50	210	62.1
>70	102	30
>150	32	9.4
>300	14	4.1
>500	6	1.8
>1000	2	0.6

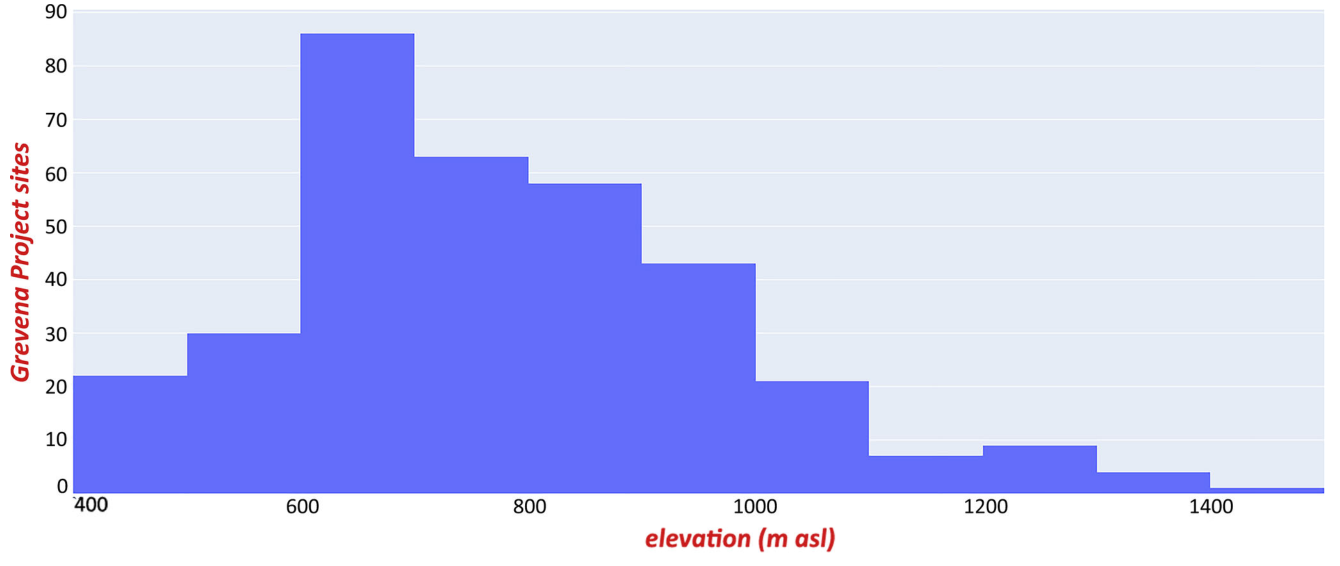

FIGURE 3 Histogram of the number of the Grevena Project sites in relation to the local elevation. [Colour figure can be viewed at wileyonlinelibrary.com]

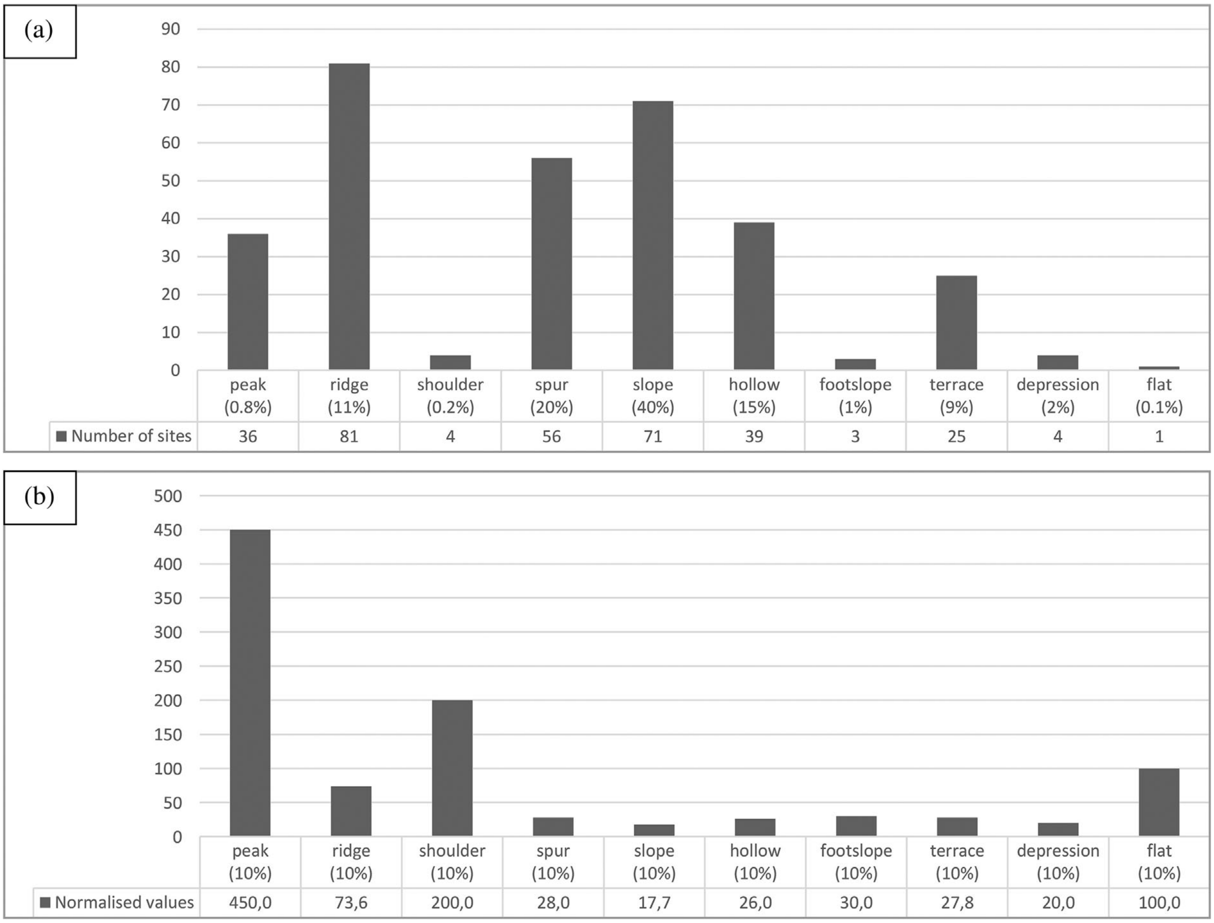

FIGURE 4 (a) Number of sites per geomorphological class and (b) hypothetical number of sites in equal projections (10%) of each geomorphological class.

4.3 | Assessment of site visibility through photointerpretation

Different resolutions of the produced orthomosaics enabled different levels of visual inspection over the areas of study: for example, the 1945 RAF series (taken at 42000 ft) was helpful in perceiving ground conditions and terrain use but did not allow to detect anthropogenic features or assess the surface preservation of archaeological sites. On the other hand, the 1944 RAF series (taken at 20000 ft) provided a much higher ground resolution and resulted in recording remains of abandoned or destroyed settlements, a variety of temporal rural elements and topographic characteristics nowadays lost because of the introduction of mechanical means in agriculture (e.g. stockyards, threshing floors and minor pathways). Continuous mechanical ploughing since the 1950s and land reclamation processes between the 1960s and the 1980s has indeed resulted in the levelling of ridges and other topographic expressions and thus in rapid erosion, including archaeological strata that have been washed away. Because settlements are, for example, found at the top of ridges and hills, surface artefacts are prone to slide towards the slopes, even for some dozens of meters.

Photointerpretation of archaeological features was limited to a few standing fortifications in upland, mostly forested areas. Today in Grevena, natural reforestation has developed into a major obstacle for any ground-designed archaeological reconnaissance. Turning back to historical airborne imagery from the middle of the 20th century, however, reveals a landscape with much less tree coverage probably because of extensive animal grazing (Arabatzis, 2005; Christopoulou & Minetos, 2009). At the same time, these aerial views exposed better ground visibility conditions and allowed the detection of structures that are hardly or not at all visible today. A well-shown case was the fortified Hellenistic site of Kastri Philippei, situated on a steep, nowadays fully forested hill at approximately 1110 m altitude in Eastern Pindus. Earlier accounts described a hill with an acropolis wall and successive terraces, which, however, had never been mapped before (Pikoulas, 2002, p. 674; Samsaris, 1989, pp. 116–117). Using the 1945 aerial series, it was possible to extract visual information about the known parts of the site for the first time in complete, such as the acropolis wall and the terraces, and at the same time document new features, which include a second peripheral wall or terrace and possibly the area of the main gate (Figure 5). All the above features were subsequently groundtruthed and recorded during visits to the site.

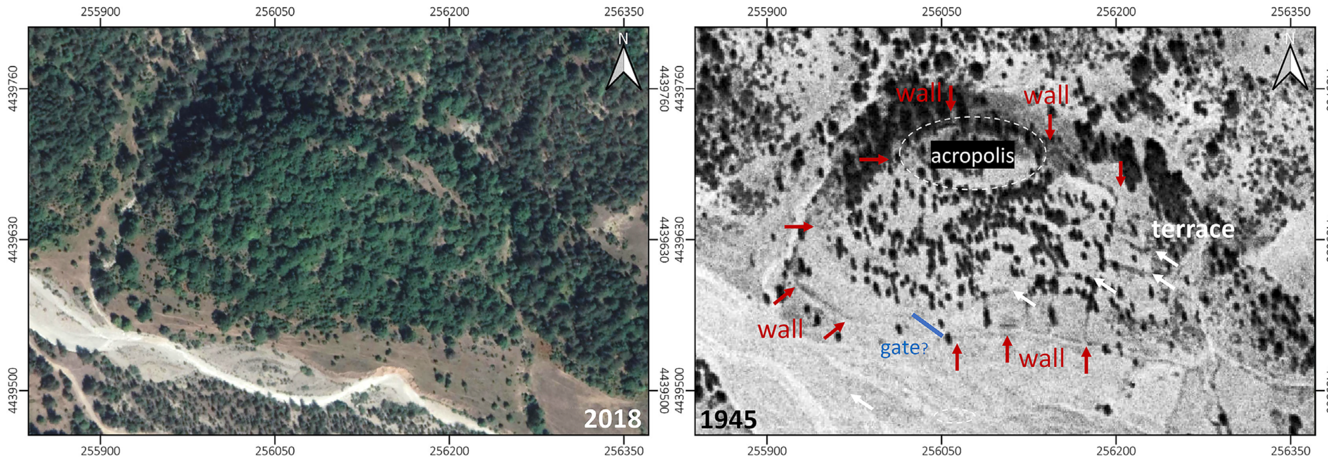

FIGURE 5 Aerial view of Kastri Philippei from the 2018 Google Earth imagery (left) and 1945 RAF series (right). [Colour figure can be viewed at wileyonlinelibrary.com]

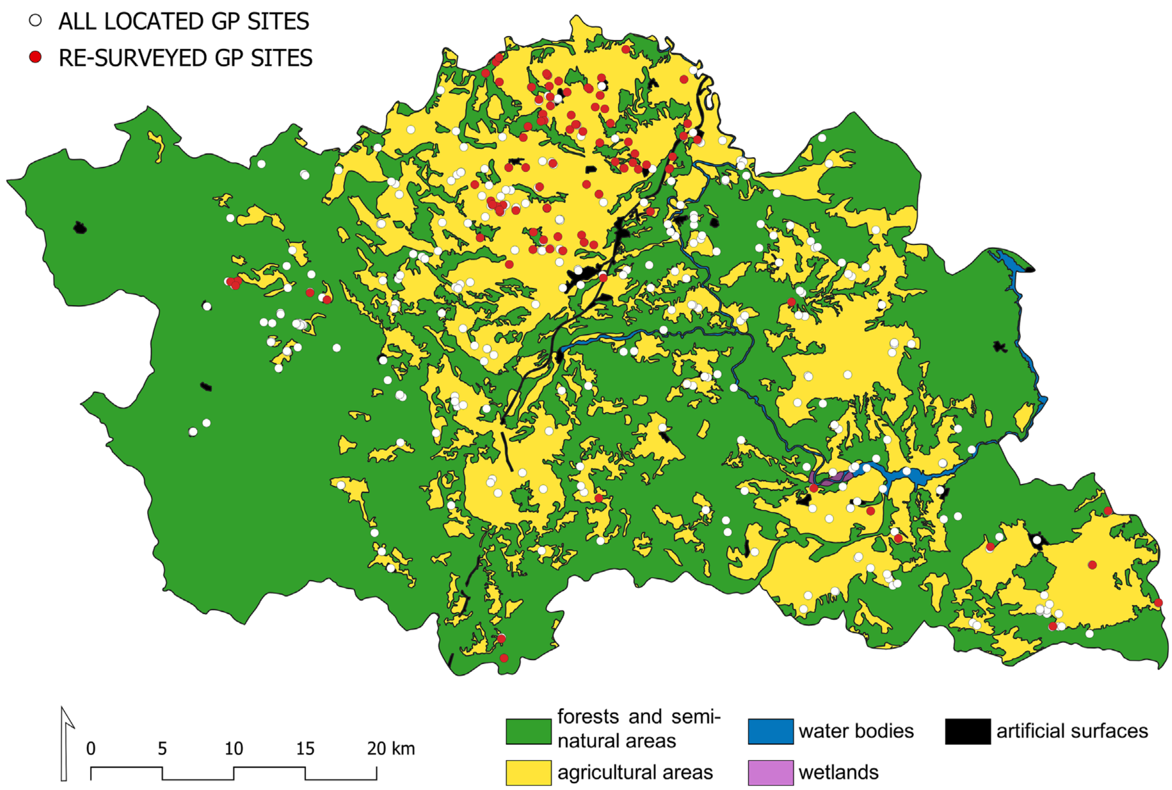

FIGURE 6 Map of Grevena illustrating the distribution of all located Grevena Project sites in white and the sites that have been re-surveyed in red. The basemap was created with vector data of land cover acquired from The CORINE Land Cover (CLC) inventory (2018). The data have been classified into the five major groups proposed by the Copernicus Land Service to indicate land use. Minimum mapping unit: 25 ha (status layer); thematic accuracy: >85%. [Colour figure can be viewed at wileyonlinelibrary.com]

4.4 | Groundtruthing results: The case of Ayios Georgios

So far, 80 sites (25%) of the old dataset have been re-surveyed in selected sub-regions of Grevena (Figure 6). The survey was stretched over 2 seasons of 4 weeks with a single team of four fieldwalkers. Our field experience suggests that revisiting sites and repeating artefact collections of surface scatters may reveal cultural phases of use undetected before; at the same time, systematic walking around known sites has led to the discovery of new locations of human activity in the landscape. On the contrary, anthropogenic intervention (e.g. mechanical cultivation, sand extraction, dam construction, solar panel installation, looting and the previous archaeological survey by Wilkie) combined with natural processes (e.g. natural succession, reforestation, soil loss and landsliding) in the landscape of Grevena deteriorates the available archaeological record, making it at times impossible to identify on the surface (see also Cherry, 2003, p. 157).

Ayios Georgios in the northern part of the region was chosen as the starting point to test the new methodology, by locating and groundtruthing all documented sites within an approximately 6 km radius. Previous archaeological record and recent excavations pinpoint the existence of an important multi-period settlement since the Bronze Age, which evolved to be the political centre of the area during the Classical Antiquity (Hatzinikolaou, 2009, pp. 10–11; Samsaris, 1989, pp. 72–75). The *Grevena Project* reports 17 sites in the vicinity, with chronologies ranging from the Neolithic to the Ottoman periods. During fieldwalking, we managed to locate and characterize all previously reported sites, including the multi-period hill settlement of Ayios Nikolaos, the possibly Roman/Late Roman farmstead complexes of Arsalia, Ayia Varvara and Parvanas and the cemeteries of Ayia Zoni and Pefkakia. In the same study area, 13 new sites were discovered, resulting in almost doubling the total number of known sites (Figure 7). Some of these are the Hellenistic cemetery of Tsigkodendro, the Late Roman cemetery of Miha and the Ottoman pottery workshop at Keramario. During groundtruthing, re-surveyed sites appeared as low, discontinuous scatters of surface artefacts and only in Ayios Nikolaos and Arsalia was a concentration more evident. Local topography and erosive processes had a high impact on ground visibility, and much of the collected material was considered to have been displaced.

As already mentioned, most catalogued sites of the *Grevena Project* do not include any type of descriptive characterization. At the site of Parvanas in Klimataki, for example, kiln debris of unknown context had only been collected by the *Grevena Project*, without any information about dating or activity at the site. The new survey was able to locate the kiln but also to identify a wide range of building remains (a column capital or base, roof tiles, mortar fragments) that can be attributed to a structure. Collected pottery during the re-surveying indicated the dominance of large, closed vessels and, secondarily, tablewares dated to the Late Roman period (Figure 8). Interestingly, three more Late Roman sites in a zone no larger than 3 km from Parvanas expose similar material culture and size, approximately 0.5 ha. Such information, for example, adds up to the possible interpretation of Late Roman farmstead networks in Grevena.

5 | DISCUSSION

Following our methodology, it has been possible to use unpublished legacy survey data to extract information about aspects of the archaeological landscapes of Grevena that would have not been possible to understand from previously published reports. Furthermore, the management and integration of heterogenous sources into a single geodatabase, which in our case involved previously collected surface finds with location notes, historical aerial imagery and maps, contributed to the production of new knowledge for the area of study. Similar works have been carried out in Europe denoting the necessity for efficient georeferencing of survey data not only for a better assessment of the archaeological landscapes but also for developing strategies in cultural heritage management (Brancato, 2019; Casarotto, 2022). A practical constraint to add to the success of our methodology already addressed before concerns the lack of LiDAR data for the visual recognition of archaeological sites, particularly under forest cover. Drawing from the framework and outcomes of recent projects at a global level (Berganzo-Besga et al., 2021, 2022; Chase et al., 2012; Maté-González et al., 2022; Megarry et al., 2016), LiDAR would have been a useful tool for enhancing site recognition and evaluating the photointerpretation results in Grevena. Future developments and directions towards easier access to such datasets in Greece would overall

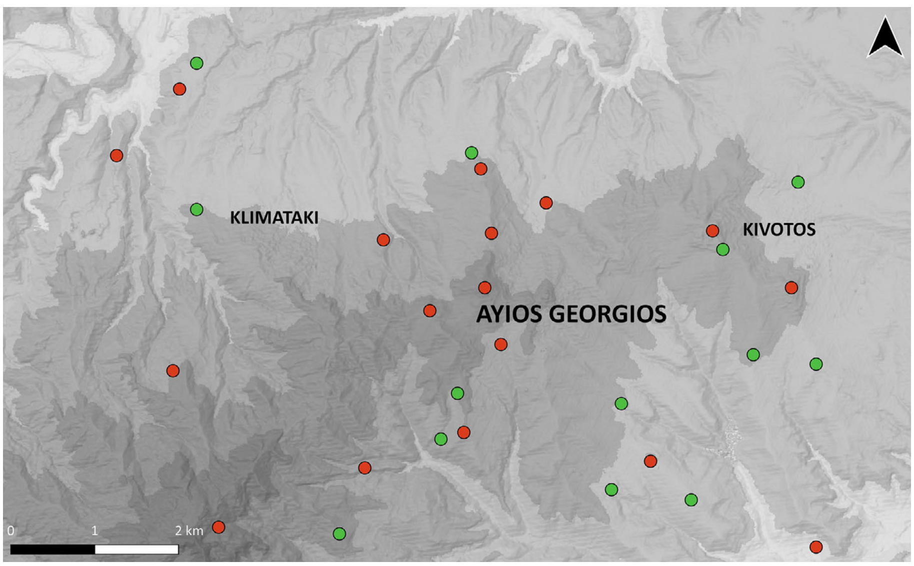

FIGURE 7 Extensive survey in the proximity of Ayios Georgios. Red dots show Grevena Project sites and green dots new sites discovered during groundtruthing. [Colour figure can be viewed at wileyonlinelibrary.com]

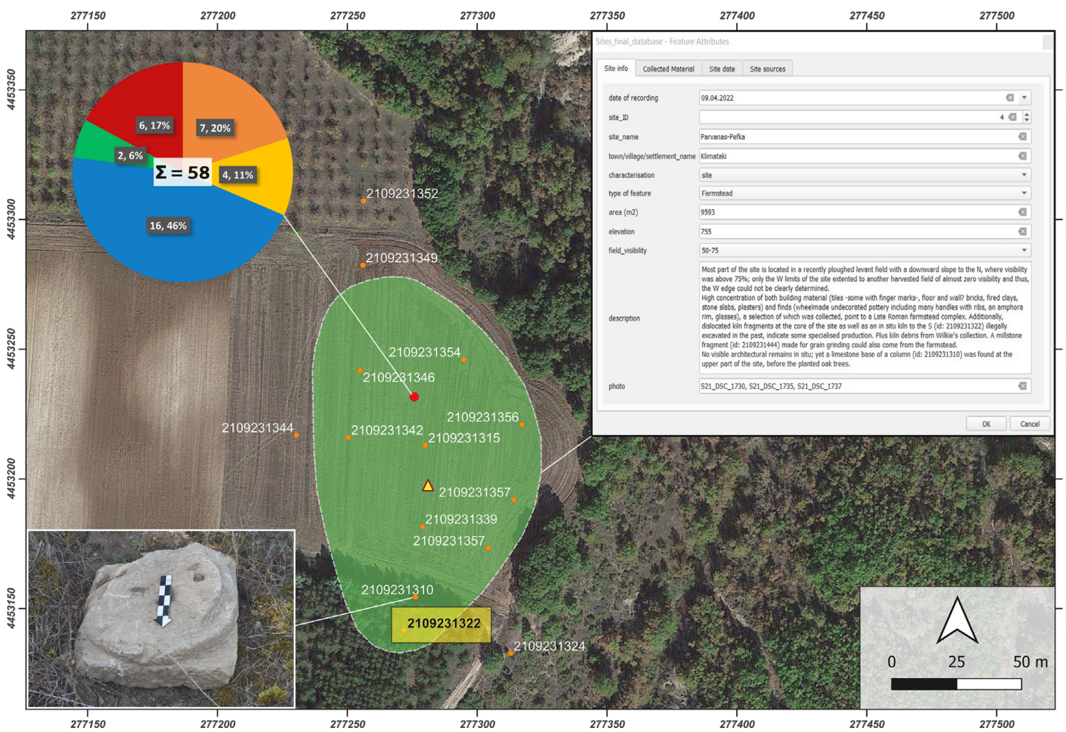

FIGURE 8 Example of site registry in QGIS. The top right image illustrates the database interface, and the pie plot to the top left expresses the percentage of different artefact categories collected during the new survey. Point symbols represent unique GPS entries of various information (such as the column base or capital to the bottom left). Finally, the yellow rectangle is created to show the identified part of the site based on the old materials and the green polygon visualizes the approximate extent of the site based on surface material distribution. [Colour figure can be viewed at wileyonlinelibrary.com]

benefit archaeological prospection and survey techniques in the area as well as across various parts of the country.[5]

To begin the discussion with the chronological distribution of the sites, the lack of any reference to the existence of 20 Palaeolithic locations is surprising. We are not able to know whether Wilkie has included the number of Palaeolithic artefact locations in site counting and subsequently to what extent the total site numbers are trustworthy. Regardless, our analysis brings to the front an important Palaeolithic assemblage of lithics, which finds parallels to the work undertaken in the Pindus mountains and the terraces of Aliakmon and can contribute to the discussion of early human presence in Grevena (Biagi et al., 2017, 2022; Efstratiou, 2008; Efstratiou et al., 2006; Efstratiou & Biagi, 2013; Harvati et al., 2008; Panagopoulou et al., 2004).

Locating Wilkie's sites required much attention. We know that around 80 sites had been given GPS coordinates back in 1993–1994 (Rosser, 1999, p. 795; Wilkie, 1994, p. 341) and must have been included in the ASCSA maps, yet the low accuracy of GPS technology at the time resulted in spatial displacements that were only now corrected. Such errors can also be explained on the grounds that, during fieldwork, the *Grevena Project* team instead of using the 1:5000 scale military maps, being the most reliable at the time, chose the 1:50000 scale geologic maps provided by the Greek Institute of Geology and Mineral Exploration (*IGME*), which present poor resolution in terms of contour lines, toponyms and visible human structures (Rosser, 1999, p. 976; Wilkie, 1994, p. 341). Most likely later digitization of the dataset caused the discrepancies observed today in the ASCSA map. Therefore, cross-checking cartographic materials with groundtruthing is crucial even when digital tools have been previously deployed to record site coordinates (Allison, 2008).

Regarding possible patterns of distribution, the highest density of the *Grevena Project* sites appears in the lowland, arable areas, where most settlement is concentrated today. *Grevena Project* did not show the same attention to the montane landscapes, such as in the case of Eastern Pindus, where a more recent survey by Efstratiou and Biagi offers a total of 196 new spots of archaeological interest along the summits of Samarina dated from the Middle Palaeolithic to the Late Antiquity (Biagi et al., 2022; Efstratiou, 2008; Efstratiou & Biagi, 2013). This evidence offers new insights into the role of the montane landscapes in the diachronic human activity at Grevena and suggests that any generalizations taken from *Grevena Project*'s database cannot be projected to the whole territory (Wilkie, 1999). It also questions the hearsay method of characterizing archaeological sites. In other words, all *Grevena Project* sites become automatically human settlements without any effort to distinguish between different

[5]Currently, two research projects are known to have used LiDAR for archaeological prospection in Greece, Kephissos Valley Project (https://www.dainst.org/forschung/projekte/noslug/2676, last accessed: 30/11/2023) and the Small Cycladic Islands Project (https://smallcycladicislandsproject.org/, last accessed: 30/11/2023) but results have not been published yet.

activity categories (e.g. villages, farmsteads, cemeteries and workshops) rendering comparisons between them incorrect. For example, Rosser (1999, pp. 979–980) forwards an idea of population expansion in the Roman Grevena with new locations being occupied towards areas of the landscape that had not been exploited before. However, the existence of sites with specialized production aspects, like in Parvanas, casts doubts on such suppositions during the same period and dictates more careful discussion on the actual importance of site distribution in population trends or location patterns.

Large-scale geomorphometric analysis based on the geomorphons tool, on the other hand, allowed the classification of site topography prior to any field visits. According to this analysis, sites at the top of topographical expressions (peaks and ridges) are remarkably overrepresented. Given that *Grevena Project* followed a methodology based on the guidance of oral testimonies, we believe that such distribution does not reflect the sum of the local archaeological record (Wilkie & Savina, 1997) but rather describes a methodological bias introduced inevitably towards surveying mostly elevated parts of the landscape, especially in the cultivated semi-mountainous basins of Grevena where artefact exposure was more evident than in the forested zones of the uplands. A much more diverse image comes, for example, from the rescue excavations conducted along Aliakmon in the south-eastern part of Grevena that revealed a dense appearance of sites on lower slopes and river terraces including settlements, farmsteads and workshops (Karamitrou-Mentesidi, 2009, 2016).

Concerning in-field collection practices, a quantitative look at the legacy dataset and at the numbers of the diagnostic potsherds collected demonstrates the employment of different collection methodologies during *Grevena Project*'s campaigns. There is no given explanation of why the project chose to proceed with this methodology (Rosser, 1999; Wilkie, 1989, 1990, 1991, 1992, 1993, 1994, 1999; Wilkie & Savina, 1997). The only possible deduction that can be made is a particular yet unclarified interest of the team in certain sites by collecting as many artefacts as possible, including a very high percentage of non-diagnostic pottery potsherds. The large number of collected finds can be related to a high density of material culture at the time of surveying, an intensive collection strategy for specific sites or repeated collections of materials during revisits to the same sites at different times.

Revisiting sites in Grevena has offered mostly qualitative rather than quantitative information in evaluating ground visibility and defining the activity of the sites, information that was unavailable in the different publications of the project. On many occasions, the old material provided better data for the chronological and typological analysis of the sites than our own collection of artefacts, and notably, many surveyed sites gave today much fewer surface finds in comparison.[6] Estimations from Boeotia in southern Greece also suggest that half of the sites recognized in the 1970s and 1980s do not appear today as artefact concentrations or have completely disappeared (Attema et al., 2020, p. 27). The latter has been noted for cemeteries and small rural structures, in principle farmsteads, that become 'temporarily invisible' because of the changing land-use (Bintliff et al., 2017, p. 62).

Fieldwork experience in Ayios Georgios suggests that ground visibility in tandem with the local erosional processes impact significantly on site recognition. The density and spatial distribution of pottery, tiles and other finds appear low and discontinuous, and no carpet of finds across the landscape has been observed anywhere (Alcock et al., 1994; Bintliff, 2005; Bintliff & Snodgrass, 1988, pp. 506–508). Most of the sites provided a few dozen of artefacts even with excellent ground visibility (freshly ploughed fields), and there is not enough evidence to distinguish in-site from off-site areas of activities (Attema et al., 2020, pp. 13–19; Bintliff, 2000; Bintliff et al., 2007, pp. 21–25; Georgiadis et al., 2022, pp. 9–16). On the contrary, the surrounding landscape beside the strict limits of the sites is almost completely deprived of surface finds, a note that may find parallels in the landscapes of Northern Greece, for instance in the Langadas basin survey (Andreou & Kotsakis, 1999, p. 38). Finally, such an observation reflects upon the statistical reappraisal of the *Grevena Project* collection, where most possibly any locale that provided even a few potsherds was counted a 'site' and, as we already showed earlier, almost 50% of the recorded sites included less than 30 artefacts (both diagnostic and undiagnostic).

6 | CONCLUSIONS

During this study, we successfully tested a multi-source methodology for the re-evaluation of a large legacy dataset of archaeological sites. Starting from the storehouse, GIS-based cataloguing of the available artefacts provided an effective way of initially placing the sites in their landscape context with the help of supplementary cartographic information, satellite and aerial imagery and oral interviews. In many cases, in-field validation of toponyms and topographic elements was necessary for validating the exact location of the archaeological sites. During the groundtruthing stage, we made use of a completely digital surveying system to record in real-time a range of qualitative (e.g. physical description of the area) as well as quantitative (material numbers registry) aspects of archaeological sites.

Remote-sensing sources illustrated well the terrain changes that occurred during the last decades and confirmed local testimonies about the existence of traditional field systems but also the impact of the reclamation process that followed and altered the agricultural landscapes of Grevena. It still remains a question how such changes impacted on the surface visibility, extent and preservation of archaeological sites. Historical photographs and satellite imagery, for instance, brought important yet geographically limited results about site recognition, particularly concerning forested areas, as the case of Kastri Philippei shows. Unlike other regions of Greece where archaeological sites may present a certain morphology, such as the tell formations in Central Macedonia and Thessaly (Alexakis et al., 2009; Andreou et al., 1996; Orengo et al., 2015), or linear features based on

[6] We find it important to include Mr Spyros Tsakstaras' contribution, the local warden of the Archaeological Service in Grevena for 30 years, who was also present in Wilkie's campaign. Mr Tsakstaras notes that when re-surveying many of the sites after Wilkie's initial collection, the available surface record was much lower than before or ceased to be visible on the ground.

cropmarks and modern land division (Donati & Sarris, 2016; Orengo et al., 2015; Orengo & Knappett, 2018), in Grevena, the irregular topography of the landscape coupled with visible erosion marks obstruct the aerial identification and delimitation of archaeological sites. Lastly, geomorphometric analysis using the geomorphons analysis provided a fast and large-scale morphological recognition of the located sites that can be used to prioritize geoarchaeological, site-specific fieldwork. Its accuracy depends on the spatial resolution of satellite data, and therefore, in our case, the TanDEM-X DSM produced a very detailed model that satisfied our needs at this stage of the research.

As a concluding remark, it is important to stress that each of the above methods offered valuable information on the archaeological landscapes of Grevena at different scales, but their combination has made possible the first overall, large-scale reuse of unpublished legacy data in the surface archaeology of Greece. Our proposed workflow can be subsequently used by other archaeologists conducting similar research elsewhere.

Despite given limitations, we were able to integrate and visualize an entire legacy dataset, creating the first archaeological catalogue of the *Grevena Project*. In the absence of detailed publications and archival materials, we have also managed to reconstruct the ideas and practices of an extensive survey that took place 30 years ago. The *Grevena Project* developed a very ambitious research plan to cover the entirety of the region at the time but the extensive and non-systematic character that followed led reasonably to the omission of sites, as we highlighted in the case of Ayios Georgios. However, it has provided the backbone material that is now available to be evaluated by researchers for further and focused investigations in Grevena. In future work, we plan on contextualizing the archaeological sites around Ayios Georgios in terms of topographic examination and study of the recovered material culture, while testing hypotheses and previous interpretations about potential patterns of site distribution and human activity in this part of Macedonia during Antiquity.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, GA, upon reasonable request.

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