Article

Precision Forestry Versus Non-Precision Archaeology—Integrating Forest Management and Archaeological Site Protection

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Abstract: This study examines the precision of spatial data required for archaeological sites in Finland from a forest management perspective, identifies archaeological sites at risk due to forestry activities, and investigates potential collaboration between archaeology and forestry to enhance the preservation and understanding of these sites. Due to outdated methods and the lack of systematic field surveys, challenges in achieving accurate spatial data for archaeological sites are highlighted through a literature review, case studies, and fieldwork. Our findings indicate that a significant portion of sites lack boundary delineation, exposing them to the risk of destruction. Moreover, the study reveals limited collaboration between the archaeology and forestry sectors, despite mutual interests in site preservation. We advocate for improved spatial data accuracy using modern technological methods like precision GPS and enhanced cooperation between archaeologists and forestry professionals. This approach aims to protect Finland’s archaeological heritage while promoting responsible forestry practices. Notably, fieldwork enabled the precise determination of the location of Finland’s first separate plague cemetery, underscoring the value of direct field verification in enriching historical and archaeological understanding.

Keywords: archaeology; archaeological sites; cultural heritage; digital archaeology; forestry; forest management

1. Introduction

In Finland, there are currently over 37,000 archaeological sites (or archaeological remains) protected by the Protection of Antiquities Act. Spatial data concerning the sites are stored in the Register of Ancient Sites [1]. About 60% of these sites are located in forests [2]. These sites encompass various types and historical periods, including settlement places, burial sites, defensive structures, work and manufacturing sites, and culturally significant locations spanning from the Stone Age to the present day. The Finnish Heritage Agency maintains an archaeological database and a register of ancient sites, containing essential information about all mainland Finnish sites [3]. This information includes, at minimum, the site’s name, coordinates, a unique identification code, and basic details regarding its age and type. Despite these protective measures, archaeological sites in Finland suffer annual damage or destruction, most commonly as a consequence of forestry activities, according to a report by the Finnish Heritage Agency [4]. While
archaeological remains do not impede forest utilization, it is crucial that forest management practices do not inflict damage upon these sites.

In Finland, forestry is a central and rapidly evolving sector. Therefore, this research focuses on forestry practices and their implications for archaeological spatial data. Cooperation between both fields could be utilized to address the shortcomings presented earlier in this section. Finland is, proportionately, the most forested country in Europe, with forests covering over 75% of its land area [5]. Abundant forest resources have historically shaped Finnish society, culture, and lifestyle, emphasizing the importance of forests in Finnish identity. The economic importance of forests has also motivated the development of national forest inventories and more detailed forest attribute information.

The type and intensity of forest operations greatly impact their effect on archaeological sites and, for example, thinning operations generally have a positive effect on the sites [6]. As the surrounding landscape opens up, the site becomes visible, making its preservation easier. The soil surface and structures related to an archaeological site must not be damaged [6]. Some sites are particularly susceptible to damage, for which manual harvesting is advisable [6]. In even-aged forestry, new trees should not be allowed to grow on the archaeological site during the seedling stand phase, because this makes it easier to preserve the sites as treeless later [6]. However, due to restrictions related to regeneration, it is recommended to use continuous cover forestry methods in and around archaeological sites to avoid mechanical soil preparation [6]. Prior to harvesting, landowners are required to submit a notification of forest use. This notification must be presented to the Finnish Forest Centre at least 10 days and no more than 3 years before the commencement of logging or any other relevant operations [7]. The notification system is used to enforce the laws (Forest Act, Environmental Protection Act, Waters Act, and Protection of Antiquities Act) and restrictions of land use plans affecting forest use. In general, the responsible governmental organization is informed about the intended forestry action if it overlaps spatially with their area of responsibility. In the case of the Protection of Antiquities Act, regional responsibility museums’ archaeologists provide assessments related to these notifications. Notifications automatically reach the museum authorities if the proposed forestry action is within 200 m of a registered ancient monument. However, the substantial volume of forest management notifications places a significant workload on archaeologists affiliated with the responsible museums.

The Finnish Heritage Agency has published guidelines on its website regarding forestry activities and archaeological sites [6]. Additionally, instructions and quality guidelines for archaeologists conducting field work have been published by the Finnish Heritage Agency [8]. Archaeological surveys in Finland are primarily conducted by commercial archaeology enterprises, often in conjunction with urban planning and construction projects. During the surveys, archaeologists visit already-known sites as well as new potential areas to find possible new sites. The number of registered archaeological sites has been increasing by approximately a thousand annually in recent years, revealing the richness of Finland’s cultural heritage. Many undiscovered sites likely remain, especially in areas where construction and land use are less active, although these areas often coincide with active forestry practices.

The relevance and significance of this research topic is particularly pronounced in the current context. Finland is undergoing legislative reforms concerning archaeological cultural heritage [9]. This legislative reform will significantly impact the research and protection of archaeological cultural heritage, and thereby also affect forestry practices in Finland. However, the proposed legal draft does not adequately address the precision of archaeological spatial data. Furthermore, the guidelines for archaeological fieldwork do not provide directives on the level of precision required for spatial data on archaeological sites [8]. Consequently, it is not possible to directly deduce the accuracy of an archaeological site’s location or the method by which the location was determined from the register’s information. As a result, the accuracy and quality of archaeological spatial data vary significantly. Archaeological sites are not systematically surveyed in the field,
and some registry spatial data may rely on surveys conducted decades ago or even observations made in the 1800s. Some practitioners are still employing outdated and imprecise handheld GNSS (Global Navigation Satellite System) devices for on-site measurements of archaeological site coordinates. Under the forest canopy, the mean positioning error of such devices rises to over ten meters [10]. Nevertheless, these sites enjoy legal protection, regardless of the precision of their spatial data. The Register of Ancient Sites was originally created for use by archaeologists working as authorities, and the descriptions of sites vary widely in both quality and content. Some verbal descriptions may be very brief, consisting of only a few sentences, and may not be easily understood by users unfamiliar with the field of archaeology and its terminology. Concurrently, the Finnish Heritage Agency is initiating a renovation project for the archaeological information infrastructure, although it is still in the phase of seeking funding [11]. With the legal reform, it will also be necessary to update the register of ancient sites and other archaeological databases administered by the Finnish Heritage Agency.

The proposed new legal amendments include stricter penalties for damaging or destroying archaeological sites, emphasizing the importance of accurate spatial data from a preservation standpoint. Legal provisions alone, however, cannot safeguard archaeological sites if their spatial data lack precision or are inaccurate. During the initiation phase of the registry renovation project, the Finnish Heritage Agency found that almost 42% of ancient sites lack territorial boundaries (polygons) [12]. The absence of a boundary delineation may also suggest that an archaeological site has not been inspected in the field for a considerable period, since contemporary practices typically aim to define boundaries for sites unless they are clearly very small or point-like phenomena, such as individual find spots. The current registry contains unreliable spatial data in many instances, making precise spatial data beneficial for researchers, authorities, and landowners alike. Inaccurate spatial information may burden landowners unnecessarily or complicate land-use projects, resulting in avoidable additional costs. This research is pertinent due to the demonstrated significance of location accuracy in previous studies [13,14]. For instance, from the perspective of spatial data analyses, correct location information is essential for ensuring the reliability of results. While precise location data may not always be inherently crucial or interesting solely from the standpoint of archaeological research, the broader infrastructure requiring and utilizing spatial data must also be considered.

In this study, our primary aim is to (1) investigate the precision of spatial data required for archaeological sites from the perspective of forest management. Concurrently, the forestry sector is moving towards increasingly precise spatial data and adopting precision forestry techniques. At the same time, archaeological spatial data in Finland often lack accuracy and precision. As a secondary research question, we aim to (2) identify archaeological sites that may be endangered by forest management activities. According to a survey by the Finnish Heritage Agency, Stone Age settlement sites in particular could be at risk of destruction due to forest management, based on reports collected between 2010 and 2019 [4]. However, there is currently no clear understanding of all the types and the number of archaeological sites that are at risk of being destroyed by forest activities in Finland. The third research question (3) addresses the utilization of forest resource data in archaeology and collaboration between the fields. While some collaboration has taken place between the forestry sector and archaeologists, like the project that was conducted in 2011–2013 [15], comprehensive projects on this topic are reportedly scarce. Archaeologists who are employed in the Finnish Forest Administration have experience collaborating with forest researchers, but this collaboration has not spread more widely.

2. Materials and Methods

This study uses and combines several different research materials and methods, which are presented in the table (Table 1) as well as in more detail below.
The research methodology chosen for this study involves a literature review and case studies to construct a current comprehensive overview of both archaeology and forestry in Finland. The literature review and case studies aim to address the first and third research questions, facilitating the dissemination of contemporary research findings to experts in both fields and encouraging dialogue between them. Scientific articles on archaeology and forestry, including various reports and studies, particularly those produced by the Finnish Heritage Agency, serve as the primary written sources for our research. Additional literature, including works aimed at the general public, was also reviewed as part of the information-gathering process. In the absence of prior research data in Finland regarding the accuracy of location information for archaeological sites, case examples were sought to address this gap. The registry’s descriptions of archaeological sites have been utilized to find case examples, as the registry does not always allow for the assessment of location accuracy, or the method used for determining locations for all sites. The register in point form includes a column named “annotation”, which describes the basis of the site’s location. However, for the most part, this column is empty, and only a small fraction appears to have an annotation indicating the location method used for each site. Archaeological fieldwork reports also provided information on different fieldwork methodologies and practices related to location. These reports often reveal how the work was conducted, although older reports may lack detailed information. Background information was further obtained from experts at the Finnish Heritage Agency and archaeologists working in regulatory roles, whose expertise was instrumental in identifying case studies for this article.

The study’s funding did not cover archaeological fieldwork; however, it was decided to inspect a few example sites in the field to gather more detailed background information. The fieldwork was conducted collaboratively by the first and second authors, serving as a case study of cooperation between the archaeology and forestry sectors. Field inspections at several archaeological sites were carried out within a single day. Subsequently, a decision was made to apply for a research permit to verify the location of one legally protected archaeological site. Following the grant of the research permit, a small-scale invasive investigation was undertaken at this archaeological site. The objective of the research was to locate a mass grave of individuals who died of the plague in 1711, located in a forest. The method chosen for this purpose was the excavation of a test pit, as it was deemed the only way to confirm the existence and precise location of the archaeological site. No visible structures or phenomena on the surface could aid in locating this particular archaeological site. This approach highlights the challenges and methodologies involved in archaeological research, especially when dealing with sites that lack surface indications of their presence. The collaboration between authors and the integration of fieldwork, even on a limited scale, underscores the importance of direct site verification to enrich historical and archaeological understanding.

The Register of Ancient Sites served as the material for addressing the second research question. By utilizing the existing classifications within it, the study aims to identify those sites or phenomena that are more likely to be at risk of destruction and which should, therefore, receive special attention in the future. This approach has allowed for a targeted analysis of the register’s data, highlighting areas of potential vulnerability and
informing strategies for the preservation and protection of archaeological sites. Through this examination, the research aims to contribute to the development of more effective conservation practices by pinpointing specific sites of significance that are in urgent need of safeguarding against the impacts of modern activities, including forestry. Despite numerous problems in the register’s utility for research purposes, it still provides valuable statistical background information.

The spatial data from the register were downloaded on the first of September 2023, and any changes made thereafter were not considered in the statistical information. While minor updates to the register are likely to have occurred during the autumn of 2023 and in the beginning of 2024, there do not appear to have been significant changes in the number of protected sites, meaning that the statistical results are still valid in spring 2024. Furthermore, the research background included information gathered from earlier studies of the Register of Ancient Sites [14]. Reviewing the previous study's data (585 archaeological sites from the Eastern Häme region) already highlighted the variability in the accuracy of archaeological spatial data and the different methods by which archaeological spatial information has been collected over the decades [14]. Thus, a comprehensive understanding of the accuracy of archaeological spatial information had already been formed before the commencement of this study, which, in turn, guided the selection of this research topic.

The spatial data downloaded from the Finnish Heritage Agency’s website [16] at the beginning of September includes all registered sites in point form (muinaisjaannospiste_t_point) and, as a separate layer, those sites with boundary delineations in polygon form (muinaisjaannosalueet_t_region). Regrettably, the polygon-form spatial data lack all attributes of interest for statistical analysis, such as date, type, and subtype. The point-form table, on the other hand, does not allow for the differentiation of sites without polygon delineations since there is no column in the table to indicate such a status. A solution was selected that employs the simplest possible method of data extraction, ensuring that it could be easily replicated by all stakeholders in the field and does not require extensive expertise in working with spatial data or special programming skills. This approach aims to facilitate the accessibility and usability of the data for a wide range of users, underscoring the necessity for straightforward and effective methods of data analysis in archaeological research.

QGIS geographical information system software was applied in this study due to its open availability and its use in institutions such as the Finnish Heritage Agency and numerous museums. Both attribute tables, representing point- and area-form sites, were exported from QGIS to Excel spreadsheet format. Subsequently, these tables were imported into Microsoft Access to create a unified database. Both tables contain a unique identifier column for the sites, specifically the site’s numerical code, which was used as a primary key to establish a linking relationship between the two tables. This setup enabled the creation of queries in Access to identify all sites listed in the point-form table that were absent from the area-form data table (a query for finding unmatched records). The query generated a new table listing all registry sites lacking boundary/polygon delineation. Further filtering in Access allowed for the direct extraction of interesting statistical information. This table was also exported as a CSV file, from which a vector file (shapefile) was created and then opened in QGIS. This process enabled the visualization and further filtering of information directly on a map, enhancing the spatial analysis capabilities of the study. This methodology underscores the necessity of integrating various software tools when facilitating comprehensive archaeological data analysis, from database management to spatial visualization.

3. Results

3.1. Accuracy of Archaeological Spatial Data (Research Objective 1)

Based on the literature review, the discussion around the accuracy and quality of archaeological spatial data in Finnish archaeology has, to date, been minimal. However,
there are some studies addressing forestry and archaeology. For instance, Laulumaa et al. [17] explored the intersection of archaeology and forestry in Finland in 2014 from the perspective of cultural heritage crime. Laulumaa [17] presented a case study of a Stone Age settlement destroyed by forestry activities. The study [17] highlighted the importance of collaboration in solving such problems in the future and preventing similar incidents. A significant issue identified in the article is the challenges related to the accuracy of spatial data and the lack of detailed information on the extent of archaeological sites. Laulumaa and Koivisto [18] further continued the theme and discussion of [17]. The 2010 anthology [19] included several articles on this topic. It should be noted that since the 2010s, technology has evolved rapidly, particularly in the use of laser scanning datasets to aid in archaeological site location. In Finland, laser scanning has been increasingly used in the detection of archaeological sites. For example, the collaborative project between the University of Oulu and the Finnish Heritage Agency, known as LIDARK [20], explored how laser scanning data and machine learning-based techniques can be leveraged for the protection and research of archaeological cultural heritage. They underscored a significant shift towards integrating modern technological methodologies in archaeological practices, enhancing the ability to identify, protect, and study ancient sites with greater precision and efficiency.

In Finland, the continuous series of national forest inventories (NFI) was launched in 1921 [21]. Since 1972, satellite data have been studied in Finland for forest inventory [22]. Over the decades, the development of remote sensing technologies has affected data collection dramatically. Satellite images were finally adopted by the National Forest Inventory in 1990 (Tomppo 1990), and from 2010 onwards, operational stand level forest inventories have been produced using a combination of field-measured sample plots, aerial images, and airborne laser scanning (ALS) [23]. Further technological developments have ensured that by the year 2025, the whole of Finland will be covered with dense ALS point data suitable for mapping the forests at the level of individual trees [24,25]. Investments in forest information also relate to the intensity of forest management. Between 1990 and 2020, the annual forest area undergoing felling has increased from 373,000 ha to 708,000 ha [26]. Precision forestry has been studied for many years, and with the enablement of technological development, the direction is increasingly towards more precise forestry practices. Precision forestry refers not only to the development of technologies but, more importantly, to the generation of added value through increasingly accurate information. Examples of what precision forestry enables include enhanced forest planning, optimized timber harvesting, improved forest valuation, and the initiation of electronic timber trade [27]. The literature review revealed that in Finland, the accuracy of spatial data and the development of related methodologies have long been and continue to be an actively researched topic within forest studies. For instance, various remote sensing techniques and individual tree detection for large areas are currently being actively investigated in several projects [28,29]. On a practical level, Finland is moving towards increasingly precise spatial information production and utilization. For example, a news release in 2023 announced that MetsäGroup plans to equip its logging machines with precision GPS devices by the end of 2023 [30]. With the technology implemented by Ponsse, the number of standing trees can be measured in addition to felled trees [31]. Finland is also actively engaged in general research on spatial data and its accuracy [32]. The history of forestry and the cultural heritage of forests have been highlighted, for instance in the book “Metsien känköissä”, aimed at the general public [33]. The cultural heritage of the forestry sector and the history of forest use, on the other hand, have been extensively studied, and the topic will be addressed at a conference in Helsinki in the spring of 2024 [34].

Because of the lack of discussion or definition regarding the accuracy of archaeological spatial data in publications or even in sector guides, we present a few example sites that illustrate the issue and introduce related perspectives.

Case Example 1 highlights the challenges of location information based on very old studies. An archaeological survey in 2020 related to zoning revealed several sites whose locations were based on research from the 1930s [35]. For instance, an archaeological site
named Brasas Himlaberget [36] (Register of Ancient sites ID 613010017) proved difficult to determine. The original maps from the 1927 and 1933 studies have not been digitized or made available. The site was re-examined in 1997, and even then the number of cairns in the area and the exact location remained unclear. The site was inspected again as part of the 2020 studies [35]. No additional cairns were found, and the site’s exact type, location, and status remained unclear. Due to these uncertainties, the site currently has alternative coordinates in the register. As this example shows, it can be very difficult to locate original archaeological sites or find spots today, and exact locations may remain a mystery despite research efforts.

Case Example 2 illustrates how changes in the landscape can complicate the finding of a site when location data are unreliable. During a survey conducted in the year 2020 [37], two possible archaeological sites named Iso-Ruokojärvi 1 [38] (ID 81000001) and Iso Ruokojärvi 2 [39] (ID 81000002) were visited, but neither could be found nor located. Both were discovered in a 1998 survey, but the landscape has since changed, and the site descriptions no longer matched the conditions of the 1990s. Therefore, the sites could not be located at the current coordinate points or nearby, leaving their exact locations unclear in the field studies. The link to the original research report is missing from the register.

Case Example 3, the site named Kansolaiti 1 [40] (ID 1000003285), is a stone age settlement site visited during the same survey as the previous example in 2020. The site lacks boundary delineation in the register and cannot be directly determined on a map by contour lines or shadow relief, as the plateau mentioned in the report is not distinguishable in either. This archaeological site was discovered through test pits, and defining its boundaries would require new invasive research with test pits and on-site evaluations of terrain features. Often, the verification of stone age settlements requires invasive research, and estimating the extent of the site and delineating it is not always straightforward.

Case Example 4, Kaunelant Palsta [41] (ID 73010020), is a site where archaeological monitoring was conducted in 2019 [42]. It serves as an example of how, even when an archaeological site has relatively precise spatial information and boundary delineation, incorrect data can cause problems and additional costs. At that time, the area’s delineation was a large, symmetrical circle, and previous studies did not clarify the basis for this strange delineation. The archaeological site area included built environments, such as previously modified and excavated residential yard soil, which was also the focus of the monitoring. It quickly became apparent that the site was not located in the yard, and the area delineation did not match the site’s actual location in the landscape. Archaeological monitoring during construction work is common in Finland and requires a lot of work, but the same work time could be used, in some cases, to determine the exact location of archaeological sites more accurately. The same site was re-examined in 2022.

Case Example 5, the site named Ruttokangas [43] (ID 611000111), was surveyed as part of this study. It is a mass grave/plague cemetery discovered in 1975 during sand extraction. Locating the site is particularly challenging. The graves do not stand out at all on the ground surface. The burials are also deep enough that they are not easily detectable with a metal detector. In the forest, the use of geophysical methods, such as ground-penetrating radar, is difficult due to trees and other vegetation. Upon reviewing the site’s spatial data and visiting the location, there was a strong suspicion that the coordinate point in the register was incorrect. The original inspection reports from 1975 do not include maps or coordinates. Eventually, a research permit was obtained to locate the graves mentioned with minimal intrusion. The method chosen was to dig test pits. The fieldwork was conducted in one day, and fortunately, the objective was achieved. A coffin lid was encountered from a test pit dug in a potential area at about 75 cm deep and digging was halted. The pit’s location was measured with a VRS-GPS device (Trimble R12i GNSS, Trimble Inc., Sunnyvale, CA, USA), significantly refining the site’s location. It turned out there was about an 80 m error in the original register coordinate point. However, assessing the area’s extent would require significantly more fieldwork, as locating graves, especially in forested areas, is very challenging. The survey results were reported [44] by following
the Finnish Heritage Agency’s instructions. The discovery and precise location determination of the graves was a significant achievement of this study, as the site is, according to the register, the only confirmed separate plague cemetery in Finland. Due to the site’s remote location, the graves are likely to be well-preserved and hold great potential for future research.

3.2. Literature Review and Case Studies (Research Objective 2)

To form a comprehensive understanding of which archaeological sites may be endangered by forestry activities, observations were specifically extracted from the register for those archaeological sites that lack boundary delineation. From the new table formed from the Register of Ancient Sites, which includes information on all sites lacking a boundary delineation in the register, the following data were extracted: the register contains 37,309 legally protected archaeological sites (Kiinteä muinaisjäännös), and of these, a total of 14,082 sites, or 37.74%, were without a boundary delineation (polygon in the register). This aligns with the Finnish Heritage Agency’s report from 2022, which indicated that approximately 42% of sites in the register lacked boundary delineation at that time [12]. In this instance, it was decided to exclude other cultural heritage sites, potential archaeological sites, find spots (which are usually point-like anyway), natural formations, and other sites from the statistics, as the absence of an area form is not as critical for these as it is for legally protected archaeological sites. The archaeological sites lacking boundary delineation are geographically distributed fairly evenly across Finland; however, differences can be observed between the locations of sites from different periods (Figure 1).

![Figure 1](image-url)

Figure 1. Archaeological sites lacking boundary delineation are geographically distributed quite evenly across Finland, but differences can be observed between the locations of sites from different periods. However, in interpreting these results, it is absolutely essential to take into account the problems associated with the registry, such as the fact that the same site can have multiple different dating entries in the registry. Additionally, there are errors and ambiguities in the dating, which also affect the reliability of the data extracted from the registry (low-res version for peer review).
When evaluating different datings and types, it is crucial to recognize that a single archaeological site, represented as a point on the map, can encompass multiple categories. Therefore, a site may have several different dates or be defined by various types simultaneously, such as being both a dwelling place and a burial site. Consequently, some points statistically fall into multiple categories in this context. Data related to datings also present problems within the registry. A single archaeological site may have multiple datings, or there may be errors in the information. For instance, medieval village sites are sometimes classified as belonging to the historical period in the registry. Statistical issues also arise from the fact that sites may have so-called sub-sites, meaning that in some cases a single site encompasses several nearby archaeological sites, such as a Stone Age settlement and a historical village area. Although these sites do not necessarily relate to each other, as in the previous example, they may still be classified as a single site and represented by only one coordinate point on the map. Conversely, phenomena related to a single entity may be classified as separate individual archaeological sites. These issues inevitably reflect on all analyses made from the registry data. These problems associated with the registry are well-known and have been discussed in a previous publication [14].

Nonetheless, the results provide intriguing information about archaeological sites lacking boundary delineation. The distribution of dates across different classes existing in the current register is as follows: Prehistoric 3.10%, Stone Age 22.07%, Early Metal Age 1.90%, Bronze Age 4.41%, Iron Age 5.46%, Medieval 1.03%, Historical 53.82%, Modern 0.04%, Undated 13.19%. This distribution offers valuable insights into the temporal span and typological diversity of the sites, highlighting the significant proportion of historically dated sites. As the following table (Table 2) shows, the largest categories of sites missing the boundary definition are work and manufacturing sites, settlement sites, and stone structures. There were a total of 2999 Stone Age settlement sites without boundary delineation (Figure 2). These almost 3000 sites could be defined as the most vulnerable.

**Table 2.** Sites missing the boundary definition.

<table>
<thead>
<tr>
<th>Site Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipwrecks</td>
<td>600</td>
</tr>
<tr>
<td>Settlement sites</td>
<td>4154</td>
</tr>
<tr>
<td>Burial sites</td>
<td>973</td>
</tr>
<tr>
<td>Church-related structures</td>
<td>80</td>
</tr>
<tr>
<td>Stone structures</td>
<td>1918</td>
</tr>
<tr>
<td>Roads</td>
<td>203</td>
</tr>
<tr>
<td>Places of worship</td>
<td>450</td>
</tr>
<tr>
<td>Natural formations</td>
<td>3</td>
</tr>
<tr>
<td>Finds spots</td>
<td>76</td>
</tr>
<tr>
<td>Soil structures</td>
<td>309</td>
</tr>
<tr>
<td>Defense structures</td>
<td>201</td>
</tr>
<tr>
<td>Wood structures</td>
<td>7</td>
</tr>
<tr>
<td>Raw material procurement sites</td>
<td>173</td>
</tr>
<tr>
<td>Art and memorials</td>
<td>296</td>
</tr>
<tr>
<td>Historical event site</td>
<td>7</td>
</tr>
<tr>
<td>Industrial sites</td>
<td>67</td>
</tr>
<tr>
<td>Work and manufacturing sites</td>
<td>4927</td>
</tr>
</tbody>
</table>
3.3. Collaboration between Archaeology and Forestry (Research Objective 3)

Based on the literature review, collaboration between archaeology and the forestry sector has been relatively limited so far. The Finnish Heritage Agency has initiated a few projects related to the topic, such as the SKAIK project mentioned in the introduction [45]. The primary goal of the project was to reduce the damage caused by forestry to archaeological sites [46]. However, the project was geographically limited to a relatively small area. Currently, one person at the Finnish Heritage Agency works on monitoring the condition of forest cultural heritage, among other tasks. In Finland, Metsähallitus employs...
archaeologists annually and facilitates collaboration between archaeology and the forestry sector. Metsähallitus is a state enterprise that provides natural resource services, utilizing, managing, and protecting state-owned land and water areas. It conducted an extensive survey project in state forests from 2008 to 2015, during which over 10,000 sites were documented from the forests [47]. Metsähallitus uses its geographic information system (PAVE) to record information about archaeological sites [48]. The data are made available to museum authorities via an interface as spatial data, as well as in traditional survey reports when surveys are conducted [48]. Additionally, the Finnish Heritage Agency and regional responsible museums have been granted browsing rights to Metsähallitus’s GIS [48]. However, the museum authority, currently mainly the regional responsible museums, is always responsible for updating the register’s information [48]. Thus, there have been delays and regional differences in updating site information in the register [48].

In archaeology, spatial data are particularly utilized in the planning phase of surveys. For instance, datasets produced by the National Land Survey of Finland, such as elevation models that are openly available, can be used. Similarly, open datasets on soil types produced by the Geological Survey of Finland (GTK) can be incorporated into planning. Especially for historical periods, old maps have become an important source of information, and Finland has a very good availability of historical maps in digital format open to the public [49]. The Finnish Forest Centre (Metsäkeskus) provides open spatial datasets about Finnish forests, which could also be utilized in the planning phase of archaeological surveys. These data were tested in a previous study [13] in an area where no other detailed soil information (produced by GTK) was available. These data produced by the Finnish Forest Centre are probably unfamiliar to archaeologists and have thus far been underutilized in archaeology. However, the dataset could have high potential for research, for example, for Stone Age settlement sites, which are often found on similar soil types (fine sand).

Archaeology has addressed forestry in publications and theses to some extent, but conversely, very little research or discussion on archaeology and archaeological sites can be found in forestry studies. However, research has been conducted on topics such as precision agriculture and archaeology [50]. Nevertheless, there are several publications aimed more at serving as guides for the forestry sector and providing instructions for the industry [51,52]. The topic is also somewhat covered on websites dedicated to forest management recommendations, where a few types of archaeological sites are presented [53]. However, guides and instructions alone do not protect the sites if the instructions are not followed. A significant thesis related to this subject matter was completed in Finland in 2021 [54]. The thesis focused on “Compliance with Archaeological Site Management Guidelines in Forestry in Kainuu”. The research demonstrated that the compliance with the management guidelines provided by museum authorities was rather poor. Out of eight categories under review, only four had over 50 percent compliance with the guidelines. A striking 58 percent of archaeological sites experienced some form of damage during forestry activities. The findings indicate that there is a substantial need for education regarding the handling of archaeological sites in conjunction with forest management. A master’s thesis from the year 2022 also introduced some archaeological sites damaged by forestry activities. The thesis, titled “Unauthorized Intrusions into Archaeological Sites in Pirkannmaa during 2010–2019”, explored how the destruction of archaeological sites could be prevented. In addition to considering improvements to legislation, the significance of communication was particularly contemplated as a solution [55]. This study was conducted through collaboration between archaeologists and forestry researchers, thereby serving as an exemplar of cooperation in itself. The jointly conducted field research yielded an excellent outcome; namely, a difficult-to-locate archaeological site (Case example 5) was precisely identified. The study achieved its objectives thanks to this collaborative effort.
4. Discussion

First, we would like to discuss accuracy in general. How is accuracy or precision defined in archaeology, especially in archaeological surveys? How do we define or conceptualize ‘a site’ in archaeology [56]? For forest resource information, accuracy is more easily defined and can utilize quite a few clear metrics. However, precisely determining the location of an archaeological site is not always straightforward. Archaeological phenomena or sites, for instance, are not always clearly defined, and they are influenced by several factors such as origin, time, soil, materials, natural conditions, and subsequent human activity. Not all archaeological sites are distinguishable from the land’s topography, and they may be difficult to detect, especially in forests, due to vegetation. Remote sensing, other geospatial technologies and, for example, geophysical methods can assist in locating archaeological sites [57]. These methods do not work for all types of sites, as Case Example 5 in this research clearly demonstrates. Therefore, more research on the applicability of new geospatial methods to archaeology is needed. Above all, however, there needs to be a discussion on how to define the precision of spatial data in terms of archaeological sites.

In concluding research objective 1, we suggest that efforts should be made to ensure the accuracy of archaeological spatial data, taking into account the specific conditions, the type of site, and the objectives of the research. For some archaeological sites, determining the exact location may be impossible due to conditions or the type of site. However, the aim should be to achieve a level of accuracy comparable to that of forest compartment data. In practice, this could mean favoring precision GNSS devices whenever possible and especially reducing the use of old hand-held GNSS devices as the primary recording method in archaeological fieldwork. However, it is crucial to keep in mind that archaeology and archaeological sites are not ‘exact sciences’. Precise spatial data are often only achieved after excavating the archaeological site and meticulously documenting the structures, finds, or observations. Often, the location information is merely an estimate, and this should be clearly indicated, for example, in the metadata. On the other hand, the forestry sector’s trend towards more precise spatial data, along with general advancements in location accuracy, should be taken into account in archaeological surveys, striving for increasingly accurate spatial information for archaeological sites as well. Given that information on archaeological sites is not systematically updated in the register and inspections are not conducted regularly, it is desirable that the currently produced data are collected as carefully and accurately as possible to avoid the need for re-examining the same archaeological sites after a short time due to insufficient spatial data. Resources in archaeological fieldwork are scarce, and fieldwork and site visits especially are costly and time-consuming. As Laulumaa noted in 2014, inaccuracies in the location data of ancient sites are one of the most significant issues [17]. Unfortunately, there has not been much progress in ten years, nor has there been a discussion on location accuracy in Finland, although the problem is well recognized in the field. With new legislation, new quality requirements for archaeological fieldwork will also emerge [9]. In this context, it would be logical to update requirements or guidelines related to the accuracy of spatial data.

There are some solutions for improving the accuracy of archaeological spatial data. At the very least, future data repositories should include information on how or by which method the coordinates were collected, their estimated accuracy, and the rationale for choosing that method (for example, the so-called handheld GNSS device) as the positioning method. In some cases, even inaccurate data can be important and useful, for example when dealing with a potential archaeological site whose status is still under investigation. However, the chosen method should be justified, and information about the method should be available, so that later researchers or entities using the data can assess its suitability for their intended use. Consequently, it is not possible to directly deduce the accuracy of an archaeological site’s location or the method by which the location was determined from the register’s information. This limitation underscores a significant gap in the register’s utility for precise archaeological research, highlighting the need for enhanced documentation and data collection practices to improve the reliability and
comprehensiveness of archaeological site records. Moreover, this gap poses a considerable challenge for this study, as the accuracy of the sites could not be statistically analyzed at all. Additionally, the registry should be developed so that archaeological data are available in accordance with the FAIR principles and more easily utilized for research purposes. The current deficiencies and errors in the registry significantly affect the scientific reliability of the analysis results.

The issue with archaeological sites endangered by forest management is important to discuss. There are many archaeological sites endangered by forestry, and the resources available for their study are limited. It is, therefore, important to prioritize those archaeological sites that are at the greatest risk of being damaged as a result of forestry activities. Archaeological sites lacking boundary delineation information can be extracted from the register using the simple steps described in the Methods section. Subsequently, information such as Stone Age settlement sites can be selected in GIS software, and those located on forestry compartments can be identified by utilizing the open data on forest stock figures provided by the Finnish Forest Centre [58]. Prioritization would be most sensibly conducted by regional responsible museums, as these authorities are most familiar with the specific characteristics of their area and would be able to select the most critical sites for field inspection. The same so-called critical sites could also be emphasized in commercial surveys, if such are being conducted in the area.

Furthermore, entirely new innovative solutions could be explored for updating the information on archaeological sites. Finland has active amateur archaeologists and hobbyist associations [59]. These enthusiasts participate in excavations, and those using metal detectors, especially, generate a lot of new information. An app has been created for enthusiasts to report finds and new sites [60]. The information and location accuracy of archaeological sites could potentially be improved in a manner similar to that tried by the National Land Survey for locating boundary markers, for which a dedicated game app was developed [61,62]. Crowdsourcing is the art of the collection of geospatial data by a large group of voluntary people. In Hyyppä et al. (2018), the feasibility of smartphone-based Lidar for crowdsourcing forestry information was demonstrated [63]. Since then, Apple has integrated Lidar to many of their products, and it is possible to create 3D models for documenting valuable sites. Additionally, crowdsourcing and smartphones have been successfully used in documenting landmarks [63]. The use of crowdsourcing in cultural heritage and conflict archaeology has been discussed, for example by Seitsonen in 2017 [64].

The literature review clearly demonstrated that the discussions and research on archaeological sites and their impact on forest management are highly one-sided. The subject has been addressed to some extent in archaeological publications, but hardly at all in publications related to forest research. This indicates a gap in interdisciplinary research and highlights the potential for more integrated studies that could benefit both archaeological conservation and forestry management. However, the discussion on forestry in Finland is very active at a general level, with the current focus on issues such as climate change, technological advancements, logging practices, and conservation perspectives. To date, there has been little to no research or discussion on archaeology or cultural heritage within this discourse. There could be several reasons for this one-sided perspective, but from a Central European viewpoint, the topic may not be deemed as crucial since forestry does not hold as significant a role in many areas as it does, for example, in Finland. Dialogue and cooperation would benefit from incorporating perspectives from both fields and enhancing interaction. Archaeological publications often focus on the protection of sites and the negative impacts of forestry on archaeological sites, which are indeed important subjects. While there is likely practical or field-level dialogue between the sectors, there appears to be a lack of interaction in terms of scientific research.

New innovations are also needed to increase collaboration. Approaching the accuracy of archaeological spatial data and related details, such as site descriptions, from the perspective of the forestry sector could be intriguing. Future studies could, for example, aim to determine whether the register’s information is sufficiently understandable for
different user groups, such as forestry experts or forest owners. Archaeological sites often interest landowners, and many may have substantial further knowledge about their own land. Case Example 5 in this research was familiar to the owner of the forest, who also wanted to protect that archaeological site. In this instance, the forest owner voluntarily refrained from conducting thinning operations in the area where they believed the archaeological site was located. According to a survey conducted in 2021 on behalf of the Finnish Heritage Agency, the Ministry of Education and Culture, and the Ministry of the Environment in Finland, nine out of ten people consider cultural heritage important, and over a third would like to be more involved in protecting cultural heritage [65]. On the other hand, the protection of archaeological sites and reporting about them is associated with certain beliefs, and many landowners may fear the consequences of protection for their own activities, such as forestry, farming, or construction [66]. Cooperation could be increased, for example, from the study phase itself. Both archaeology [67] and forest sciences [68] are taught at the University of Helsinki, and joint courses could encourage collaboration between the fields. Shared research projects could also lay the foundation for dialogue and make discussions more open. Clearly, the forestry sector is often viewed in archaeology more as a threat or as endangering archaeological sites. One of the most significant results of this study was achieved through practical cooperation. Case example 5 is a significant archaeological site, as it has now become the first confirmed separate plague cemetery in Finland, thanks to this research. While individuals who died of the plague have indeed been buried in common cemeteries, a separate, secluded plague cemetery where victims were buried within a relatively narrow time frame is a rare type of site. Future research on this site could address many research questions related to, for example, the plague or the rural population of the early 1700s.

Finally, we would like to discuss some general future directions. Possible topics for further research could include a follow-up study a few years after the new law on archaeological heritage has been implemented. Only then will it be possible to see the practical effects of the new legislation, for example, on forestry and the damage to archaeological sites as a consequence of forestry activities. The use of archaeological spatial data and the methods used for collecting spatial data could be further examined, for example, through surveys aimed at industry stakeholders. Surveys targeted at the forestry sector could also generate valuable information and lay the foundation for new types of cooperation. Regarding cooperation, it would be interesting to see if efforts to organize collaboration between the fields are pursued in the future. Additionally, technological advancements and new innovative inventions in both fields are possibilities, and could enable the collection of even more precise spatial data in archaeology as well. The topic is very timely. For example, the Finnish Heritage Agency is initiating a reform project related to the archaeological research infrastructure [11]. In Sweden, a large project somewhat similar to this, known as Swedigarch, is underway [69]. There is also a need to update the register of ancient sites in line with new legislation, which uses the term ‘archaeological information repository’ instead of ‘register’ (muinaisjäännöskisteri) [9]. Several industry discussion events have been organized on the topic, the most recent being a meeting/workshop for archaeological fieldwork practitioners in March 2024 [70]. Discussions on archaeological surveys and their practices have also recently been initiated by archaeologist Timo Jussila on an archaeologists’ email list [71]. New guidelines and practices are currently sought from the perspectives of both fieldworkers and authorities. The forestry perspective has so far been underrepresented, but future collaboration could bring this viewpoint to the fore as well. Field work is also common in forest studies, and some of the field methods for forest inventories could be tested for archaeology as well.

5. Conclusions

In conclusion, this study underscores the critical need for enhanced precision in archaeological spatial data and strengthened collaboration between the fields of archaeology and forestry within Finland. Our findings indicate that a significant number of
archaeological sites, particularly those from the Stone Age, lack precise boundary delineations and are consequently at risk of damage or destruction due to forestry activities. The integration of modern technological solutions, such as precision GPS and advanced GIS applications, is paramount for improving the accuracy of spatial data concerning these heritage sites. Moreover, we advocate for regular updates to the Register of Ancient Sites and increased field verification to ensure the accuracy and relevance of the data held within. However, it is important to remember that the accuracy and quality of archaeological spatial data are only as good as the archaeological research itself. In Finland, research is conducted on a limited scale and with scarce resources, which has negatively impacted the quality of archaeological information for years, so that we have a so-called “research deficit”. Therefore, there is much to improve, and further research is needed.

**Author Contributions:** Conceptualization, J.R. and M.H.; methodology, J.R.; software, J.R.; validation, J.R. formal analysis, J.R.; investigation, J.R. and T.T.; resources, J.R.; data curation, J.R.; writing—original draft preparation, J.R.; writing—review and editing, J.R., T.T., J.H., and M.H.; visualization, J.R.; supervision, M.H.; project administration, J.R.; funding acquisition, J.R. and M.H. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by KONE FOUNDATION, grant number 202006680, and the APC was funded by the UNIVERSITY OF HELSINKI.

**Data Availability Statement:** Data available in a publicly accessible repository that does not issue DOIs. Publicly available datasets were analyzed in this study. These data can be found here: https://www.museovirasto.fi/en/services-and-guidelines/data-systems/kulttuuritietoaerjestelmae/kulttuuritietojaerjestelmae/kulttuuritietojen-paikkatietoaineistot. (accessed on 23.05.2024)

**Acknowledgments:** Many thanks to Jenna Ermala, Eetu Kilpeläinen, Nimmi Mikkonen, and Matti Hytkö for their assistance in the fieldwork. Open access funding provided by University of Helsinki.

**Conflicts of Interest:** The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

**References**


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