10-21-2021

Mapping Historical Archaeology and Industrial Heritage: The Historical Spatial Data Infrastructure

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Recommended Citation
Trepal, D., Lafreniere, D., & Stone, T. (2021). Mapping Historical Archaeology and Industrial Heritage: The Historical Spatial Data Infrastructure. *Journal of Computer Applications in Archaeology, 4*(1), 202-203. http://doi.org/10.5334/jcaa.77
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CASE STUDY

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Mapping Historical Archaeology and Industrial Heritage: The Historical Spatial Data Infrastructure

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ABSTRACT

While a vibrant and growing research literature exists on the value of GIS to archaeology in general, the application of geospatial digital data to the subfield of historical archaeology is less well developed, especially in North America. This is particularly true for the era of industrialization, where the archaeological record is accompanied by a comparatively rich historical record. Historical and industrial archaeology are fundamentally bound up in the interplay between material and historical data, and it is in enhancing the dialogue between these two evidentiary bodies that interdisciplinary geospatial approaches are most fruitful to these subdisciplines. Drawing on recent discussions in digital archaeology and Historical GIS (HGIS), which has a robust history in the social sciences and humanities, we present an approach to modelling, visualizing, and analyzing longitudinal physical and social environment data for historical and industrial archaeology: a Historical Spatial Data Infrastructure (HSDI). Our HSDI, which is data-rich and highly flexible in scale, is especially well-adapted to facilitating this dialogue within archaeological research, as well as having important applications to heritage management and public engagement, as demonstrated in our case study.

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KEYWORDS:
GIS; Historical Archaeology; Industrial Archaeology; Heritage; Spatial Humanities; Big Data

TO CITE THIS ARTICLE:
Trepal, D, Lafreniere, D and Stone, T. 2021. Mapping Historical Archaeology and Industrial Heritage: The Historical Spatial Data Infrastructure. *Journal of Computer Applications in Archaeology*, 4(1), 202–213. DOI: *https://doi.org/10.5334/jcaa.77*

1. INTRODUCTION

Archaeology as a discipline continues to increase its reliance on the use of digital data, especially spatial digital data, within both academic research and heritage management (McKeague et al. 2019). This process has played out differently within various subfields of the discipline, however, and the following study focuses particularly on the challenges faced in defining the role of digital spatial data within historical and industrial archaeology in North America.

Drawing on one particular field of social sciences research, Historical GIS (HGIS), we present a new approach to modelling, visualizing, and analyzing longitudinal built environment and social data within an industrial heritage landscape: a Historical Spatial Data Infrastructure (HSDI). Historical archaeology and the subfield of industrial archaeology are fundamentally bound up in the complex interplay between material and historical data (Little 2007; Martin 2015). Our Copper Country HSDI (CC-HSDI), which is data-rich and highly flexible in scale, is especially well-adapted to facilitating this dialogue, as shown in our case study of the Copper Country, an industrial heritage landscape, dominated by copper mining, located in Michigan's Upper Peninsula. First launched in 2015, The CC-HSDI now supports an active interdisciplinary blend of archaeological, geographic, and historical research, and robust public engagement.

Historical archaeology in North America has, until quite recently, been a relatively slow adopter of digital approaches and of GIS in particular (González-Tennant 2016). This may stem in part from historical archaeology's particular relationship with the historical record. Ongoing discussions of the key challenges of digital archaeology (Huggett 2015; Huggett 2020a), and the bulk of digital archaeology research as represented by the CAA conference proceedings of the last decade or so, tend to feature digital archaeology as applied to archaeological sites predating the period most familiar to North American historical archaeologists, which is generally defined as falling within the last 500 years (Orser 2017). Until recently, these discussions also somewhat privilege discussions of what Richards-Risetto and Landau (2019) call "raw" data – the prevalent and continually growing suite of tools for digitally recording material remains and landscapes for archaeological research. The accelerating accumulation of raw data has been characterized as an archaeological "Data Deluge" (Bevan 2015), lending an air of urgency to these discussions. Richards-Risetto and Landau contrast raw data with "derived" data, which, within digital archaeology, is most typically associated with field notes, representations such as maps and 3D models, and the results of some form of analysis – all data that are shaped through some form of interpretation or "post-processing" (Richards-Risetto and Landau 2019: 121).

Critical understandings of the process of creating and using data, and reflexive and transparent processes of digital datafication, particularly with respect to GIS, have long been recognized as important within both archaeology (Aldenderfer and Maschner 1996; Lock 2000) and more broadly within the social sciences and humanities (Goodchild 1992; Schuurman 2000; Goodchild and Janelle 2004) The emergence of a "New Empiricism" in archaeology (Huggett 2020b), and the recognized need to leaven empirical approaches with more reflexive, qualitative, and experiential archaeological practice (Caraher 2016; Huvila and Huggett 2018; Caraher 2019) indicate that this will remain an important concern for the foreseeable future.

Historical archaeologists are, of course, intimately familiar with derived data in the guise of the historical record, a vast, tremendously diverse, illuminating, and yet tantalizingly incomplete body of evidence which encompasses a wide range of cartographic, artistic, diagrammatic, textual, and tabular records of past people, places, objects, and events. The critical contextualization of and interplay between various pieces of archaeological and historical data lies at the core of historical archaeology practice.

While archaeologists heavily involved in the use of "raw" digital data may be particularly (and quite rightly) concerned with interpretations or representations influenced by "algorithmic agency" (Hugget 2020a), historical archaeologists are faced with the challenge of identifying digital approaches permitting the mutual contextualization of voluminous bodies of both archaeological and historical evidence of the past, both quantitative and qualitative, raw and derived, that aid in addressing the inherent limitations of each body of evidence when explored in isolation (Trepal, Lafreniere, & Gilliland 2020). In doing so it becomes necessary to ask questions drawn from scientific and humanistic research perspectives, and address them using methods pulled from both paradigms (Earley-Spadoni and Harrower 2020). We see echoes of Richards-Risetto and Landau's argument for a more reflexive and iterative approach to the process of 'datafication' in calls within historical archaeology for applications of GIS as a reflexive, iterative process that can be applied to both quantitative and qualitative data (González-Tennant 2016; González-Tennant 2018). An important source of inspiration for the latter lies in the digital humanities with respect to discussions of practice, particularly with historical records or other "derived" forms of evidence (Bodenhamer, Corrigan, & Harris 2015).

There is a growing recognition within historical archaeology that GIS has a much bigger role to play in the future of the subdiscipline, especially in the form of interdisciplinary collaboration (Warner-Smith 2020). Archaeologists have increasingly recognized that digital humanities scholarship has developed interdisciplinary approaches that can aid archaeologists using GIS in tackling current issues revolving round the processes of generating, translating, and interpreting digital data using spatial, digital approaches (Earley-Spadoni 2017; Earley-Spadoni and Harrower 2020).

HISTORICAL GIS AND THE HSDI: DIGITAL HUMANITIES APPROACHES TO THE PAST

Historical GIS (HGIS) has matured as an academic discipline. A growing body of researchers have in recent years recognized the value of GIS for exploring and visualizing historical documents, maps and datasets. GIS has proven an increasingly popular means for embracing the broader "spatial turn" in the social sciences and humanities (Withers 2009; Bodenhamer, Corrigan, & Harris 2010; Gregory and Geddes 2014; Gregory, DeBats & Lafreniere 2018). Early HGIS work focused on the mapping of large national-scale data such as censuses (Gregory et al. 2002; McMaster and Noble 2005), administrative boundaries (Bol and Ge 2005) and gazetteers (Southall, Mostern & Berman 2011). As HGIS techniques have grown in sophistication, HGIS research has drawn on finer-scale data such as city directories and tax rolls to address research questions of a more local nature (Debats 2008; Dunae et al. 2013; Lafreniere and Gilliland 2015; Van Allen and Lafreniere 2016; Olson 2018). HGIS research subsequently expanded beyond tabular datasets to different forms of historical evidence, such as the exploration and analysis of the contents of historical newspapers and narrative accounts (Gregory, et al. 2015; Taylor et al. 2018), and to aid in uncovering patterns of historical events such as the 1918 influenza pandemic (Lafreniere et. al 2021).

The chief challenge of HGIS research remains the difficulty of spatializing historical data in a GIS within an appropriate longitudinal context and across multiple scales. The aforementioned examples of HGIS rely primarily on modern cartography, often at one spatial scale, for their spatial backdrop. This relatively crude time-space contextualization limits the representative potential of the data, the ability to mutually contextualize different sources within a GIS, and the ability of HGIS to foster better understandings of historical people, places, and events. In order to address this limitation, the next generation of HGIS needs to be more flexible still in terms of the types of data it may ingest. More importantly, data should be spatialized by referencing cartography that is as close in age and scale as possible to the data being mapped (Lafreniere and Gilliland 2015; Trepal, Lafreniere & Gilliland 2020).

The Copper Country HSDI project presented here is an advance on recent HGIS scholarship in several ways. First, the CC-HSDI is an advanced application of the environmental stage approach developed by Lafreniere and Gilliland (2015) for use in studying personal time-space. In this approach, the fine-grained movements of people through historical environments (as originally recorded in historical sources including the census, city directories, diaries, and historical cartography) can be traced and visualized in greater detail than previously possible. Second, the CC-HSDI, as its name implies, incorporates its HGIS datasets within a Spatial Data Infrastructure (SDI). The SDI concept, developed in the 1990s as a way to manage the large-scale creation, use, and sharing of spatial data (NRC 1993), has since been adopted by a wide variety of users (Craig 2005), and remains the standard for the creation and management of government datasets (Geospatial Data Act of 2018). Finally, as we will demonstrate in the following overview of our applications of the concept, the HSDI transcends HGIS scholarship itself and serves as a broader platform for visualizing, studying, and sharing past physical and social landscapes across a variety of disciplines and audiences.

The CC-HSDI project was born out of the need for a single, interdisciplinary digital platform capable of supporting the study and management of an industrial heritage landscape in collaboration with the public. The design and development of the HDSI was thus influenced from the beginning by an interdisciplinary group of scholars and professionals, with major contributions from archaeologists, geographers, historians, archivists, professionals engaged in heritage preservation and interpretation, and the public. The nature of the project area itself, an industrial heritage landscape in the US Upper Great lakes region, also played a substantial role in the design and development of the CC-HSDI.

STUDY AREA: THE COPPER COUNTRY

The region modeled in the CC-HSDI is Michigan's Copper Country. The Copper Country, located in Michigan's Upper Peninsula, contains the largest deposit of unalloyed, native copper in the world. For over six millennia, Native Americans living in the region extracted small amounts of the metal for the production of tools and ornaments. Euro-American settlement in the region soon led to a mining boom and the transformation of the region into an industrial extractive landscape active for nearly 120 years between 1840–1960. The Copper Country contributed three quarters of the US copper production during the second half of the nineteenth century, just as the country was electrifying and indoor plumbing was entering homes. The work of copper extraction and related industrial processing, the building of company towns, and the waves of immigrant miners who populated them, has dramatically impacted both the cultural, social, and natural landscape of the region. The result is a living heritage landscape partially managed and interpreted by two national parks – Keweenaw Historical National Park and Isle Royale National Park – though the totality of the archaeological and heritage landscape (and the CC-HSDI) substantially exceeds the boundaries of the two parks.

2. METHODS

The Copper Country is an ideal candidate for the development of an HSDI for several reasons. To begin with, there are an abundance of archaeological and historical resources available to contribute to a digital infrastructure. Large-scale historical mining activities left behind a vast archaeological landscape feature the remains of mining and milling locations, transportation infrastructure, and company towns in various states of preservation, neglect, or adaptive reuse. Contemporary scientific management approaches employed by the mining companies generated a very large body of detailed corporate records that document, with high-precision, the personal details and activities of employees as well as changes to the built environment through time. Finally, from a heritage management and preservation perspective, the Copper Country's historical built environment and archaeological landscape have been under constant threat of demolition since the 1960s due to economic stress from the closure of the mines, and the massive depopulation as workers migrated elsewhere to find work.

THE STRUCTURE OF THE CC-HSDI: MODELING BUILT AND SOCIAL ENVIRONMENTS THROUGH TIME

The basic structure of the HSDI consists of a series of databases containing record-linked, spatialized, digital historical big datasets. These can be served to the web using ArcGIS Server software and PostgreSQL Server for discovery, access, and exploration of the data through a JavaScript API-based interface. The data may be accessed using either desktop GIS software, a web portal, or user-friend public web-based apps. Building on the environmental stage HGIS approach developed by Lafreniere and Gilliland (2015), the data infrastructure is organized into **built environment** and **social environment** "stages" that can be mutually contextualized and visualized in a variety of ways (***Table 1***).

The **built environment stage** of the CC-HSDI is based on a large corpus of digitized and spatially referenced historical and modern cartography that provide a detailed landscape within which we may contextualize other historical data. Using a combination of historical fire insurance plans (primarily Sanborn Map Company fire insurance maps), the Copper Country HSDI models each building's use, number of floors, construction material, and position within the lot to a very high cartographic precision of 1 inch to 50 feet. Local mining company maps and cross-sectional drawings provide additional details, such as the ownership of each building, housing plans, street lights, telephone service, sewer and electrical hookups. In industrial areas, we capture rail lines, storage lots, shipping facilities, smelters, mills, mine shafts, engine houses, machine shops, and other components of the industrial landscape.

All maps and drawings are georeferenced to one-meter ground resolution digital orthophoto quadrangles provided by the USGS. For maps in the same series and spatial scale, we start with the most recent historical map set (for example, 1949 in the case of Sanborn fire insurance maps) and subsequently georeference each earlier set to the next most recent map set. This methodology, outlined previously by Lafreniere and Gilliland (2015), allows for the precise overlay of built environment features which facilitates highly-accurate depictions of change over time. We capture a very comprehensive representation of the built environment for every 10 years between 1860–1950. Each building footprint has been digitized (some 116,000 to date) and attributes from the cartographic sources are stored in a relational SQL database.

Building footprints are a crucial important component of the built environment stage, as they function as the dwellings, workplaces, schools, and places of worship for the historical population. Each discrete address is assigned a unique ID number. Multicomponent buildings (such as a house with an attached porch) or industrial buildings with clearly delineated activity areas) may be composed of several polygons representing each building component, but they share the same building ID number. Changes to a building footprint over time are thus easily tracked and can be visualized in a variety of different ways.

	DATASET	TOTAL RECORDS	TOTAL DATA POINTS
CC-HSDI Built Environment Stage	Historical Maps	1,150	**1,150**
	Historical Building Footprints	116,420	**2,328,400**
CC-HSDI Social Environment Stage	City Directories	69,401	**902,213**
	Decennial Census	379,736	**16,328,648**
	School Records	25,879	**491,701**
	Employee Records	40,000	**2,600,000**
User-Submitted Spatial Stories		850	
Current as of June 2021		**Total:**	**22,652,112**

Table 1 Spatial historical data included in the CC-HSDI.

Architectural details, when available, are tracked as well. This permits archaeologists, heritage interpreters and managers to link specific features or layouts of a building to a distinct period, determine key dates of significance, model streetscapes, and analyze the impacts of changes to technology to the built heritage.

The second stage of the CC-HSDI, the **social environment stage**, populates the built landscape with its historical populations as represented in historical big data sets including a complete count of the decennial census, local and business directories, and tax rolls. These sources provide important contextual information on property ownership, occupancy, demographic details on past owners, and other socio-economic characteristics. Detailed mining companies' records include details on employees such as who had running water, sewer, electricity, and the valuations of properties. All of these data points are relationally linked across datasets but also through time, providing an essential resource to heritage preservationist when determining and advocating a building's significance. Of equal importance is a complete record of civic addressing that accompanies each structure, which are used to create decennial historically and temporally accurate automatic geocoders. When possible, all datasets across the HSDI are geocoded to their temporally and spatially specific building element, not just the street frontage or postal address. For industrial sites this permits fine grained analysis of change to manufacturing processes, employment, and technological change- further supporting the management and interpretation of heritage resources.

Historical and archaeological data are by nature fragmentary. Even with the benefit of historical big datasets there are gaps in the CC-HSDI's representation of the built and social environment of the Copper Country, and similar kinds of data may carry spatial reference information at different scales. Within the social environment stage, individual records are geocoded to one of four spatial resolutions: to an individual building or building component, to a street, to a settlement or district, and within census enumeration districts. Each record indicates which scale it was geocoded to, and the source record used to derive the spatial location assigned. This represents a much more sophisticated spatial contextualization than is typical within HGIS projects geocoding tabular records such as the census (c.f. Logan & Zhang 2018).

The current version of the CC-HSDI features two modes of access. The first uses Portal for ArcGIS as the primary interface for the construction and management of the built and social environment stages, and the main route for research access. The spatial datasets in the CC-HSDI portal can be directly accessed using desktop GIS software or using the visualization and editing tools within the portal software itself. The datasets themselves, while stored in an ESRI ArcGIS platform are developed to meet open-source geospatial data formats. Portal for ArcGIS also supports the creation and management of publicly-accessible web apps and dashboards, including the increasingly popular Esri StoryMaps. From a pedagogical standpoint, these app-building tools are a useful feature for introducing students to the creation and use of digital "derived" historical and archaeological data without the need for fully-fledged desktop GIS software, and with the additional advantage of being web-based, and thus supporting remote teaching and collaboration activities.

The second mode of access is a public engagement and education focused project called the Keweenaw Time Traveler (*www.keweenawhistory.com*). The Time Traveler uses the same datasets stored within the CC-HSDI portal, but here they are accessed through a custom-built, user-friendly, interactive public web interface (***Figure 1***). The map view within the Time Traveler web interface allows users to pan and zoom across the Copper Country over a backdrop of historical cartography that can be toggled to represent different time periods, with a transparency slider available to reveal modern aerial imagery underneath to aid in navigation and the visualization of change over time. From the data sidebar to the left of the map view, users can keyword search and filter the data to find specific people, places, and events. Once selected, the chosen individual, place, or story appears as a popup in the map view. Users can also contribute spatialized stories based on a selected location and time that can also be posted on social media such as Facebook and Twitter. The CC-HSDI team is currently in the process of developing a second-generation interface that will improve the user interface and incorporate all of the historical big datasets outlined above.

3. APPLICATIONS OF THE CC-HSDI TO ARCHAEOLOGY AND HERITAGE

The CC-HSDI has supported a number of archaeology, history, and heritage research and outreach projects within the Copper Country, several of which are summarized here. Each project not only drew on the built and social environment data within the CC-HSDI, but also subsequently contributed new data to the CC-HSDI. This continual growth and integration of spatialized digital archaeological and historical data reinforces and expands the value of the CC-HSDI for future projects.

ARCHAEOLOGICAL INVESTIGATIONS AT AN EARLY 20TH CENTURY CHINESE LAUNDRY, CALUMET, MI

The mining boom that led to the emergence of the Copper Country in Northern Michigan in the 19th century attracted waves of domestic and international migration to the region, resulting in a diverse and rapidly changing population in Copper Country mining towns. Michigan

Tech Archaeologists exploring one example of this broader story in the Copper Country town of Calumet in 2018 used the CC-HSDI during the research design, excavation, and interpretation phases of an investigation of a now-vacant house lot. Of particular interest was the period 1900–1917, during which the lot contained a structure labeled a "Chinese Laundry." The Copper Country hosted a small Chinese community through the first few decades of the 20th century; most Chinese residents of the Copper Country were business owners running laundries. The built environment stage of the CC-HSDI permitted archaeologists planning their fieldwork to examine changes over time in the use of the property and helped establish discrete occupation periods to use as an initial baseline for the archaeological survey and excavation (***Figure 2***).

Figure 1 The Keweenaw Time Traveler Web interface.

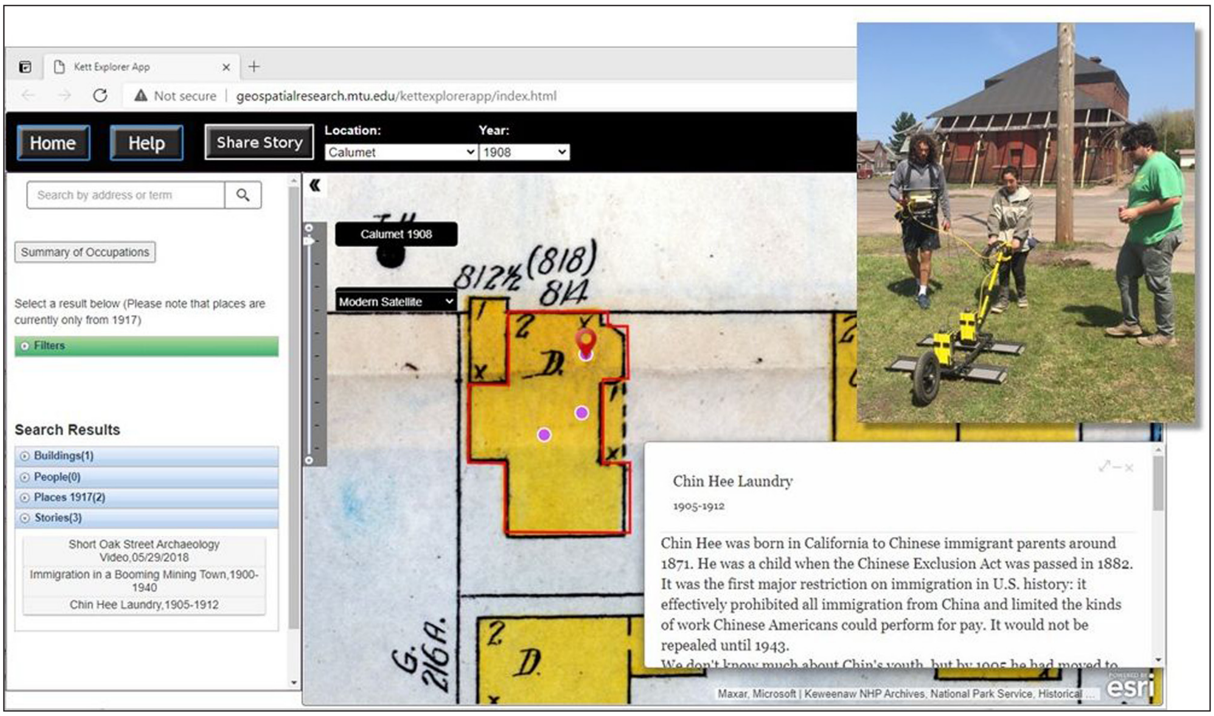

Figure 2 The historical Chin Hee Laundry in Calumet, visualized within the Keweenaw Time Traveler web interface. The purple dots within the building footprint represent user-submitted spatial stories about the laundry. Inset: MTU archaeology field school conducting remote sensing survey at the site of the former laundry.

The CC-HSDI also proved a valuable asset for aiding in the interpretation of the collected archaeological data. Excavations at the site revealed early 20th century artifacts and features that can be linked to the Chinese proprietor of the laundry and his family, and to the building's subsequent occupation by an African-American family, using datasets such as the local city directories within the CC-HSDI's social environment stage. The CC-HSDI also supported outreach activities in real-time; the location of the dig could be linked via social media posts to the Explore app in the Keweenaw Time Traveler, contextualizing excavation and artifact photos using the same historical sources drawn on by the archaeologists during the project. Local heritage interpreters have appended spatialized stories in the Explore app publicizing the excavation work and its historical subjects.

AUGMENTING REMOTE SENSING INVESTIGATIONS AT THE QUINCY SMELTER, RIPLEY, MI

As the Copper Country evolved into a mature mining district in the last quarter of the 19th century, regional mining companies increasingly invested in the construction of local processing facilities such as mills and smelters to reduce transportation costs and the reliance on distant, third-party processing facilities. A notable extant example of this phase in the region's history is the Quincy Mining Company's copper smelter in Ripley, MI. Built in 1898, the smelter is one of very few remaining historic early 20th century smelter sites in North America, and remains the best preserved, being part of the Quincy National Historic District National Historic Landmark (Lidfors, Hrenchir, & Feller 1988). The site is currently owned and managed by the Keweenaw National Historic Park Advisory Commission.

A large and complex industrial site, heritage managers at the Quincy smelter face numerous challenges as they work to preserve the site and facilitate public access in the form of guided tours. Environmental contaminants such as mercury previously detected at portions of the site led to a series of environmental remediation projects, but the identification and remediation of environmental hazards at the site remains a crucial precondition to future preservation, maintenance, and public access efforts (US EPA 2017). To further these efforts archaeologists and remote sensing specialists based at Michigan Tech, working in concert with National Park Service and KNHP Advisory Commission staff, have recently undertaken surveys of the site to better understand the location and condition of historical subsurface features at the smelter. The CC-HSDI's collection of spatialized historical maps and blueprints of the smelter served as a historical spatial context for planning, executing, and interpreting the results of photogrammetry, thermal imaging, and ground-penetrating radar surveys of the smelter site. The project generated a large number of high-quality aerial photographs of the site and located numerous previously unrecorded subsurface features, which were visually juxtaposed against the historical representations and shared among collaborators using a GIS-based web app (*Figure 3*). This ongoing project will aid in identifying the potential for disturbance of intact historical subsurface features by future environmental remediation efforts. The data generated by this project also contributed to expanding the scale and accuracy of the CC-HSDI's representation of the smelter within the built environment stage. The collected aerial photographs, post-processed

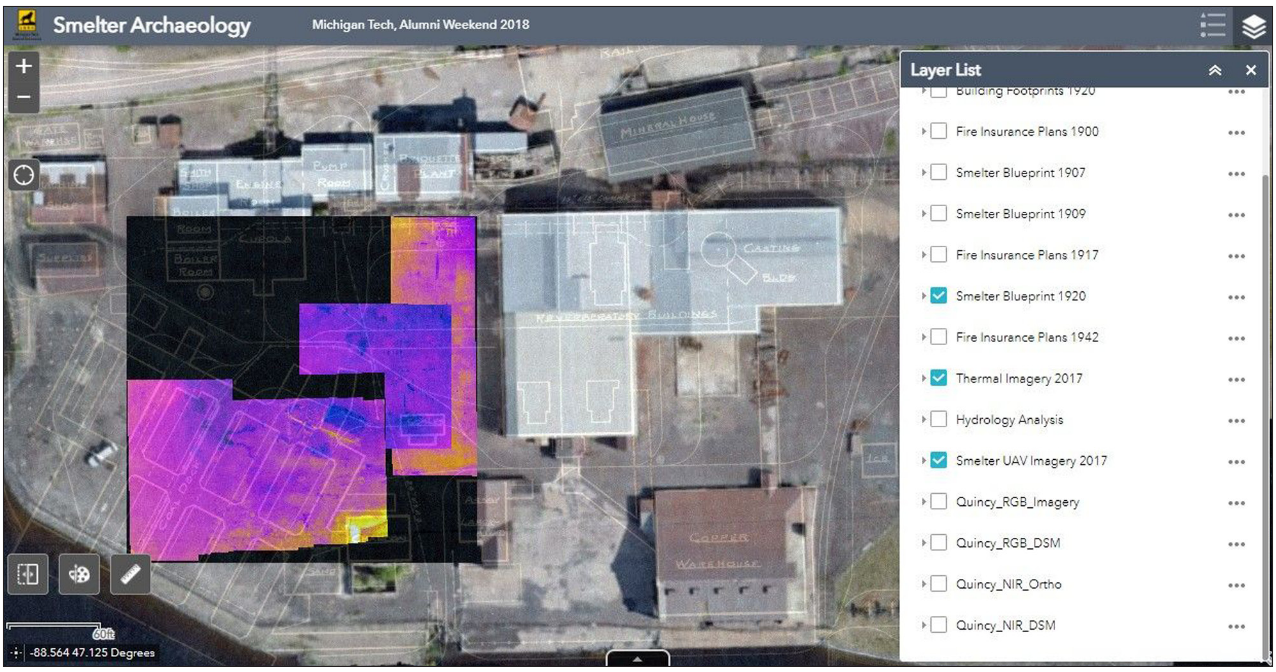

Figure 3 Quincy Copper Smelter Archaeology GIS web app using CC-HSDI data.

thermal imagery and GPR data are stored within the CC-HSDI and collectively support new representations of the smelter as an archaeological and heritage site.

POPULATING THE COPPER COUNTRY'S HERITAGE LANDSCAPE USING HISTORICAL DEMOGRAPHIC DATA

As briefly touched upon in the previous example of the Chinese laundry, the CC-HDI's social environment stage allows archaeologists to connect historical places and people through the use of multiple linked datasets. Linked datasets also allow us to trace the movement of historical people to and from the Copper Country. This is greatly aided by the availability within the CC-HSDI of sources, such as detailed school records, that raise the visibility of groups such as children that are less well represented. The history of the Chopp family provides an illustration of these capabilities. The head of household is Nicholas Chopp, aged 36, an immigrant miner living at 3593 Temple Street in Calumet, MI in 1901 as indicated by his Calumet & Hecla Mining Company employee record, transcribed and digitized within the CC-HSDI. Through a combination of spatial and tabular record linkages, we can trace Chopp and his wife and six children across time as their employment, schooling, and place of residence changes. With their identities firmly established we can even follow them after they leave the Copper Country when Nicholas Chopp takes a job working for Ford Motor Company in the Detroit era in the late 1920s (***Figure 4***).

Whether used to link people to archaeological sites and material culture, to populate a preserved heritage landscape, or to learn more about an ancestor, this advanced spatialized, longitudinal social environment stage data strengthens the connections between different datasets within the CC-HSDI, and further fleshes out the stories of interlinked people, places, and things.

PREDICTING POLLUTION EXPOSURE EXPERIENCES OF 20TH CENTURY CITIZENS

The CC-HSDI can also be used to visualize the movements of historical Copper Country residents at local scales and explore the ways they interacted with their physical environment; these movements can then be compared with other data to explore the potential risks of daily life in an industrial mining district. With the local mining industry expanding rapidly, the pool of available housing

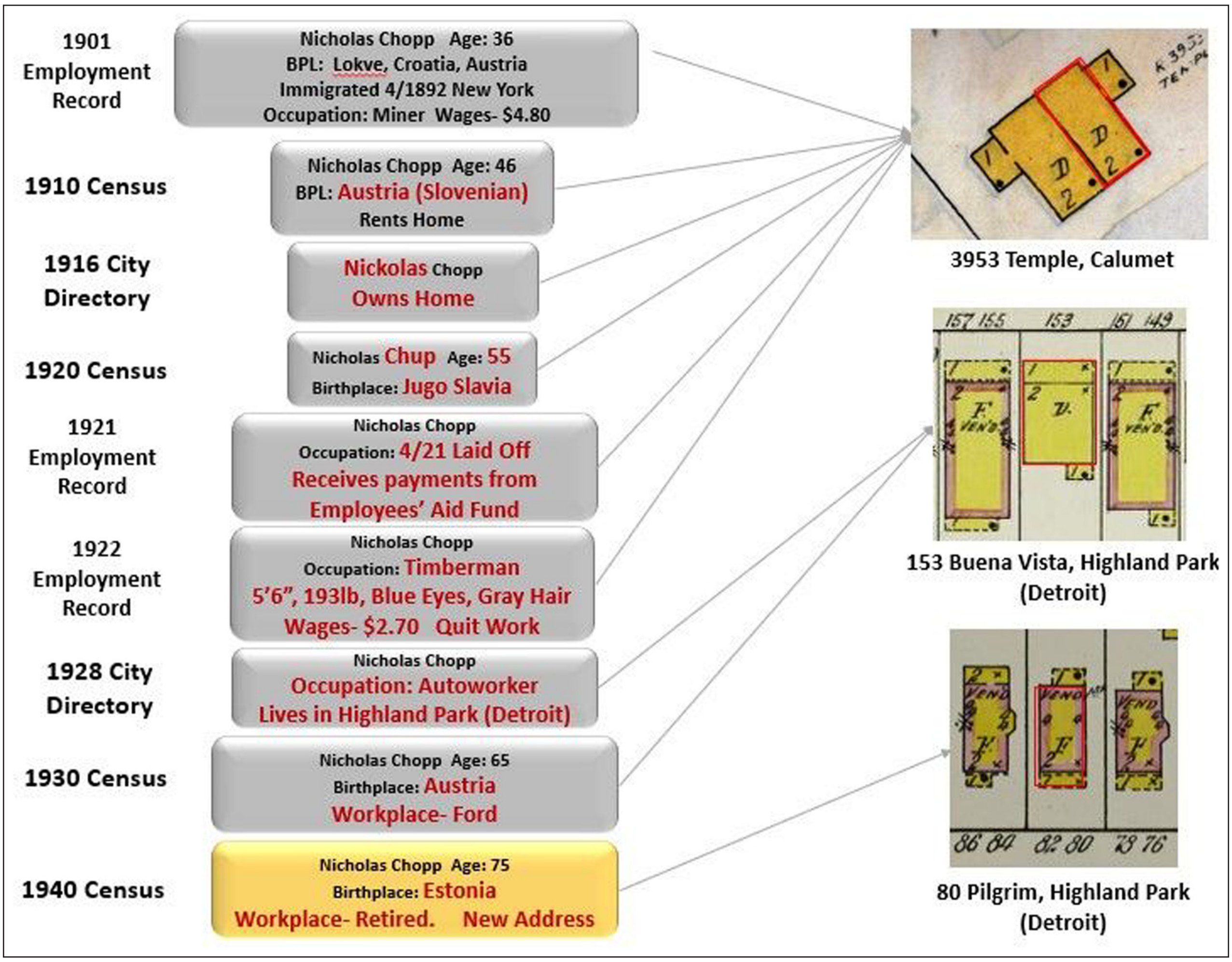

Figure 4 Linked, spatialized historical datasets within the CC-HSDI permit users to trace migration of historical Copper Country residents. Explore their journey in our interactive web map located at *www.keweenawhistory.com/stories*, choose 'Children's Geographies'.

stock struggled to keep pace with demand around the turn of the twentieth century. Houses rubbed shoulders with mining company buildings as residential and industrial districts expanded in parallel, especially in Calumet. Residents grew accustomed to the constant hammering of stamp mills, the noxious smell of smelters, and smoke billowing out of the smokestacks that populated the landscape. The CC-HSDI replicates this environment geospatially through the use of a recently-developed hazard projection index. Building on the methodology developed by Trepal and Lafreniere (2019), we assigned a projected hazardous output based on the size and use of each building, and a survey of industrial toxic releases. We then interpolated those projections across the entire study area, producing a hazard risk layer, which displays the predicted relative amount of industrial pollution for the study area. This visualization illuminates both individual and group experiences of the built environment, as well as the social dynamics that led to differing experiences by class, ethnic group, and other socioeconomic factors. The visualization provides more depth to the built environment stage of the CC-HSDI through studying how industrial pollution output changed over time, which will be the subject of later study.

The area in and around Calumet's downtown demonstrates this mix of land usages well (***Figure 5***). In addition to the commercial buildings typically found in a downtown area, such as theaters, saloons, laundries, and other stores, Calumet's downtown was home to blacksmith and gunsmith shops, printing shops, several tenements, and a dress factory. Many churches can be found within two blocks, as well as schools and more tenements. Beyond that are railroad yards, stables, coal storage, mine shafts and their associated steam hoists, which mingle with more dwellings, schools and churches. The integration of land uses leads to the seemingly random patterning of the interpolated layer, with residential, commercial, and industrial structures neighboring each other in several areas. Ongoing research is using this spatial visualization of sources of pollution in concert with the social stage demographic data to reconstruct historical children's spaces, their experiences within the historical built environment, and also to visualize the socioeconomic mobility of the region's residents (Stone, Lafreniere and Hildebrandt in review). The CC-HSDI's detailed reconstructions of both the structure and function of the built environment as well as its resident population, at fine spatial scales and across time, make it an invaluable environment for this research.

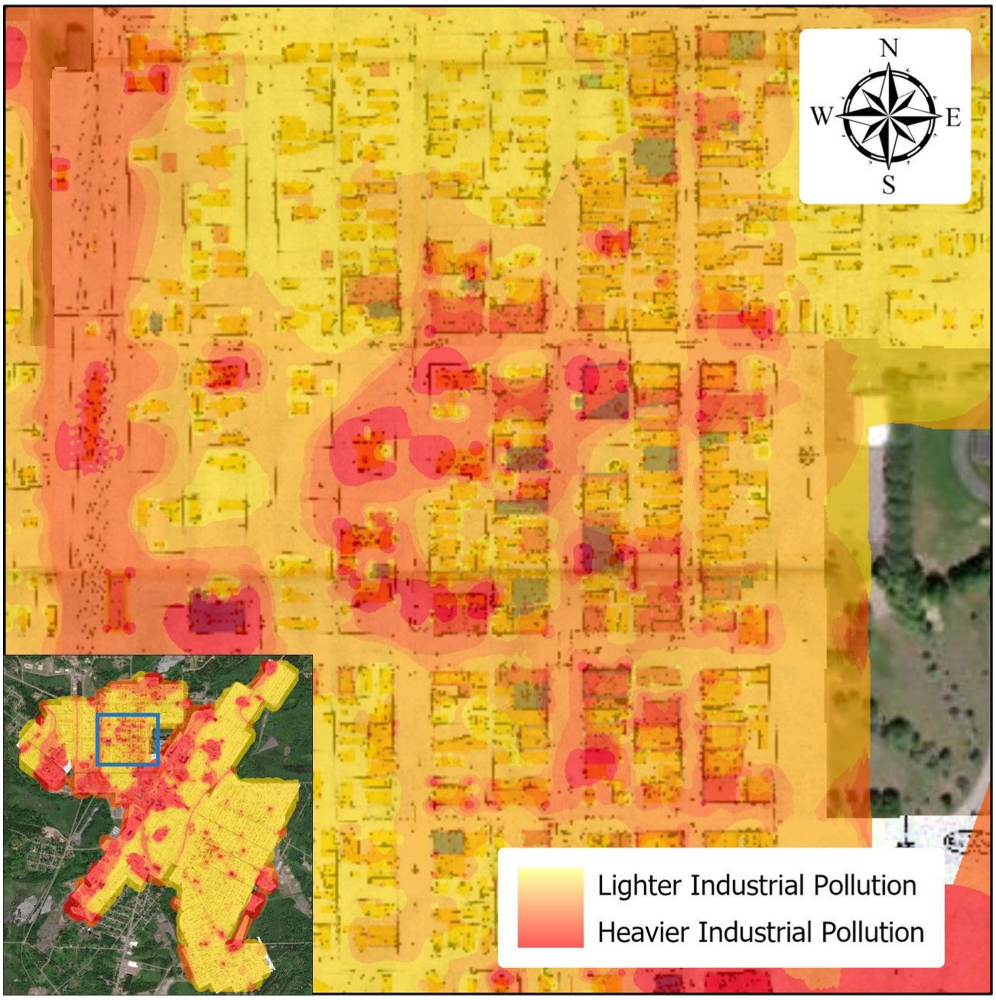

Figure 5 Industrial pollution risk analysis for downtown Calumet, Michigan.

4. DISCUSSION

Archaeologists have taken note of the potential value of the SDI concept to serve as the underpinnings for larger-scale spatial digital archaeology infrastructures; Indeed, the SDI concept offers the potential for eventually developing a transnational, standardized, very large-scale infrastructure for archeology and cultural heritage (McKeague et al. 2020). Current large-scale archaeological data infrastructures, such as tDAR in North America, and ARIADNE Plus in Europe, represent robust and highly ambitious portals for the storage and management of archaeological data. Projects to develop digital ontologies for cultural heritage, particularly CIDOC-CRM, hold out the promise of a comprehensive set of tools for standardizing the format of digital archaeological data across all regions and time periods (ICOM CIDOC 2021). Still, at present large archaeological data infrastructures have only partially achieved their potential, as their spatial capabilities are limited, and efforts to adopt a universal model infrastructure and metadata standard remain in their early stages (McKeague et al. 2019; McKeague et al. 2020).

The CC-HSDI, now in its sixth year of development, is not a competitor in these efforts towards developing large-scale digital infrastructures for archaeology and cultural heritage, as it is interdisciplinary in focus and not designed primarily as a portal, nor was the development of a universal standardized schema for data a priority. Instead, the CC-HSDI serves as a GIS-based model infrastructure for the applications of digital, spatial archaeological and historical data to interdisciplinary research, to cultural heritage preservation and management, and as a platform for public collaboration. With that being said, the application of the SDI concept within the CC-HSDI necessitated the creation of a user-friendly portal and the adoption of established, robust, replicable data and metadata standards. This leaves open the possibility for a future transition to compatibility with new data frameworks when a broader standard for an archaeology or digital humanities SDI emerges.

5. CONCLUSION

By combining interdisciplinary scholarly approaches and public-collaborative components, The CC-HSDI project aims at a more transdisciplinary process of making the most of our knowledge of the past in its various forms. This process relies fundamentally on the use of geospatial approaches to aid in addressing an expanding variety of interleaved scholarly, professional, and public needs. It is a digital, spatial platform at its core, and one that takes advantage of the analytical power of computers – it is composed entirely of "derived" or post-processed digital data. However, the vast majority of the "processing" within the project is accomplished manually by a large interdisciplinary team of researchers, students, professionals, and volunteers. The end product is not by any means automated. The spatialization and record-linking of historical big data sources requires a great deal of "slow" scholarship – the expert manual review and mutual contextualization of multiple datasets that results in an intimate familiarity with the data acquired over years. In the CC-HSDI, computational power is harnessed not primarily for the sake of efficiency or for the greater automation of analysis, but rather for visualization and exploration of evidence of the past, both qualitative and quantitative, by experts and the public alike, for the purposes of observing change over time, making more deeply informed decisions, telling stories, and fostering heritage making within the community.

The HSDI is a GIS-based digital platform well suited to supporting historical and industrial archaeology research and public engagement from new visual and conceptual perspectives. More broadly, The HSDI is also a demonstration that archaeology and the digital humanities have much to offer each other as both wrestle with the broader questions of digital and GIS-based scholarship It permits a sophisticated, reflexive, iterative juxtaposition of archaeological and historical information; it harnesses computational power to aid in the storage, access, discovery, analysis, and visualization of data – but also both demands – and rewards – a manual, intimate experience with the data as a feature of its construction and use. Ultimately the CC-HSDI project's structure, incorporating mutually reinforcing public collaborative and interdisciplinary research components, is aimed at creating an approach to understanding the past that is genuinely greater than the sum of its parts.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. Timothy Scarlett and the 2018 Industrial Archaeology Field School Crew for the use of their work as an example in this study. We also wish to thank the staff of the Geospatial Research Facility at Michigan Tech for their ongoing technical support of the project. The authors also gratefully acknowledge the institutions that provided critical funding for the CC-HSDI and Keweenaw Time Traveler Projects including: The National Endowment for the Humanities, the Council on Library and Information Resources, Portage Health Foundation, Michigan Technological University, and the Keweenaw National Historical Park Advisory Commission.

COMPETING INTERESTS

The authors have no competing interests to declare.

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TO CITE THIS ARTICLE:
Trepal, D, Lafreniere, D and Stone, T. 2021. Mapping Historical Archaeology and Industrial Heritage: The Historical Spatial Data Infrastructure. *Journal of Computer Applications in Archaeology,* 4(1), 202–213. DOI: *https://doi.org/10.5334/jcaa.77*

Submitted: 14 June 2021 Accepted: 01 August 2021 Published: 21 October 2021