*Vivian S. James*
*http://dx.doi.org/10.15496/publikation-43223*

# Context as Theory: Towards Unification of Computer Applications and Quantitative Methods in Archaeology

**Vivian S. James**
University at Albany, State University of New York
vsjames@tds.net

## Abstract

Context in archaeology is a theory of inclusion, differing from context in computer science and other fields where context is a theory of exclusion or only part of a whole. Context is multidimensional, each layer of which is embedded and overlapping in multiple scales, constituting the dimensionality of archaeological research. Context as theory defines relevancy and theorizes GIS as a method that organizes this multidimensionality – ontologically based in the site, subsite, feature(s), assemblage(s), artefact(s), and the detail(s) of the artefact – literally, inclusively, everything! GIS layering and sequencing enable modelling and analysis of the multidimensionality of context. Geodatabase hyperlinks and multimedia within a GIS provide synergistic opportunity for alternative curation strategies and (re) connect detached research. A multidimensional, multiscalar perspective of context as theory crosscuts themes and archaeological settings to unify the seemingly fractured character of computer applications and quantitative methods in archaeology.

**Keywords:** archaeological theory, context, GIS

## Introduction

This short essay describes my thinking about context as theory and theories about context over the last ten years. The term context, according to Butzer (1980: 418) and reiterated by Burke (2002: 153), comes from the Latin word *contexere*, meaning "to weave" and is related to *contextus*, which indicates "connection." Context as theory grew out of archaeological boundary-crossing research into the North American and Mesoamerican Protohistoric Period that found me juggling incommensurable paradigms with their extreme and mutually exclusive theories (Bowers 2011; Bowers 2012; Bowers 2014; Pickering 1995: 186-192) and a recognition of the converging need to theorize complex projects involving multiple scales and methodologies in archaeology (Renfrew 1990: 663; Renfrew 1993: 5, 8, 14; Renfrew 1994: 3, 5, 9-11)and the use of geographic information systems (GIS) in archaeology (Lock 2001; Lock 2003; Wheatley 1993; Wheatley 2000). This may stem from inaccurate understandings that conflate qualified and unqualified context, which are discussed here. Also, periodic synthesis of conflictive and confusing theory as well as reconciliation of ideographic and nomothetic research, it should be noted, are part of the science process (Huxley 2010 [1942]; James 2010a; Mayr 1982; Peebles 1993).

The application of context as theory to research detachment was inspired by my research of the Garoga Site in Central New York State, which was discovered in the nineteenth century and has been periodically researched across the entire span of archaeology as a profession, and the session abstract of Pouncett, Reilly & Stead (2016), titled "Digital Archaeology - Where are we and how do we fit in?" that expressed concern about the "fractures and silos" of "computing and digital technologies" in archaeol-

ogy. The perceived silo effect and fractured nature of computer applications and quantitative methods in archaeology is a feature of all archaeological research, indeed of all science (Pickering 1995: 2-3). Research detachment is a product of the research context that (hyper)linked GIS-based archaeological geodatabases can (re)connect, maintaining the metadata necessary for scientifically useful curation. This essay introduces innovative concepts, such as tense theoretical continuums and the dispersion effect, from my thinking about context as archaeological theory to archaeologically theorize computer applications and quantitative methods for archaeology and argue that a GIS-based solution can resolve or at least improve the problems of research detachment (geographically, linguistically, and physically) and enable alternative curation strategies.

## Research Detachment

### Geographical Research Detachment

Research detachment is a barrier to knowledge creation, which affects and is affected by the research context. Three of the ways that research becomes detached are: geographically, linguistically, and physically. Archaeology is a global endeavour, so requires access to materials and knowledge that may be geographically located anywhere in the world. The archaeological site, the artefacts, the documentation, and the data from that site as well as the researcher or researchers are likely to be in three or more different geographic locations, which may be relatively local or dispersed across the globe. This situation can be referred to as the *dispersion effect* of archaeological research and it is the primary cause and condition of geographic detachment.

The dispersion effect is greater for important and large sites with multiple funding sources that have involved many researchers from around the world, such as Çatalhöyük (Hodder 2008). New York, on the other hand, which does not have any archaeological world heritage sites (only the Historic Period Statue of Liberty), is impacted by geographical dispersion to a far lesser degree. Snow (1995: xi, 1-4) undertook an effort in 1984 to locate artefacts and documentation from Mohawk Valley sites, including Garoga, and found that the majority were located in New York, but spread amongst more than a hundred collections, most of them private. Collections from Mohawk Valley sites outside of New York are still located within the United States, at the Peabody Museum of Harvard in Massachusetts and the collections from the National Museum of the American Indian in New York City that were relocated to establish the Smithsonian National Museum of the American Indian (NMAI) in Washington, D.C. (Snow 1995: 3-4, 113-117, 156-157). It requires the time and funding for travel to overcome the dispersion effect and when this involves crossing international boundaries, is impacted by the current political context.

Another issue due to geographical detachment is that researchers working on the same site or the same idea from different parts of the world may be unaware of one another. This can lead to unnecessary duplication of effort instead of a collaborative effort toward knowledge production. This effect is further compounded when researchers approach the same site or idea from different academic disciplines or archaeological specializations, an effect that Marcus (1983: 454, 456-457, 480-481) noted more than thirty years ago in Mesoamerican archaeology. We form associations, such as Computer Applications and Quantitative Methods in Archaeology (CAA), to reduce unnecessary duplication of effort through networking and interface (Goodrum 2009). This strategy is often successful but is impacted by linguistic detachment.

### Linguistic Research Detachment

English is the *lingua franca* of science and therefore, of archaeology. Huang and Chang (2008: 1824-1825, 1827) demonstrated that there is an indexing bias against scientists who publish in a language other than English. And two more recent studies done by the University of Wolverhampton in England demonstrated that science researchers who use Mendeley citation software tend to read English language literature published in their own country rather than publications from other countries, even when English is not an official language of their country (Fairclough and Thelwall 2015; Thelwall and Maflahi 2015). The historical solution to language differences in archaeology is translation. The lake(shore) dwellings of Switzerland, known since 1472, were systematically excavated by Ferdinand Keller in 1853

and his first report published in the proceedings of the Antiquarian Society of Zürich the following year (Keller 1854; Menotti 2001: 319-320). The sixth report was published in 1866, the same year that Lee compiled, edited, and translated Keller's reports from the original German to English (Keller 1866; Lee 1866). Keller's published site reports have never been translated into English. This can lead to a situation where the primary literature is not cited in English-speaking locations. Rather, Lee's (1866) edited translation is cited or worse, secondary sources such as Menotti (2001) on Keller are cited. Additionally, only works considered important are translated and there may be works that, while perhaps less important at the time of their writing, are now important because of recent scholarship and are completely detached because their existence is unknown or unreadable by the current researcher(s) because of the language barrier.

### Temporal Research Detachment

Thus, the research context is impaired by linguistic detachment and is also affected by the practice of citing only the most current literature because archaeological careers are tied to citations, an example of temporal research detachment (Smith et al. 2015). Temporal research detachment can be thought of as the taphonomy of archaeology. Older archaeological research either decays through disuse and detachment or becomes fossilized through the secondary literature. According to Marcus (1983: 480), Maya archaeologists "lack awareness...[of] the older stages in the history of their own subdiscipline," contributing to a stagnant, circular research pattern in Mesoamerican archaeology. The traditional solutions to the problem of temporal research detachment are indices, bibliographies, citation, and more recently, searchable databases, which require entry accuracy or the search algorithm will be unable to retrieve the document, so that it becomes functionally detached. Providing hyperlinks to every document, publication, and other forms of media related to a site in a globally linked geodatabase along with the ability to translate those media into any language at the click of a button, however imperfect the translation might be, will help to prevent older research from becoming detached. Additionally, it will save future researchers time and money searching for documents that may be held in repositories anywhere in the world.

### Physical Research Detachment

More serious than the temporal detachment of published literature is the physical detachment of data loss, which is sometimes related to time and taphonomy. Archaeological data is lost at an alarming rate through warfare, deculturizing and demoralizing the enemy by intentional heritage destruction (Bokova 2015; Gerstenblith 2016). Data can become physically detached due to natural processes or a combination of natural and anthropogenic processes, such as the erosion of coastal and maritime archaeological sites (Erlandson 2012). Data can be physically detached through theft or looting by groups and individuals, including archaeologists, for personal gain or economic subsistence (Proulx 2013; Saad El-Gendi 2012; Schier 2011). Archaeological data detached through looting and theft is sometimes reattached when that data is returned such as the Fremont clay figurine returned to the Utah State University-Eastern Prehistoric Museum after being detached for almost forty years (Lobell 2012). Finally, archaeology is a destructive science that can result in detached data through poor excavation techniques and inaccurate or incomplete documentation. Digitization and digital redundancy, linked through a GIS geodatabase will help reduce risk and protect at least some types of archaeological data from complete loss by physical detachment.

## Curation Context in Crisis

The curation context adds another dimension to archaeology. Curation includes everything archaeologists do with their data after excavation other than analyse it (e.g., cataloguing, disseminating, displaying, educating, and otherwise engaging stakeholders). The curation context is an intersection point of archaeology with everything and everyone else and facilitates both storage and access to archaeological data. The curation context is in crisis. There is insufficient space to store the millions of archaeological artefacts excavated over the last couple of hundred years, let alone those being excavated today and those that will be excavated in the future.

Members of the New York Archaeological Council are working on guidelines for culling artefacts in the field and laboratory, primarily from historic sites, where at least the decision is being made by archaeologists and not museum staff that may not be trained to recognize the scientific value of archaeological artefacts. The current thinking is to cull large quantities of redundant materials, such as nails, bricks, and industrial slag in the field after counting, weighing, sampling, photographing or filming, and documenting. The visual documentation could be used in educational and heritage recreation projects, including virtual and interactive exhibits. The concept relies on that information to be available to archaeologists in the future, but there is no plan yet for how that will happen. Digital connection through a globally linked geodatabase would ensure that future archaeologists anywhere in the world would have access to the related documentation and could even (re)excavate the original materials if they were needed because documentation would be available to locate the culled material on a map.

We cannot know now what may be important in the future. New York archaeologists that excavated in the mid-twentieth century without stratigraphic control considered all unworked bone to be "refuse" and there was little more they could do with it beyond identification and calculating species frequency. More sophisticated methodologies of extracting information from bones have been developed since then, but it is rare for researchers to weave legacy collections into more recent research projects. Legacy collections in museums and repositories around the world become detached from later research, forgotten in the handwritten catalogues and indices of the past. Hyperlinked archives, museum catalogues, publication databases and the multimedia capability of GIS provide synergistic opportunity for alternative curation, such as virtual exhibits and digital curation, facilitating research and (re)connecting legacy collections.

## Context as Theory

The essay up to this point has detailed the problem of research detachment. Additionally, some suggestions as to how GIS can improve the situation have been offered. There are no doubt other ways of protecting archaeological data and reconnecting detached research, which will come to light through continuing work with GIS by archaeologists. The essay will now turn to archaeologically theorizing GIS. The lack of a defined theoretical connection between GIS and archaeology has resulted in a silo effect where archaeologists working with GIS are disconnected from the rest of archaeology. This section attempts to explain the difference of context as theory and theory about the dimensions of context that may theoretically empower archaeologists to move forward with projects that will increase the capacity and capability of GIS to restore and maintain context for archaeologists in the future.

Context as theory defines relevance. While a researcher can define the parameters of the research project, the context exists, having been created through all of the previous research about the theories, methodologies, topic(s), material(s), and site(s) that are being examined in the current research project. For example, there are more than fifty publications about Garoga as well as unpublished documents (e.g., field notes, maps, manuscripts, drawings) held in multiple repositories. All have some relevance to future research about Garoga, though the intensity of that relevance varies by project. All must be included as context for the current project because new research must explain how it complements, supports, or refutes previous research. Every project, each bit of knowledge created, becomes a part of the context for future research. Besides the relevance of previous research about a specific archaeological site, there is also the relevance of previous research about materials (e.g., bone, stone, ceramics), topics (e.g., diet, settlement, demography), methodologies, and theories, though the system of citation allows the exclusion of all but the most recent research because it is assumed that earlier work is already incorporated into the conclusions. The relevance of these is defined by the dimensions of context, which are project-driven and optional, and explains why context appears polysemic in archaeology.

## Dimensionality of Context

The term "context" is seemingly polysemous in archaeology but is not at risk of "*hypertrophie*" because it is unqualified when referring to context as theory

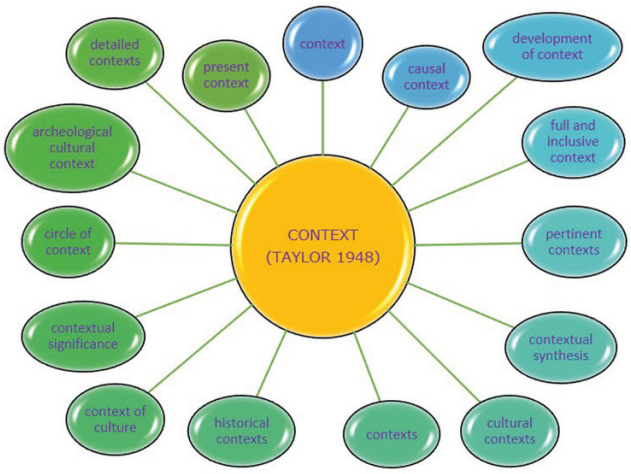


**Figure 1.** Polysemic constellation of context (after Taylor 1948).

and qualified when referring to the dimensions of context (Chouquer 2013). Taylor (1948: 111) wrote about the "circle of context" as well as using context in more than a dozen other ways, with context in the singular generally denoting an overarching concept related to the reconstruction of past culture and context in the plural to describe the dimensions, here modelled as a constellation in Figure 1. Context related to function was discussed by Phillips and Willey (1953: 616) and Binford (1962) coined "functional context" for his theory of tool use. Schiffer (1972) discussed "archaeological context," "systemic context," and "secondary context." Beginning in 1978, Butzer (1978; Butzer 1980; Butzer 1982) was writing about an ecological "contextual approach." Hodder (1992) wrote about "contexts of rapid site destruction," a social and symbolic "cultural context," "contextualization," and a "contextual archaeology" Ingold (1993) introduced "taskscape," a task-oriented context, into archaeology. Archaeological stratigraphy was the focus of Harris and associates' (Harris 1979; Harris 1989; Harris et al. 1993) writings about context and stratigraphy, followed by the "structured deposition" of Richards and Thomas (1984) and stratigraphic context in relation to pedasols discussed by Cremeens and Hart (1995). Stratigraphic context was returned to by Stein (2000; Stein 2008: 113-115), which Lyman (2012: 211-212) responded to by defining archaeological context as provenience plus association. The stratigraphy references listed here are theory-based methodologies based on much older theoretical works by Stenonis (1699) and Worsaae (1843), mentioned here to avoid conceptual detachment, which occurs when only the most recent sources are cited for an idea without an attribution to the originator. Most of these theories are solidly based in archaeological practice and can be considered as much data-driven as philosophical because they resulted from the authors' many years of experience in archaeology.

It was my attempt to understand how these various meanings – these dimensions of context – could exist at the same time in archaeology and all be correct (despite sometimes conflicting with one another, they are all accurate and logically consistent within themselves) that led me to recognize that the only way this could be possible is if context was theory (Parsons 1979-1980; Sutton and Staw 1995). Specifically, that context as theory defines relevance throughout the research process and all these theories about context define various aspects or dimensions of what may be relevant (i.e., defining the relevance for topics and materials) to a research project. Where Ritchie and Funk (1973: 1-2) and Taylor (1948) did not recognize that context is something that emerges from the work of many archaeologists through time (Taylor 1948:79-82, 94), Hodder (1986) and Lock (2003) did not distinguish between theoretical context that *must* be included and the *optional* inclusion of any or all of the dimensions of context, though Lock has envisioned how GIS maintains context and enables the exploration of context at multiple scales (James 2016; Lock 2003: 12). Context explains what archaeologists do and why we do it, connecting epistemology with praxis (Hodder 1992: 4; James 2016). Context is able to do this because it is polysemic, it is "good to think" with (Lévi-Strauss 1964: 89) providing "enlightenment" (DiMaggio 1995: 391). These examples demonstrate that in praxis, archaeologists have tested their hypotheses and ideas about context in every project and created middle-range theories to access particular aspects of context (Binford 1981). Both theory and methodology as well as context as theory and the dimensions of context are necessary if archaeology is to create accurate knowledge.

Archaeology – at least in praxis – has been increasing the dimensionality of context. Initially two dimensional to the culture historians in the mid-twentieth century – an object in space and time – context was relatively easy to represent with two

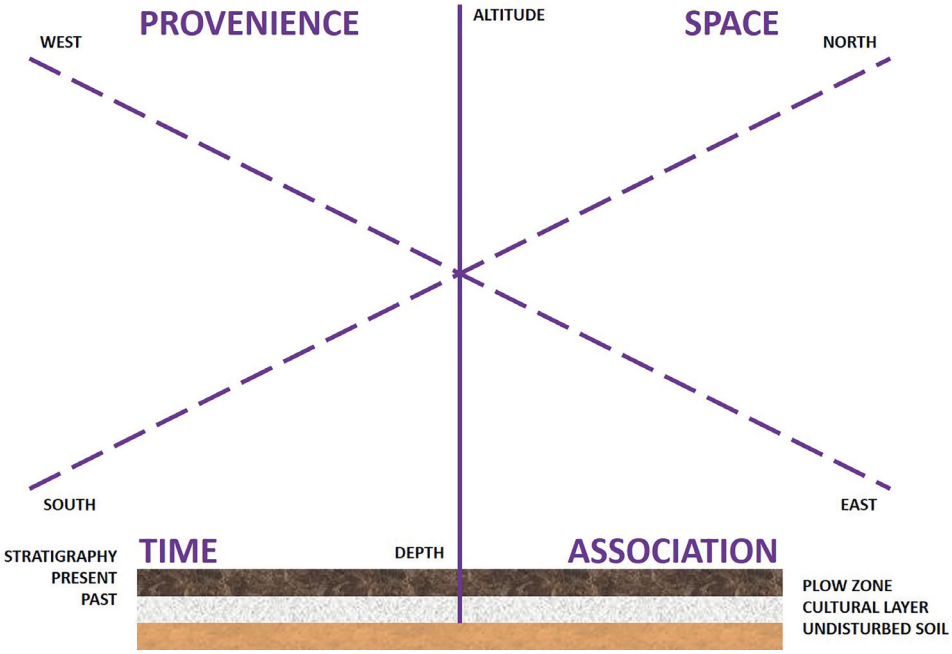


**Figure 2.** The seven dimensions of archaeological description.

dimensional models such as diagrams and maps. The end of the twentieth century was marked by models of the three dimensions of human visual perception – verticality, horizontality, and depth – often for public display. The twenty-first century brought innovative models, such as the space-time cube extension, which is a three-dimensional structure that may have analytical potential (Huisman et al. 2009; Kveladze, Kraak & Van Elzakker 2015). Lyman's (2012) definition of archaeological context as the three dimensions of provenience – longitude, latitude and depth (as a proxy for time) – plus association includes four dimensions of context. Butzer's (1978; 1980; 1982) "refined contextual paradigm" maps onto a four-dimensional tesseract and De Roo and associates (De Roo et al. 2013; De Roo et al. 2014; De Roo 2016) have been developing a methodology for a four-dimensional GIS that displays three dimensions of space plus time. Green (2011: 69) discussed thinking of fuzziness as a fifth dimension of a temporal GIS or tGIS. Considered together, these theories demonstrate that there are more than five dimensions in archaeology; thus, context is multidimensional.

The foundational epistemological stance of archaeology is that something can be known through studying the material traces of the past. This does *not* say that something can be known *about* the past through archaeological research. While it is true that archaeology produces knowledge about the past, it also produces knowledge of the present and sometimes of the potential future, which all impact interpretation. Time, alone then, is three dimensional in archaeology. Thus, time and the four dimensions of archaeological context (depth being factually independent of time due to taphonomy) account for seven dimensions of context, which are illustrated in Figure 2, before moving beyond the merely descriptive. The temporal dimensions of past and present overlap the archaeological context at depth, stratigraphy, and association. Context as archaeological theory organizes this multidimensionality and is ontologically based in the site, subsite, feature(s), assemblage(s), artefact(s), and the detail(s) of the artefact – literally, "context is everything in archaeology" (Conard et al. 2008: 236).

Context in archaeology differs from other fields that view context as being the surroundings of an object that are examined to understand the object, the *exclusive* perspective. Archaeology takes the *inclusive* perspective that there is a bidirectional, interactive relationship between objects and their surroundings (i.e., both are relevant), and it is as necessary to examine the object to understand the surroundings as it is to examine the surroundings to understand the object (Hodder 2012). Archaeology takes into consideration multiple dimensions of context, including: the research context (the conditions under which research is conducted), the archaeological context, the geographical context (past or present political designations), the ecological or environ-

mental context, the social context, the taphonomic context, the curation context, the hermeneutical or interpretive context, and the "institutional context" defined as: "the provenienced archaeological site or subsite where a specific type of operation occurred in the past that is identified by associated features and artefact assemblages" (James 2015; James 2016). These are the spaces and places that for all of their variability in appearance from site to site, are archaeologically recognizable as institutions and are often denoted in the literature as "ritual contexts," "domestic contexts," "production contexts," and so on. And as Turner (1997) informed us, *Homo sapiens* have a long history of creating institutions. Each layer of these contexts is embedded and overlapping in multiple scales, constituting the dimensionality of archaeological research. The dimensionality of context forms the interwoven texture of the tapestry we call the archaeological record, which is written through the contributions of every archaeologist working ideographically and nomothetically on their particular thread over the last hundred or so years under a variety of theories and methodologies, providing the complementary and contrasting colours, thin and thick descriptions, and overlapping conceptions of what it has been, is, and could be to be human (James 2010b; Ponterotto 2006).

## Tense Theoretical Continuums

Both processual and postprocessual archaeology are valid epistemologies and there is nothing in either that precludes the use of the other and using both may be more productive than either alone. The same can be said of modern versus postmodern, objective versus subjective, anthropology versus history and all other debates that compare the two endpoints of a theoretical continuum. Additional tension is exerted on theoretical continuums by scale (e.g., artefact, assemblage, site), and the general versus the particular (Hodder 1992: 4). Tense theoretical continuums create boundaries that empower knowledge creation and knowledge emerges from the tension. The many theories that exist between the tense endpoints are modulated, are pushed and pulled, by tensity shifts between the extremities. The theoretical structure, the frame, is strengthened through the research process and the tapestry of knowledge emerges, is created, and incorporated into what it is to be human. Context is that theoretical structure, and it explains why context is everything in archaeology. Just as a tapestry requires the warp threads to remain tied tautly to the frame during the weaving so the emerging representation is not distorted, the threads of every archaeological research project are kept taut by the frame of context so that our representation of what has been in the past, is now, and perhaps will be in the future to be human remains clear.

## Theorizing Geographic Information Systems for Archaeology

It is generally believed that archaeology does not write theory, but only transforms theory imported from other fields (Lyman 2007). Most archaeologists have focused on middle range theory or the development of methodology (e.g., Binford 1977: 1-10; Merton 1949: 39-53). It is no surprise then that Wheatley (1993; Wheatley 2000) and Lock (2003: 1-12), looking to archaeologically theorize geographic information systems (GIS), found little archaeological theory and lots of functional methodologies (Lock 2001). One reason is that many methodologies can operationalize a single theory. Another factor is the call from big data science for data-driven in opposition to theory-driven research, though this is a tense theoretical continuum, paralleling Wheatley's finding that GIS is often thought to be a theory-neutral methodology, though there is no such thing (Kitchin 2014; Wheatley 1993: 133-135). Generally speaking, GIS is theorized by an array of cartographic and design theories as well as theories from mathematics and computer science. and it is hoped that the previous discussion about context will theoretically connect archaeologists creating and/or using GIS in their research to other archaeologists because all of archaeology is connected through context and the many dimensions of context.

GIS is particularly well-suited to restore and maintain context. GIS layering and sequencing as well as recent advances in three-dimensional voxel mapping enable modelling and analysis of the multidimensionality of context (Noon 2012). As scientists, we want things to be perfectly functional and there are various individuals and groups working towards a true temporal GIS. But as archaeologists,

we are used to dealing with uncertainty and can make do with what we have available, though a full discussion of this is beyond the scope of this essay. GIS enables multiple layers of data to be visualized separately and together. Layers can be named and features labelled to display the various contexts in different time periods. Artefacts can be displayed within features and features within sites. Hyperlinks can attach documents such as field notes and publications, photographs, videos, drawings, two and three-dimensional reconstructions, vertical perspectives, and other unique archaeological data to a map that is temporally based on the excavation along with a layer or multiple layers that are based on known landscape differences, such as changed waterways and coasts – even when those documents are maintained outside of the geodatabase. By changing scale, we can visualize regional social relationships – the trading, alliances, and antagonisms of human life in the past. These are just a few examples of the possibilities for GIS in archaeology. The ability to connect different types of data, however imperfectly, also applies to detached research. To describe it mathematically:

$$R_d = -C + -c$$

where Rd is research that has become detached, C is unqualified context, and c is qualified context. Restoring and maintaining connection to archaeological data and analyses is vital because it is the context that archaeology relies on to inform future research.

## Closing Remarks

A multidimensional perspective of context as theory crosscuts themes and archaeological settings to unify what only appears to be the fractured character of computer applications and quantitative methods in archaeology. The digital preservation of archaeological data, including GIS data, is already moving towards national-level unification, exemplified by the Digital Archaeological Record (tDAR) in the United States and the Archaeology Data Service (ADS) in the United Kingdom. There are still many different tasks to be accomplished to build a globally linked geodatabase, to provide the capabilities to visualize archaeology, and to secure the data while providing appropriate access to archaeologists. The different types of projects that are being done by CAA members are needed if we are to move beyond description into analysis and knowledge creation. Context is the theory that unifies all archaeology – from the excavation to the documentation through visualization and analysis to research dissemination, publication, and public engagement. No one archaeologist can do it all, no one lifetime is sufficient, but through time and continued research, the past, present, and future will be globally accessible. New vistas of research possibilities will open. Every archaeologist contributes to the tapestry, whether with a long or short, thin or thick, flat or braided thread. Every archaeological project brings the weaving into clarity or highlights an area where clarity is needed. It is context that frames the tapestry, holding all of the archaeological threads taut as each generation of archaeologists weaves their data and interpretations into the archaeological record. All archaeological research is connected through time and space by context as theory.

## Acknowledgements

There is an emergent magic to the coming together of ideas and thanks are owed to Merlin James for believing that my ideas have value and inspiring me to pursue them. My appreciation is also given to the two anonymous reviewers whose insightful comments on an earlier version of this paper helped me to express my ideas more clearly as well as to Jeffrey Glover for his work in bringing the paper to publication. Additional thanks are owed to Dennis Zeller and Helaine Hornsby for making it possible for me to attend the CAA Conference in Atlanta to present this paper. The coming together of these people from around the world to form the social context of this work in progress is reflected in the idea that there are no silos, only opportunities awaiting action and connections waiting to be linked together in the production of knowledge.

## References

**Binford, L R 1962** Archaeology as Anthropology. *American Antiquity* 28(2): 217-225.

**Binford, L R 1977** *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, and Systemic Modeling.* New York: Academic Press.

**Binford, L R 1981** Bones: Ancient Men and Modern Myths. San Diego, California: Academic Press, Inc. Bokova, I 2015 Culture on the Front Line of New Wars. Brown *Journal of World Affairs* 22(1): 289-296.

**Bowers T D 2011** Towards a Framework for Multiparadigm Multimethodologies. *Systems Research and Behavioral Science*. DOI: 10.1002/sres.1120

**Bowers, T D 2012** Towards a Framework for Multiparadigm Multimethodologies in Systems Thinking and Practice. Unpublished thesis (PhD), California State Polytechnic University, Pomona.

**Bowers, T D 2014** Developments in Critical Systems Theory: On Paradigms and Incommensurability. *Proceedings of the 58th Meeting of the International Society for the Systems Sciences, Washington DC July 27-August 1, 2014*

**Burke, P 2002** Context in context. *Common knowledge* 8.1:152-177. DOI: 10.1215/0961754X-8-1-152

**Butzer, K W 1978** Toward an Integrated, Contextual Approach in Archaeology: A Personal View. *Journal of Archaeological Science* 5: 191-193. DOI: 10.1016/0305-4403(78)90039-0

**Butzer, K W 1980** Context in Archaeology: An Alternative Perspective. *Journal of Field Archaeology* 7(4): 417-422. DOI: 10.2307/529520

**Butzer, K W 1982** *Archaeology as Human Ecology: Method and Theory for a Contextual Approach*. Cambridge: Cambridge University Press.

**Chouquer, G 2013** Les "Nouveaux" Collecteurs Hypertrophiés: L'Exemple de l'Environement. In *Quels Scénarios pour l'Histoire du Paysage?: Orientations de Recherche pour l'Archéogéographie*, pp. 155-164. Coimbra, Portugal: Imprensa da Universidade de Coimbra.

**Conard, N J, Walker, S J, and Kandel, A W 2008** How Heating and Cooling and Wetting and Drying Can Destroy Dense Faunal Elements and Lead to Differential Preservation. *Palaeogeography, Palaeoclimatology, Palaeoecology* 266(3-4):236-245. DOI: 10.1016/j.palaeo.2008.03.036.

**Cremeens, D L and Hart, J P 1995** On Chronostratigraphy, Pedostratigraphy, and Archaeological Context. In M E Collins, B J Carter, B G Gladfelter and R J Southard (eds.) *Pedological Perspectives in Archaeological Research*, Special Publication 44. Madison, WI: Soil Science Society of America, pp. 15-33.

**De Roo, B 2016** Putting the Past in Place: A Conceptual Data Model for a 4D Archaeological GIS. Unpublished thesis (Ph.D), Universiteit Gent, Ghent.

**De Roo, B, De Maeyer, P and Bourgeois, J 2013** On the Way to a 4D Archaeological GIS: State of the Art, Future Directions and Need for Standardization. In A C Addison, G Guidi, L De Luca and S Pescarin (eds.) *Proceedings of the 2013 Digital Heritage International Congress, October 28-November 1, Marseille, France*, Volume 2, Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc., pp. 617-620.

**De Roo, B, Ooms, K, Bourgeois, J and De Maeyer, P 2014** Bridging Archaeology and GIS: Influencing Factors for a 4D Archaeological GIS. In M Ioannides, N Magnenat-Thalmann, E Fink, R Žarnic, Yen A and Quak E *Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection*, Switzerland: Springer International Publishing, pp. 186-195.

**DiMaggio P 1995** Comments on "What Theory is Not". *Administrative Science Quarterly* 40:391-397.

**Erlandson, J M 2012** As the World Warms: Rising Seas, Coastal Archaeology, and the Erosion of Maritime History. *Journal of Coastal Conservation* 16(2): 137–142. DOI: 10.1007/s11852-010-0104-5

**Fairclough, R and Thelwall, M 2015** National Research Impact Indicators from Mendeley Readers. *Journal of Informetrics* 9(4): 845–859. DOI: 10.1016/j.joi.2015.08.003.

**Gerstenblith, P 2016** The Destruction of Cultural Heritage: A Crime Against Property or a Crime Against People? *The John Marshall Review of Intellectual Property Law* 15(3): 1.

**Goodrum, M R 2009** The Creation of Societies for the Study of Prehistory and Their Role in the Formation of Prehistoric Archaeology as a Discipline, 1867–1929. *Bulletin of the History of Archaeology* 19(2): 27. DOI: 10.5334/bha.19204

**Green, C T 2011** *Winding Dali's Clock: The Construction of a Fuzzy Temporal-GIS for Archaeology*. Oxford: British Archaeological Reports.

**Harris, E C. 1979** The Laws of Archaeological Stratigraphy. *World Archaeology* 11(1): 111-117.

**Harris, E C 1989** *Principles of Archaeological Stratigraphy*, 2nd edn. London, England: Academic Press.

**Harris, E C, Brown, M R, and Brown G J 1993** *Practices of Archaeological Stratigraphy*. London, England: Academic Press.

**Hodder, I 1986** *Reading the Past: Current Approaches to Interpretation in Archaeology*. Cambridge: Cambridge University Press.

**Hodder, I 1992** *Theory and Practice in Archaeology*. London and New York: Routledge.

**Hodder, I 2008** Multiple Teams at Çatalhöyük. The SAA *Archaeological Record* 8(3): 6–10.

**Hodder, I 2012** *Entangled: An Archaeology of the Relationships between Humans and Things*. Chichester, West Sussex: Wiley-Blackwell.

**Huang, M and Chang, Y 2008** Characteristics of Research Output in Social Sciences and Humanities: From a Research Evaluation Perspective. *Journal of the American Society for Information Science and Technology* 59(11): 1819–1828. DOI: 10.1002/asi.20885

**Huisman, O, Santiago, I F, Kraak, M and Retsios, B 2009** Developing a Geovisual Analytics Environment for Investigating Archaeological Events: Extending the Space-Time Cube. *Cartography and Geographic Information Science* 36(3): 225-236. DOI: 10.1559/152304009788988297

**Huxley, J 2010** [1942] *Evolution: The Modern Synthesis*. Cambridge, Massachusetts and London, England: The MIT Press.

**Ingold, T 1993** The Temporality of the Landscape. *World Archaeology* 25(2): 152-174.

**James, V S 2010a** Connecting the Dots: Interdisciplinary Program Design for Undergraduate Anthropology Students. 18-21 February 2010. Savannah, Georgia: Southern Anthropological Society.

**James, V S 2010b** Science to Narrative: Using GIS to Construct Narratives of Prehistoric and Modern Lifeways. 18-21 February 2010. Savannah, Georgia: Southern Anthropological Society.

**James, V S 2015** Operational Context: Stating the Obvious (And the Not So Obvious). University at Albany Anthropology Graduate Student Organization Student Symposium, Albany, N Y, 24 April 2015.

**James, V S 2016** Archaeological Epistemology and Praxis: Multidimensional Context. 81st Annual Meeting of the Society for American Archaeology, Orlando, FL 6-10 April 2016.

**Keller, F 1854** Die Keltischen Pfahlbauten in den Schweizerseen. *Mitteilungen der Antiquarischen Gesellschaft in Zürich* 9(3): 65–100.

**Keller, F 1866** Pfahlbautensech: Sechster Bericht. *Mitteilungen der Antiquarischen Gesellschaft in Zürich* 15(7): 245–320.

**Kitchin, R 2014** Big Data, New Epistemologies and Paradigm Shifts. *Big Data and Society* 1(1): 1-12. DOI: 10.1177/2053951714528481

**Kveladze, I, Kraak, M J, and Van Elzakker, C P J M 2015** The Space-Time Cube as Part of a GeoVisual Analytics Environment to Support the Understanding of Movement Data. International *Journal of Geographical Information Science* 29(11):2001-2016. DOI: 10.1080/13658816.2015.1058386

**Lee, J E 1866** *The Lake Dwellings of Switzerland and Other Parts of Europe by Dr. Ferdinand Keller.* London: Longmans, Green, and Company.

**Lévi-Strauss, C 1964** *Totemism*. London: Merlin Press.

**Lobell, J A 2012** Investigating a Decades-Old Disappearance. *Archaeology* 65(4): 11–21.

**Lock, G 2001** Theorising the Practice or Practicing the Theory: Archaeology and GIS. *Archaeologia Polona* 39: 153-164.

**Lock, G 2003** *Using Computers in Archaeology*: Towards Virtual Pasts. London and New York: Routledge.

**Lyman, R L 2007** Archaeology's Quest for a Seat at the High Table of Anthropology. *Journal of Anthropological Archaeology* 26(2): 133-149. DOI: 10.1016/j.jaa.2006.11.003

**Lyman, R L 2012** A Historical Sketch on the Concepts of Archaeological Association, Context, and Provenience. *Journal of Archaeological Method and Theory* 19(2): 207-240. DOI: 10.1007/s10816-011-9107-2

**Marcus, J 1983** Lowland Maya Archaeology at the Crossroads. *American Antiquity* 48(03): 454–488. DOI: 10.2307/280556

**Mayr, E 1982** *The Growth of Biological Thought: Diversity, Evolution, and Inheritance*. Cambridge, Massachusetts and London, England: The Belknap Press of Harvard University Press.

**Menotti, F 2001** The Pfahlbauproblem and the History of Lake-Dwelling Research in the Alps. *Oxford Journal of Archaeology* 20(4): 319–328. DOI: 10.1111/1468-0092.00139

**Merton, R K 1949** *Social Theory and Social Structure*. New York: Simon and Schuster, The Free Press.

**Noon, C J 2012** A Volume Rendering Engine for Desktops, Laptops, Mobile Devices and Immersive Virtual

Reality Systems using GPU-Based Volume Raycasting. Unpublished thesis (PhD), Iowa State University, Ames.

**Parsons, T 1979-1980** On Theory and Metatheory. *Humboldt Journal of Social Relations* 7(1):5-16.

**Peebles, C S 1993** Aspects of a Cognitive Archaeology. *Cambridge Archaeological Journal* 3(2): 250-253.

**Phillips, P and Willey, G R 1953** Method and Theory in American Archeology: An Operational Basis for Culture-Historical Integration. *American Anthropologist* 55(5): 615-633. DOI: 10.1525/aa.1953.55.5.02a00030

**Pickering, A 1995** *The Mangle of Practice: Time, Agency, and Science*. Chicago and London: The University of Chicago Press.

**Ponterotto, J G 2006** Brief Note on the Origins, Evolution, and Meaning of the Qualitative Research Concept Thick Description. *The Qualitative Report* 11(3):538-549.

**Pouncett, J, Reilly, P and Stead, S 2016** Digital Archaeology - Where are we and how do we fit in?, 26 August 2016. Available at http://caaconference.org/program/sessions/#title17 [last accessed 18 June 2017].

**Proulx, B B 2013** Archaeological Site Looting in "Glocal" Perspective: Nature, Scope, and Frequency. American *Journal of Archaeology* 117(1): 111. DOI: 10.3764/aja.117.1.0111

**Renfrew A C 1990** Climate and Holocene Culture Change: Some Practical Problems. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences* 330(1615): 657-663.

**Renfrew C 1993** Trade Beyond the Material. In Healy, F and Scarre, C *Trade and Exchange in Prehistoric Europe*. Oxford: Oxbow Books, pp. 5-16.

**Renfrew C 1994** Towards a Cognitive Archaeology. In Renfrew C and Zubrow E B W, *The Ancient Mind: Elements of Cognitive Archaeology*. Cambridge: Cambridge University Press, pp. 3-12.

**Richards, C and Thomas, J 1984** Ritual activity and structured deposition in Later Neolithic Wessex. In R B and J Gardiner (eds.) *Neolithic Studies: A Review of Some Current Research*, Oxford: British Archaeological Reports, pp. 189-218.

**Ritchie, W A and Funk, R E 1973** *Aboriginal Settlement Patterns in the Northeast*. New York State Museum & Science Service. Memoir 20. Albany, NY: The University of the State of New York, The State Education Department.

**Saad El-Gendi, L 2012** Letting Farmers Be Farmers: Economic Solutions to Subsistence Looting. *Journal of Art, Technology and Intellectual Property Law* 23(1): 111–153.

**Schier, A 2011** Amick Explains Misdemeanor Mishap. Illinois *Antiquity* 46(2): 7.

**Schiffer, M B 1972** Archaeological Context and Systemic Context. *American Antiquity* 37(2): 156-165. DOI: 10.2307/278203

**Smith, C, Garvey, J, Burke, H and Sanz, I D 2015** Success Strategies for a Career in Archaeology. *Archaeologies* 11(2): 300–336. DOI: 10.1007/s11759-015-9273-z

**Snow, D R 1995** *Mohawk Valley Archaeology: The Collections*. 1st ed. 1 vols. Matson Museum of Anthropology Occasional Papers in Anthropology 22. University Park, PA: The Pennsylvania State University.

**Stein, J K 2000** Stratigraphy and Archaeological Dating. In S E Nash (ed.) *Its About Time: A History of Archaeological Dating in North America*, Salt Lake City: University of Utah Press, pp. 14-40.

**Stein, J K 2008** Exploring the historical foundations and interpretive potential of provenience. In A P Sullivan III (ed.) *Archaeological Concepts for the Study of the Cultural Past*, Salt Lake City: University of Utah Press, pp. 108–124.

**Stenonis, N 1699** *De Solido intra Solidvm Natvraliter Contento: Dissertationis Prodromvs ad Serenissimvm. Florentiae*: Sub Signo Stellae. (Concerning a Solid Body Enclosed by Process of Nature Within a Solid: Dissertation Essay to [on the] Extraordinary. Florence: Under the Sign of the Stars.)

**Sutton, R I and Staw B M 1995** What Theory is Not. Administrative *Science Quarterly* 40(3):371-384.

**Taylor, W 1948** *A Study of Archaeology. Memoirs No. 69*. Washington, DC: American Anthropological Association.

**Thelwall, M and Maflahi, N 2015** Are Scholarly Articles Disproportionately Read in Their Own Country? An Analysis of Mendeley Readers. *Journal of the Association for Information Science and Technology* 66(6): 1124–1135. DOI: 10.1002/asi.23252

**Turner, J H 1997** T*he Institutional Order: Economy, Kinship, Religion, Polity, Law, and Education in Evolutionary and Comparative Perspective*. New York: Longman.

**Wheatley, D 199**3 Going Over Old Ground: GIS, Archaeological Theory and the Act of Perception. In J Andresen, T Madsen and I Scollar (eds.) *Computing the Past: Proceedings of the 1992 Computer Appli-*

*cations and Quantitative Methods in Archaeology Conference*, Aarhus: Aarhus University Press, pp. 133-138.

**Wheatley, D 2000** Spatial Technology and Archaeological Theory Revisited. In K Lockyear, T J T Sly and V Mihăilescu-Bîrliba (eds.) *Computer Applications and Quantitative Methods in Archaeology* 1996, British Archaeological Reports International Series 845, Oxford: Archaeopress, pp. 123-132.

**Worsaae, J J A 1843** *Oldtid Oplyst ved Oldsager og Gravhöie*. Kjöbenhavn: Selskabet for Trykkefrihedens. (Prehistoric Informed by Antiquities and Barrows. Copenhagen: Company for Press Freedom.)