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Big Archaeology: Horizons and Blindspots

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ABSTRACT
Big data have arrived in archaeology, in the form of both large-scale datasets themselves and in the analytics and approaches of data science. Aerial data collected from satellite-, airborne- and UAV-mounted sensors have been particularly transformational, allowing us to capture more sites and features, over larger areas, at greater resolution, and in formerly inaccessible landscapes. However, these new means of collecting, processing, and visualizing datasets also present fresh challenges for archaeologists. What kinds of questions are these methods suited to answer, and where do they fall short? How do they articulate with the work of collecting smaller scale and lower resolution data? How are our relationships with "local" communities impacted by working at the scales of entire provinces, nation-states, and continents? This themed issue seeks to foster a conversation about how the unprecedented expansion of archaeological site detection, the globalization of archaeological data structures and databases, and the use of high-resolution aerial datasets are changing both the way archaeologists envision the past and the way we work in the present. In our introduction to the issue, presented here, we outline a series of conceptual and ethical issues posed by big data approaches in archaeology and provide an overview of how the nine essays that comprise this volume each address them.

KEYWORDS
Big data; digital archaeology; remote sensing; lidar; drones/UAVs; vision; archaeological theory; archaeological ethics

Introduction

It is hard to imagine a more enthusiastic description of an archaeological methodology than Paul Kosok's summary of aerial photography in the fifth chapter of his posthumously published *Life, Land and Water in Ancient Peru* (1965). "Aerial Photography!" he proclaims. "This new technique has become a wonderful tool in reconstructing the past"—one that "makes it possible to obtain, almost at a glance, a comprehensive and dramatic picture of the archaeological remains of a valley as a whole!" (Kosok 1965, 39). For Kosok, like so many other observers of aerial photographs of archaeological sites since the 1910's, the technique was also analytically useful, allowing him to recognize trends that were obscure on the ground, laying bare "the geographic pattern within which mankind [sic.] on the [Peruvian] Coast had evolved." And it was *fun*, to boot: " … the work was exciting! A real treasure hunt!"

Kosok's excitement surely reflects what art historian Joseph Corn (2002) calls the "airmindedness" of mid 20th century America—a belief in the "potential of airplanes to better human life" that arose in the "technological utopianism of the 1920's and 1930's" and was particularly prominent in the United States at midcentury (Corn 2002; Haffner 2013, 14). But his faith in aerial vision was certainly not something that all of his contemporaries shared. Social critics—and particularly continental philosophers—were deeply sceptical of views from above, if not also the perceptual qualities of sight in general (Jay 1993). For Michel De Certeau, the aerial view of the city was almost impossibly separated from urban reality, producing "a fiction that creates readers, makes the complexity of the city readable, and immobilizes its opaque mobility into a transparent text" (1984, 92). The observer who assumed the aerial view—the planner, the urbanist, the cartographer—became a kind of "voyeur-god" whose knowledge elided the daily practices occurring "down below" within urban landscapes (1984, 93).

For Henri Lefebvre, aerial vision wasn't simply epistemologically problematic; it was also pernicious. Aerial photography allowed the state to "colonize" everyday life, producing "homogenous, optico-geometrical, quantifiable, quantified and thus abstract space" (Lefebvre 2003, 94; in Haffner 2013, 113–114). And indeed, most systematic aerial photographic campaigns in the 20th century were sponsored by state institutions. The collections that Kosok studied at the Peruvian Servicio Aerofotográfico Nacional, for example, were collected by the Peruvian Airforce and Peruvian Instituto Geográfico Nacional in their efforts to systematically map national territory and accurately estimate the sizes of private landholdings in order to assess their tax obligations (Kosok 1965, 39). These efforts were supported by the United States Airforce and, later, the US Defense Mapping Agency (DMA), at a time when the US government maintained strategic interests in Peru.

Today, satellite-, airborne-, and UAV-mounted sensors have radically expanded the diversity, geographic scope, and temporal and spectral resolution of aerial imagery. But archaeologists remain alternately bullish on, and critical of, aerial vision. Scholars have employed satellite imagery to enhance the visibility of architecture and site boundaries (Garrison et al. 2008; Lasaponara et al. 2011; Masini et al. 2008; Parcak 2007; Saturno et al. 2006; Sever and Irwin 2003), document site destruction (Bewley et al. 2016; Casana and Laugier 2017; Casana and Panahipour 2014; Contreras and Brodie 2010; Fradley and Sheldrick 2017; Parcak 2007; Parcak et al. 2016), and map previously undocumented landscapes in extensive areas using both expert-led and

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automated classifications (Casana 2014; Menze and Ur 2012; Ur 2013a, 2013b). Airborne lidar has revealed vast areas of archaeological sites and features and generated particularly stunning results in forested landscapes (Chase et al. 2012, 2011; Evans et al. 2013; Fisher et al. 2017; Fisher and Leisz 2013; Golden et al. 2016; Henry, Shields, and Kidder 2019; Johnson and Ouimet 2014; Opitz et al. 2015). Indeed, Chase and colleagues (2012, 12916) argue that airborne lidar is sparking a paradigm shift in archaeological interpretation, particularly in lowland Mesoamerica, where it is operating as a "a catalytic enabler of rapid transformational change in archaeological research and interpretation."

Other scholars are more uneasy with how these new forms of aerial data are being employed in archaeological research. For some, views from above are fundamentally counterproductive for understanding the embodied ways in which places are experienced (Brück 2005; Oliveira Jorge and Thomas 2008; Wickstead 2009). Other observers within the field and beyond have worried that our use of these tools implicates archaeologists in the rhizomatic extension of military (particularly, US Military) surveillance across the globe (Hamilakis 2014; Parks and Kaplan 2018; Pollock and Bernbeck 2018). And further critiques have highlighted problematic aspects of how aerial research is covered in the popular press, which has repeatedly characterized sites mapped from above as "lost" cities "discovered" by archaeologists from the global North, erasing histories of local (particularly, indigenous) engagements with them (Carter 2013; Fernandez-Diaz et al. 2018; Joyce 2012, 2015).

As De Certeau and Lefebvre's words remind us, these concerns about the epistemology and politics of aerial vision are hardly new, but the scale and saturation of data collected through new aerial platforms present novel potentials and challenges (Bevan 2015). Aerial data are becoming "big"—a term that we suggest might be reconceptualized as less a reference to a fixed scale or dimension of data and more as a series of ways of working with and thinking about them. At the same time that aerial data are being collected over larger areas and at greater resolutions, data repositories are also curating ever larger archaeological datasets in the hopes that regional, national, and/or global coverage can provide both new avenues for research and better protections for archaeological heritage.

Defining Big Data

But what, exactly, makes data "big?" Coined in the 1970's to refer to datasets that were too weighty to process with existing computing resources, the term big data lacks any fixed scalar or dimensional definition. Gattiglia (2015), citing the Gartner IT Glossary (2018), suggests that the scale implicit in the term can be measured in several dimensions—volume, velocity, and variety. Kitchin (2014) identifies several other additional characteristics—exhaustiveness, fine-grained resolution, indexicality, relationality, flexibility, extensionality, and scalability. Where big datasets include geocoded information inferred from IP addresses and/or collected from GPS antennae on mobile devices, their scale can also be measured in geographic terms. Mayer-Schönberger and Cukier (2013, 6) move towards a more instrumental definition—that big data "refer to things that can be done at a large scale that cannot be done at a smaller one" and allow analysts to "extract new insights or create new forms of value, in ways that change markets, organizations and the relationship between citizens and governments, and more." Yet the thresholds defining the difference between big and "small" data are generally unclear.

For some observers, the lack of scalar clarity in the term big data suggests that the term describes old problems dressed up to look new. After all, governments have been collecting massive amounts of census information for hundreds of years, and processing it has always been a challenge. Archaeologists have been working with flexible, extensible, scalable, high-resolution data for most of the history of our discipline (Howey et al. this volume; Huggett this volume). So perhaps archaeological data have "always, already" been big (Mattern 2017).

But like so many moments of repackaging, the term big data also points to a more slippery discursive transformation—a reorientation in what we imagine data (and science) to be. In place of "the obsession for causality," prophets of the data deluge tell us that we can now be content with "simple correlations: not knowing *why* but only *what*" (Mayer-Schönberger and Cukier 2013, 7; emphasis in original). In an oft-quoted editorial from 2008, *Wired* magazine editor Chris Anderson provocatively suggested that "Petabytes allow us to say: 'Correlation is enough.' … We can analyze the data without hypotheses … . [and] throw the numbers into the biggest computing clusters the world has ever seen and let statistical algorithms find patterns were science cannot" (Anderson 2008, 17). Jeremy Huggett (this volume) cites Anderson and associates his attitude with an emerging quasi-religious faith in data among both technocrats and consumers that Brooks (2013) and Lohr (2015) call "data-ism."

The big data phenomenon is as much this *feeling* as any particular quantity of coded information. But its affects are produced through very specific practices of collection, aggregation, and analysis. Especially in commercial arenas, big datasets tend to be collected not through systematic survey, like the state-funded cadastral maps and census of the early modern and industrial ages, but through more distributed means—by users of various devices linked to the internet. During both data collection and analysis, big data science de-emphasizes sampling in the name of studying complete datasets (and, ostensibly, systems). And due to the difficulty of scaling conventional analysis, big data analysis is often carried out using machine learning algorithms, which themselves frequently incorporate training data provided through "crowd-sourced" feature identification by non-specialists.

Most of the datasets examined in this themed issue vary in meaningful ways from the kinds of big data that are the focus of commercial data mining operations and even other research domains, such as genomics. Many were collected through more concentrated means than the distributed protocols of social media platforms, and they are generally of sizes that pale in comparison to some datasets being crunched by data analytics firms and colleagues in the natural sciences. Indeed, some readers may scoff at the notion that any of the data sets examined herein are truly big enough to merit consideration as such, at a time when the International Data Corporation estimates that the global datasphere includes at least 33 Zettabytes (33 Trillion Gigabytes) of data (Reinsel, Gantz, and Rydning 2018). But our goal in this collection is not to attach the label "big" to scalar criteria; rather, it is to attend to the ways in which increasingly larger and higher resolution datasets are changing how archaeologists work in the present and how we think about the past. In our view, even the relatively modest scale of new digital datasets presents novel potentials and challenges for the field.

Big Aerial Archaeology

Most of the authors in this collection focus their analysis on a particular category of big data—geographically extensive and/or high-resolution imagery collected from aerial-, satellite-, or drone-based platforms. We call this "big aerial data" and the emerging subfield concerned with it "big aerial archaeology." Big aerial data possess qualities shared by big data collected through more distributed means, in that they promise the possibility of grasping patterns that are difficult or impossible to recognize at smaller geographic scales and/or at lower levels of resolution. Moreover, like big data culled from online sources, they are often collected not by archaeologists themselves but by third parties with their own agendas.

Big aerial imagery also has characteristics that are particular to it, including spatial continuity. When it is collected using standardized parameters, big aerial data may enable much more systematic comparison and continuous observation than is possible with archaeological data collated from individual survey and excavation projects and stored in common repositories—even when these projects employ common data schema and vocabularies. In turn, the continuity of big aerial data facilitates analyses that transcend sites and regions, even blurring the boundaries of what is considered "on" and "off" site and what is within the bounds of designated study areas (McCoy 2017; see also McCoy this volume; Howey et al. this volume).

Alongside its potentials, big aerial data poses unique challenges for archaeological research. As Kurgan (2013) argues, high resolution satellite imagery produces a strange kind of intimacy between viewer and object: it renders the surface of the earth in sub-meter resolution, providing a sense of closeness, but the views that it produces are taken from detached locations hovering above the earth. Without additional information about context, and a grounded appreciation of where one is looking *from*, this sensation of closeness can morph into voyeurism. The detached orthographic gaze engendered by satellite imagery is often called the "view from nowhere" (Nagel 1989), but this label obscures the fact that it is always produced from a series of very specific somewheres (Cosgrove 2001; Haraway 2002; Kwan 2007; Parks 2005). As Bill Rankin notes, these places have historically been "the libraries, war rooms, and corporate offices of the Euro-American sphere" (Rankin 2016, 47); and as Lisa Parks (2005, 2) reminds us, satellite vision continues to be employed in "ways that support the cultural and economic hegemony of the post-industrial West."

These issues raise important (and sometimes uncomfortable) questions for archaeologists. Is the information that we extract from satellite images, lidar datasets, and other remotely sensed data an unmitigated public good that should be open sourced? Or do some elements of it need to be either concealed or shared selectively with certain stakeholders and publics? Indeed, should archaeologists be the only people making these decisions in the first place? While previous scholars have warned that publishing data on site locations may unwittingly facilitate their destruction (Chase et al. 2016; Fernandez-Diaz et al. 2018; Parcak 2007), we have given little consideration to the perhaps even more difficult question of whether property rights to imagery should be mediated by laws that govern the people, places, and things that appear in them. Or, to put a new spin on a question that haunts modernist archaeology, who owns these images of "the past," if not also the data that we extract from them?

For example, when one of us (VanValkenburgh) recently spoke to a landowner in Peru to ask for permission to fly a drone over his property, the landowner openly speculated that the archaeologist was going to sell the video to a production company abroad and make money off of it. His gambit recalled the common perception (and indeed, if we consider the history of our discipline, the experience) that archaeologists who work in out-of-the-way-places must be searching for gold or other precious items for personal profit. And while the landowner was wrong about where the video was going to end up, his implicit question —"what's my cut?" —was a reasonable one. As people working with big aerial data, how is it that we ensure that there *is* such a cut, even if it isn't measured in dollars and cents? Should aerial images of archaeological sites ever be understood as themselves forms of intangible property? How do we act on these issues when the data we use aren't just drone photographs but satellite images that capture vast expanses of nation-states and continents? And are these questions also relevant for site gazetteers or regional databases that compile information drawn from these images?

Perhaps no current project better illustrates the potentials and challenges of big aerial archaeology than GlobalXplorer°. Sparked by archaeologist Sarah Parcak's (2019, 220) "wish for us to discover the millions of unknown archaeological sites across the globe" and subsequently funded through a TED Prize, GlobalXplorer° launched in 2017 with the ambitious goal of "map[ping] the entire world using remote sensing and the eyes of citizen scientists in just 10 years" (https://medium.com/@globalxplorer/welcome-to-globalxplorer-7bfb555260a1). The project began its work with the more pointed objective of identifying archaeological sites for the purpose of conservation—a goal shared with several additional large scale "virtual survey" initiatives, including the Endangered Archaeology in the Middle East and North Africa (EAMENA) project and TerraWatchers (Bewley et al. 2016; Savage, Johnson, and Levy 2017).

What distinguishes GlobalXplorer° from these other efforts is the sheer scale of its program of public engagement, which has built a community of tens of thousands of users who have been invited to participate in a collective project of discovery. User experience has been designed to resemble a game, with a series of ten levels through which users progress and (in the case of its first mission in Peru) sequentially unlock "content about Peru's archaeology and history." Explorers are rewarded with "Google Hangouts, Facebook Live sessions and personal messages" from the project team (Parcak 2019, 222–223). After going through a short online orientation to learn how to identify evidence of looting, users are provided with individual tiles of high-resolution imagery and asked to indicate whether they could identify evidence of looting. After each user has scanned 1000 tiles, they move on to the next level, in which they learn how to recognize "illegal construction" or "encroachment" on archaeological sites—and are once again asked to find evidence of such activity where they see it. Finally, users move up to a third level, in which they are tasked with identifying archaeological sites. Since the project's inauguration in

2017, GlobalXplorer°'s community has examined more than 15 million tiles, covering a total of over 100,000 square kilometres (Parcak 2019, 223–224). The development and analysis team has subsequently aggregated inputs to identify locations where a significant number of distinct users have identified looting, encroachment and/or archaeological features.

GlobalXplorer° has succeeded in employing a collaborative platform to build a community that extends beyond the ivory tower and has gotten a great number of people excited about archaeology, on an archaeologist's terms, at a time (at least in the United States) when the lion's share of public engagement with the field is mediated by *Ancient Aliens* and its ilk. And while the discovery of previously undocumented sites is one of the long-term goals of the project, it has the stated aim of not just capturing user-inputted data for analyses conducted behind a curtain and published in rarefied journals, but also mobilizing data for site conservation.

However, the extent to which GlobalXplorer° is meeting these goals is so far unclear. As Jesse Casana discusses in his contribution to this issue, site location data generated through large-scale crowd-sourcing faces a number of practical challenges, including the fact that it tends to produce very high numbers of false positives. While this can lead to inefficiencies, it is not in and of itself a problem, because crowd-sourcing can be framed as merely a first step in feature identification, to be filtered and refined in later stages. But in some cases, the ratio of false positives to hits may be so great that making any practical use of crowd-sourced data is nearly impossible. As an example, Casana (this volume) points to the Ghengis Khan Tomb Project, whose users identified 2.3 million potential sites of interest, of which only 53 were identified as actual sites. As Mark McCoy suggests in his paper in this issue, projects that tack back and forth between remote sensing-based and field-based observations are perhaps better positioned to understand what imagery is showing them, as well as how to respect property rights and stakeholdership on the ground.

Another critical point of discussion is the way in which GlobalXplorer° frames heritage and data sovereignty. The project's front page presents a view of heritage in essentially global terms, appealing to a seemingly universal we: "Our human story is being lost … Using satellite imagery, we can fight the loss of our cultural heritage" (GlobalXplorer° n.d.) In recent presentations, the project director has shown a willingness to reconceptualize this framing, but collaborations with local institutions (at least in the case of Peru) seem to remain somewhat secondary to its global focus. The practical effects of the global framing and execution of the project has been to widen the divide between GlobalXplorer°'s community of users and "local" stakeholders, including national institutions who are charged with stewarding their country's patrimony (see also Mickel, this issue; Kersel and Hill, this issue). This divide between global and local takes on new stakes when users in places like the Netherlands and the United States are not simply identifying sites, but are asked—as is the case when they are tasked with tagging encroachment and "illegal" construction—to carry out surveillance on the activities of Peruvian citizens and decide whether they are abiding by their own laws.

GlobalXplorer° therefore provides a number of points of guidance for big aerial archaeology. It illustrates the potential of crowd-sourcing and citizen science to bring people together to pursue common goals at a scale that would be impossible to do through archaeological fieldwork. But it is still unclear how useful the data created through these means will be for identifying meaningful patterns (and implementing meaningful change) on the ground (Casana 2014; see also Casana, this issue). Furthermore, it demonstrates potential downsides to pursuing projects, particularly those carried out in the global South, through a strictly global framework, rather than grounding them in the countries and localities that are being mapped (Meskell 2015). As we mention above, however, the project seems to be heading in newly critical directions and will no doubt have a prominent place among big data projects in archaeology for years to come.

A number of projects presented in this issue and elsewhere offer alternative models for collaboration and research employing expansive datasets. For example, Gupta and colleagues (this issue) demonstrate the importance of building databases with (and in some cases, exclusively for) descendant communities from the ground up in settler colonial contexts. The Reciprocal Research Network in British Columbia, Canada, has employed a collaborative model to develop a database on over half a million items related to the cultural heritage of Northwest Coast First Nations (Rowley 2013). Thom, Colombi, and Degai (2016) have worked with indigenous people in Russia's Kamchatka Peninsula using Google Earth and other mapping tools to record and preserve traditional knowledge, on terms established by elders and other community members. Dozens of projects employing the Mukurtu platform have similarly based their work in local collaborations and employed the nested structures of access in the Mukurtu CMS to shield culturally sensitive information from outsiders (Christen 2012; Christen, Merrill, and Wynne 2017).

This Issue

The papers in this issue collectively investigate the potentials and challenges of working with big data in archaeology, focusing in particular on data collected from aerial platforms. Initially presented at a session at the 2019 meeting of the Society for American Archaeology entitled "Archaeological Vision in the Age of Big Data," they range from case studies evaluating the potential of specific aerial datasets (Howey et al.; VanValkenburgh et al.; Wernke et al.), to considerations of the conceptual and practical challenges of working at scale (Casana; McCoy), to critical contributions focusing on the ethical and political challenges facing practitioners of big archaeology (Huggett; Mickel; Kersel and Hill; Gupta et al.)

In his opening article, Jeremy Huggett argues that recent applications of digital technologies in archaeology, rather than producing a radical break with the past, are driving a "subtle" shift in "the burdens and expectations placed upon data." In this new era, he argues, we are returning to a sense of data as something "unprocessed" and "unworked"—a kind of raw material (like oil) that needs to be exploited *en masse,* rather than as collections of atomic units plucked from the world by researchers. These sensibilities constitute a new "digital data gaze" that we must address through reflexive examination, as well as by attending to the specific affordances and limitations of digital data.

Mark McCoy then explicitly engages with these affordances by examining the ways in which geographically extensive archaeological datasets are being put to use by scholars working in his geographic area of expertise, Oceania, as well as by contributors to this issue. For McCoy, despite the fact that geospatial technologies enable us to study archaeological landscapes as spatially continuous phenomena, some archaeologists are working with big datasets in ways that implicitly reinforce the site as the atomic unit of analysis. Through a review of examples from Oceania, he considers how remote sensing work has multiplied the number of site concepts operating in archaeology and demands important revisions to both data structures and public communication about archaeological research results.

In figure 1 of their article, Megan Howey and colleagues present a plot that makes the connection between archaeology's scales of data collection and scales of analysis much more explicit. Mapping spectral vs. temporal resolution among remote sensing technologies, they argue that the greatest potential for big aerial data is not focused on what they call the "safe" (high resolution) side of the spectrum, where imaging tech has been employed for site-scale studies, but rather regional and landscape scales. They illustrate this potential by using a terrain model generated using lidar data to identify clusters of storage pits dating to the Late Precontact period (ca. A.D. 1200–1600) in Michigan, and in turn by examining what the locations of these pits can tell us about subsistence strategies and mobility in that environment.

The next two papers explicitly examine some of the ethical implications of the types of regional and remote data collection illustrated by the previous contributions. Neha Gupta and colleagues discuss the question of data governance and the rights of indigenous peoples, using as a case study the treatment of archaeological data in the Canadian provinces and territories. Despite the creation of principles for ownership, control, access, and possession (OCAP®) for indigenous data—first established in 1998 by the First Nations Information Governance Centre—a push toward online and open data across governmental agencies has held unexpected implications for indigenous communities who want to maintain ownership and oversee disclosure of archaeological heritage within their own territories. Granting full rights of ownership to indigenous groups may restrict easy access to relevant data for archaeologists, but Gupta and colleagues argue such a shift in control is essential if we are to move beyond colonial practices and into true research partnerships.

A paper by Allison Mickel further explores the many interfaces between local inhabitants and big data. Mickel develops the concept of "proximity" as an analytic for understanding the relationship between communities and archaeological sites and examines the ways in which the production of big data may aggravate the divide between embedded, proximate knowledge and detached, academic research. She argues that it is not sufficient for big data initiatives to develop a rubric for including local knowledge in data creation and storage without also changing our own perspectives towards the importance of local people and places within our work.

We then turn to a pair of case studies from Andean archaeology. Parker VanValkenburgh and colleagues' contribution on the analysis of drone lidar data from the site of Kuelap, Peru, illustrates work on the "safe" side of the spectrum. Their dataset covers less than ten hectares, but the authors find its resolution to be analytically transformational, allowing them to identify fine-grained variation in architectural form at Kuelap and to suggest new hypotheses about the site's history. Their contribution demonstrates how high-resolution aerial data of even single sites can provide measurements that reorient our objects of analysis and enable us to recognize patterns that were previously obscure.

Steven Wernke and colleagues' analysis of data from GeoPACHA (the Geospatial Platform for Andean History and Archaeology) and LOGAR (the Linked Open Gazetteer of the Andean Region) is carried out at the scale of multiple nation states. By examining the locations of 879 planned towns into which the Spanish viceroyalty forcibly resettled indigenous subjects in 1570's C.E. (called *reducciones*), they shed light on the population dynamics of Spanish (and Inka) imperialism within the former *audiencias* of Peru and Charcas (roughly, modern Peru and Bolivia). Like so many big archaeological datasets, the total number of points they examine is relatively modest, but the identification of these locations within an immense expanse of the central Andes required coordinated efforts among a team of researchers and has yielded new insights that would have been impossible to achieve at smaller scales—in particular, a meaningful relationship between the locations of *reducciones* and the Inka road system.

In his contribution, Jesse Casana draws on experiences building and using the Corona Atlas of the Middle East to consider the challenges of both crowd-sourcing and automated feature detection for identifying archaeological sites in satellite imagery at massive scales. While machine learning and crowd sourcing approaches may be appropriate for specific tasks, he maintains that expert-led classification remains both the most effective and efficient way of generating data based on the close observation of satellite imagery.

The final contribution, by Morag Kersel and Austin (Chad) Hill, integrates questions of proximate knowledge and local ownership with aerial imagery and regional data structures to demonstrate the relevance of big archaeology to national policy formation and international diplomacy. In order to enter into a bilateral agreement with the United States for the protection of Jordanian cultural property, the Hashemite Kingdom of Jordan relied on a GIS-enabled national database of archaeological heritage (MEGA-Jordan), remote aerial documentation of looting activity, UAV-survey targeting particularly at-risk landscapes, on-site recording by archaeologists, and oral histories with the local populations who encounter looted sites and their artifacts. This combination of data sources and expertise demonstrates that there is far more at stake in these debates than merely the research into past lifeways.

Taken collectively, these papers begin a discussion surrounding an ongoing massification of site detection, a growing reliance on high-resolution aerial imagery, and an increasing globalization of archaeological data structures. If, as these papers demonstrate, new technologies are transforming both the ways in which we think about the past and how we work in the present, then it is not sufficient for us to embrace their potential without also entering into a critical dialogue of their intended and unintended impacts. We must continually chart the horizons and check the blindspots of big archaeology.

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References

Anderson, C. 2008. "The End of Theory: The Data Deluge Makes the Scientific Method Obsolete." *Wired magazine* 16: 16–07.

Bevan, A. 2015. "The Data Deluge." *Antiquity* 89 (348): 1473–1484.

Bewley, R., A. Wilson, D. Kennedy, D. Mattingly, R. Banks, M. Bishop, J. Bradbury, E. Cunliffe, M. Fradley, and R. Jennings. 2016. "Endangered Archaeology in the Middle East and North Africa: Introducing the EAMENA Project." In *CAA2015. Keep the Revolution Going: Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods in Archaeology*, edited by S. Campana, R. Scopigno, G. Carpentiero, and M. Cirillo, 919–932. Oxford: Archaeopress.

Brooks, D. 2013. "Opinion | The Philosophy of Data." *The New York Times*, February 5.

Brück, J. 2005. "Experiencing the Past? The Development of a Phenomenological Archaeology in British Prehistory." *Archaeological Dialogues* 12 (1): 45–72.

Carter, A. 2013. "'Lost Cities' and the Press." *Alison in Cambodia*. Accessed May 31, 2019. https://alisonincambodia.wordpress.com/2013/06/23/lost-cities-and-the-press/.

Casana, J. 2014. "Regional-scale Archaeological Remote Sensing in the Age of Big Data: Automated Site Discovery vs. Brute Force Methods." *Advances in Archaeological Practice* 2 (3): 222–233.

Casana, J., and E. J. Laugier. 2017. "Satellite Imagery-Based Monitoring of Archaeological Site Damage in the Syrian Civil War." *PLOS ONE* 12 (11): e0188589.

Casana, J., and M. Panahipour. 2014. "Satellite-Based Monitoring of Looting and Damage to Archaeological Sites in Syria." *Journal of Eastern Mediterranean Archaeology & Heritage Studies* 2 (2): 128–151.

Certeau, M. de. 1984. *The Practice of Everyday Life*. Berkley, CA: University of California Press, Berkeley.

Chase, A. F., D. Z. Chase, C. T. Fisher, S. J. Leisz, and J. F. Weishampel. 2012. "Geospatial Revolution and Remote Sensing LiDAR in Mesoamerican Archaeology." *Proceedings of the National Academy of Sciences* 109 (32): 12916–12921.

Chase, A. F., D. Z. Chase, J. F. Weishampel, J. B. Drake, R. L. Shrestha, K. C. Slatton, J. J. Awe, and W. E. Carter. 2011. "Airborne LiDAR, Archaeology, and the Ancient Maya Landscape at Caracol, Belize." *Journal of Archaeological Science* 38 (2): 387–398.

Chase, A. F., K. Reese-Taylor, J. C. Fernandez-Diaz, and D. Z. Chase. 2016. "Progression and Issues in the Mesoamerican Geospatial Revolution: An Introduction." *Advances in Archaeological Practice* 4 (3): 219–231.

Christen, K. 2012. "Does Information Really Want to Be Free? Indigenous Knowledge Systems and the Question of Openness." *International Journal of Communication* 6: 2870–2893.

Christen, K., A. Merrill, and M. Wynne. 2017. "A Community of Relations: Mukurtu Hubs and Spokes." *D-Lib Magazine* 23), https://doi.org/10.1045/may2017-christen.

Contreras, D. A., and N. Brodie. 2010. "The Utility of Publicly-Available Satellite Imagery for Investigating Looting of Archaeological Sites in Jordan." *Journal of Field Archaeology* 35 (1): 101–114.

Cooper, A., and C. Green. 2016. "Embracing the Complexities of 'Big Data' in Archaeology: The Case of the English Landscape and Identities Project." *Journal of Archaeological Method and Theory* 23 (1): 271–304.

Corn, J. J. 2002. *The Winged Gospel: America's Romance with Aviation*. Baltimore: John Hopkins University Press.

Cosgrove, D. E. 2001. *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination*. Baltimore: Johns Hopkins University Press.

Evans, D. H., R. J. Fletcher, C. Pottier, J.-B. Chevance, D. Soutif, B. S. Tan, S. Im, et al. 2013. "Uncovering Archaeological Landscapes at Angkor Using Lidar." *Proceedings of the National Academy of Sciences* 110 (31): 12595–12600.

Fernandez-Diaz, J. C., A. S. Cohen, A. M. González, and C. T. Fisher. 2018. "Shifting Perspectives and Ethical Concerns in the Era of Remote Sensing Technologies." *The SAA Archaeological Record* 18 (2): 8–15.

Fisher, C. T., A. S. Cohen, J. C. Fernández-Diaz, and S. J. Leisz. 2017. "The Application of Airborne Mapping LiDAR for the Documentation of Ancient Cities and Regions in Tropical Regions." *Quaternary International* 448: 129–138.

Fisher, C. T., and S. J. Leisz. 2013. "New Perspectives on Purépecha Urbanism Through the Use of LiDAR at the Site of Angamuco, Mexico." In *Mapping Archaeological Landscapes from Space*, edited by D. C. Comer and M. J. Harrower, 199–210. New York: Springer.

Fradley, M., and N. Sheldrick. 2017. "Satellite Imagery and Heritage Damage in Egypt: A Response to Parcak et al. (2016)." *Antiquity* 91 (357): 784–792.

Garrison, T. G., S. D. Houston, C. Golden, T. Inomata, Z. Nelson, and J. Munson. 2008. "Evaluating the Use of IKONOS Satellite Imagery in Lowland Maya Settlement Archaeology." *Journal of Archaeological Science* 35 (10): 2770–2777.

Glossary, Gartner I.T. 2018. "Big Data." Accessed September 30, 2019. https://www.gartner.com/en/information-technology/glossary/big-data.

Gattiglia, G. 2015. "Think big about Data: Archaeology and the Big Data Challenge." *Archäologische Informationen* 38: 113–124.

GlobalXplorer. n.d. "GlobalXplorer°." Accessed November 1, 2019. http://globalxplorer.org/.

Golden, C., T. Murtha, B. Cook, D. S. Shaffer, W. Schroder, E. J. Hermitt, O. A. Firpi, and A. K. Scherer. 2016. "Reanalyzing Environmental Lidar Data for Archaeology: Mesoamerican Applications and Implications." *Journal of Archaeological Science: Reports* 9: 293–308.

Haffner, J. 2013. *The View from Above: The Science of Social Space*. Cambridge, MA: MIT Press.

Hamilakis, Y. 2014. *Archaeology and the Senses: Human Experience, Memory, and Affect*. Cambridge: Cambridge University Press.

Haraway, D. J. 2002. "The Persistence of Vision." In *The Visual Culture Reader*, edited by N. Mirzoeff, 677–684. New York: Routledge.

Henry, E. R., C. R. Shields, and T. R. Kidder. 2019. "Mapping the Adena-Hopewell Landscape in the Middle Ohio Valley, USA: Multi-Scalar Approaches to LiDAR-Derived Imagery from Central Kentucky." *Journal of Archaeological Method and Theory*, 1–43.

Jay, M. 1993. *Downcast Eyes: The Denigration of Vision in Twentieth-Century French Thought*. Berkeley: University of California Press.

Johnson, K. M., and W. B. Ouimet. 2014. "Rediscovering the Lost Archaeological Landscape of Southern New England Using

Airborne Light Detection and Ranging (LiDAR)." *Journal of Archaeological Science* 43: 9–20.
Joyce, R. A. 2012. "Good Science, Big Hype, Bad Archaeology." *Berkeley Blog*. Accessed May 31, 2019. https://blogs.berkeley.edu/2012/06/07/good-science-big-hype-bad-archaeology/.
Joyce, R. A. 2015. "There's a Real Archaeological Surprise in Honduras." *Berkeley Blog*. Accessed May 31, 2019. https://blogs.berkeley.edu/2015/03/03/theres-a-real-archaeological-surprise-in-honduras/.
Kansa, E. C., S. W. Kansa, F. P. McManamon, K. W. Kintigh, A. Brin, and A. Vianello. 2013. "Digital Antiquity and the Digital Archaeological Record (tDAR): Broadening Access and Ensuring Long-Term Preservation for Digital Archaeological Data." *The CSA Newsletter* 23 (2), http://csanet.org/newsletter/fall10/nlf1001.html.
Kansa, S. W., E. C. Kansa, and J. M. Schultz. 2007. "An Open Context for 'Near Eastern Archaeology.'" *Near Eastern Archaeology* 70 (4): 188–194.
Kintigh, K. W., and J. H. Altschul. 2010. "Sustaining the Digital Archaeological Record." *Heritage Management* 3 (2): 264–274.
Kintigh, K. W., J. H. Altschul, A. P. Kinzig, W. F. Limp, W. K. Michener, J. A. Sabloff, E. J. Hackett, T. A. Kohler, B. Ludäscher, and C. A. Lynch. 2015. "Cultural Dynamics, Deep Time, and Data: Planning Cyberinfrastructure Investments for Archaeology." *Advances in Archaeological Practice* 3 (1): 1–15.
Kitchin, R. 2014. "Big Data, new Epistemologies and Paradigm Shifts." *Big data & society* 1: 1–12.
Kosok, P. 1965. *Life, Land, and Water in Ancient Peru: An Account of the Discovery, Exploration, and Mapping of Ancient Pyramids, Canals, Roads, Towns, Walls, and Fortresses of Coastal Peru with Observations of Various Aspects of Peruvian Life, Both Ancient and Modern*. New York: Long Island University Press.
Kurgan, L. 2013. *Close Up at a Distance: Mapping, Technology, and Politics*. Cambridge, MA: MIT Press.
Kwan, M.-P. 2007. "Affecting Geospatial Technologies: Toward a Feminist Politics of Emotion." *The Professional Geographer* 59 (1): 22–34.
Lasaponara, R., N. Masini, E. Rizzo, R. Coluzzi, and G. Orefici. 2011. "New Discoveries in the Piramide Naranjada in Cahuachi (Peru) Using Satellite, Ground Probing Radar and Magnetic Investigations." *Journal of Archaeological Science* 38 (9): 2031–2039.
Lefebvre, H. 2003. "Space and the State." In *State/Space: A Reader*, edited by N. Brenner, B. Jessop, M. Jones, and G. MacLeod, 84–100. Oxford: Blackwell Publishers.
Lohr, S. 2015. *Data-ism: The Revolution Transforming Decision Making, Consumer Behaviour, and Almost Everything Else*. New York: Harper Collins Publishers.
Masini, N., E. Rizzo, R. Lasaponara, and G. Orefici. 2008. "Integrated Remote Sensing Techniques for the Detection of Buried Archaeological Adobe Structures: Preliminary Results in Cahuachi (Peru)." *Advances in Geosciences* 19: 75–82.
Mattern, S. 2017. *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media*. Minneapolis: University of Minnesota Press.
Mayer-Schönberger, V., and K. Cukier. 2013. *Big Data: A Revolution That Will Transform How We Live, Work, and Think*. London: John Murray.
McCoy, M. D. 2017. "Geospatial Big Data and Archaeology: Prospects and Problems Too Great to Ignore." *Journal of Archaeological Science* 84: 74–94.
McManamon, F. P., K. W. Kintigh, L. A. Ellison, and A. Brin. 2017. "tDAR: A Cultural Heritage Archive for Twenty-First-Century Public Outreach, Research, and Resource Management." *Advances in Archaeological Practice* 5 (3): 238–249.
Menze, B. H., and J. A. Ur. 2012. "Mapping Patterns of Long-Term Settlement in Northern Mesopotamia at a Large Scale." *Proceedings of the National Academy of Sciences* 109 (14): E778–E787.
Meskell, L. 2015. "Introduction: Globalizing Heritage." In *Global Heritage: A Reader*, edited by L. Meskell, 1–21. Malden, MA: Wiley-Blackwell.
Nagel, T. 1989. *The View from Nowhere*. Oxford: Oxford University Press.
Oliveira Jorge, V., and J. Thomas, eds. 2008. *Archaeology and The Politics of Vision in a Post-Modern Context*. Newcastle: Cambridge Scholars Publishing.
Opitz, R. S., K. Ryzewski, J. F. Cherry, and B. Moloney. 2015. "Using Airborne LiDAR Survey to Explore Historic-Era Archaeological Landscapes of Montserrat in the Eastern Caribbean." *Journal of Field Archaeology* 40 (5): 523–541.
Parcak, S. 2007. "Satellite Remote Sensing Methods for Monitoring Archaeological Tells in the Middle East." *Journal of Field Archaeology* 32 (1): 65–81.
Parcak, S. 2019. *Archaeology from Space: How the Future Shapes Our Past*. New York: Henry Holt and Company.
Parcak, S., D. Gathings, C. Childs, G. Mumford, and E. Cline. 2016. "Satellite Evidence of Archaeological Site Looting in Egypt: 2002–2013." *Antiquity* 90 (349): 188–205.
Parks, L. 2005. *Cultures in Orbit: Satellites and the Televisual (Console-ing Passions)*. Durham, NC: Duke University Press.
Parks, L., and C. Kaplan, eds. 2018. *Life in the Age of Drone Warfare*. Durham, NC: Duke University Press.
Pollock, S., and R. Bernbeck. 2018. "Reflections on Survey and Surveillance in the Archaeology of Western Asia." *Origini* 42 (2): 93–108.
Rankin, W. 2016. *After the Map: Cartography, Navigation, and the Transformation of Territory in the Twentieth Century*. Chicago: University of Chicago Press.
Reinsel, D., J. Gantz, and J. Rydning. 2018. *The Digitization of the World —from Edge to Core*. https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf.
Rowley, S. 2013. "The Reciprocal Research Network: The Development Process." *Museum Anthropology Review* 7: 22–43.
Saturno, W., T. L. Sever, D. E. Irwin, B. F. Howell, and T. G. Garrison. 2006. "Putting Us on the Map: Remote Sensing Investigation of the Ancient Maya Landscape." In *Remote Sensing in Archaeology*, edited by J. R. Wiseman and F. El-Baz, 137–160. New York: Springer.
Savage, S. H., A. Johnson, and T. E. Levy. 2017. "Terrawatchers, Crowdsourcing, and At-Risk World Heritage in the Middle East." In *Heritage and Archaeology in the Digital Age*, edited by M. L. Vincent, V. M. López-Menchero Bendicho, M. Ioannides, and T. E. Levy, 67–77. New York: Springer.
Sever, T. L., and D. E. Irwin. 2003. "Landscape Archaeology: Remote-Sensing Investigation of the Ancient Maya in the Peten Rainforest of Northern Guatemala." *Ancient Mesoamerica* 14 (1): 113–122.
Thom, B., B. J. Colombi, and T. Degai. 2016. "Bringing Indigenous Kamchatka to Google Earth: Collaborative Digital Mapping with the Itelmen Peoples." *Sibirica* 15 (3): 1–30.
Ur, J. A. 2013a. "Spying on the Past: Declassified Intelligence Satellite Photographs and Near Eastern Landscapes." *Near Eastern Archaeology* 76 (1): 28–36.
Ur, J. A. 2013b. "CORONA Satellite Imagery and Ancient Near Eastern Landscapes." In *Mapping Archaeological Landscapes from Space*, edited by D. C. Comer and M. J. Harrower, 21–31. New York: Springer.
Wickstead, H. 2009. "The Uber Archaeologist: Art, GIS and the Male Gaze Revisited." *Journal of Social Archaeology* 9 (2): 249–271.