MOBILIZING *the* PAST *for a* DIGITAL FUTURE

The Potential of Digital Archaeology

Edited by
Erin Walcek Averett
Jody Michael Gordon
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Preface & Acknowledgments

This volume stems from the workshop, "Mobilizing the Past for a Digital Future: the Future of Digital Archaeology," funded by a National Endowment for the Humanities Digital Humanities Start-Up grant (#HD-51851-14), which took place 27-28 February 2015 at Wentworth Institute of Technology in Boston (http://uwm.edu/mobilizing-the-past/). The workshop, organized by this volume's editors, was largely spurred by our own attempts with developing a digital archaeological workflow using mobile tablet computers on the Athienou Archaeological Project (http://aap.toumazou.org; Gordon *et al.*, Ch. 1.4) and our concern for what the future of a mobile and digital archaeology might be. Our initial experiments were exciting, challenging, and rewarding; yet, we were also frustrated by the lack of intra-disciplinary discourse between projects utilizing digital approaches to facilitate archaeological data recording and processing.

Based on our experiences, we decided to initiate a dialogue that could inform our own work and be of use to other projects struggling with similar challenges. Hence, the "Mobilizing the Past" workshop concept was born and a range of digital archaeologists, working in private and academic settings in both Old World and New World archaeology, were invited to participate. In addition, a livestream of the workshop allowed the active participation on Twitter from over 21 countires, including 31 US states (@MobileArc15, #MobileArc).[1]

[1] For commentary produced by the social media followers for this event, see: https://twitter.com/electricarchaeo/status/571866193667047424, http://shawngraham.github.io/exercise/mobilearcday1wordcloud.html, https://twitter.com/electricarchaeo/status/571867092091338752, http://www.diachronicdesign.com/blog/2015/02/28/15-mobilizing-the-past-for-the-digital-future-conference-day-1-roundup/.

Although the workshop was initially aimed at processes of archaeological data recording in the field, it soon became clear that these practices were entangled with larger digital archaeological systems and even socio-economic and ethical concerns. Thus, the final workshop's discursive purview expanded beyond the use of mobile devices in the field to embrace a range of issues currently affecting digital archaeology, which we define as the use of computerized, and especially internet-compatible and portable, tools and systems aimed at facilitating the documentation and interpretation of material culture as well as its publication and dissemination. In total, the workshop included 21 presentations organized into five sessions (see program, http://mobilizingthepast.mukurtu.net/digital-heritage/mobilizing-past-conference-program), including a keynote lecture by John Wallrodt on the state of the field, "Why paperless?: Digital Technology and Archaeology," and a plenary lecture by Bernard Frischer, "The Ara Pacis and Montecitorio Obelisk of Augustus: A Simpirical Investigation," which explored how digital data can be transformed into virtual archaeological landscapes.

The session themes were specifically devised to explore how archaeological data was digitally collected, processed, and analyzed as it moved from the trench to the lab to the digital repository. The first session, "App/Database Development and Use for Mobile Computing in Archaeology," included papers primarily focused on software for field recording and spatial visualization. The second session, "Mobile Computing in the Field," assembled a range of presenters whose projects had actively utilized mobile computing devices (such as Apple iPads) for archaeological data recording and was concerned with shedding light on their utility within a range of fieldwork situations. The third session, "Systems for Archaeological Data Management," offered presentations on several types of archaeological workflows that marshal born-digital data from the field to publication, including fully bespoken paperless systems, do-it-yourself ("DIY") paperless systems, and hybrid digital-paper systems. The fourth and final session, "Pedagogy, Data Curation, and Reflection," mainly dealt with teaching digital methodologies and the use of digital repositories and linked open data to enhance field research. This session's final paper, William Caraher's "Toward a Slow Archaeology," however, noted digital archaeology's successes in terms of time and money saved and the collection of more data, but also called for a more measured consideration of the significant changes that these technologies are having on how archaeologists engage with and interpret archaeological materials.

The workshop's overarching goal was to bring together leading practitioners of digital archaeology in order to discuss the use, creation, and implementation of mobile and digital, or so-called "paperless," archaeological data recording systems. Originally, we hoped to come up with a range of best practices for mobile computing in the field – a manual of sorts – that could be used by newer projects interested in experimenting with digital methods, or even by established projects hoping to revise their digital workflows in order to increase their efficiency or, alternatively, reflect on their utility and ethical implications. Yet, what the workshop ultimately proved is that there are many ways to "do" digital archaeology, and that archaeology as a discipline is engaged in a process of discovering what digital archaeology should (and, perhaps, should not) be as we progress towards a future where all archaeologists, whether they like it or not, must engage with what Steven Ellis has called the "digital filter."

So, (un)fortunately, this volume is not a "how-to" manual. In the end, there seems to be no uniform way to "mobilize the past." Instead, this volume reprises the workshop's presentations—now revised and enriched based on the meeting's debates as well as the editorial and peer review processes—in order to provide archaeologists with an extremely rich, diverse, and reflexive overview of the process of defining what digital archaeology is and what it can and should perhaps be. It also provides two erudite response papers that together form a didactic manifesto aimed at outlining a possible future for digital archaeology that is critical, diverse, data-rich, efficient, open, and most importantly, ethical. If this volume, which we offer both expeditiously and freely, helps make this ethos a reality, we foresee a bright future for mobilizing the past.

* * *

No multifaceted academic endeavor like *Mobilizing the Past* can be realized without the support of a range of institutions and individuals who believe in the organizers' plans and goals. Thus, we would like to thank the following institutions and individuals for their logistical, financial, and academic support in making both the workshop and this volume a reality. First and foremost, we extend our gratitude toward The National Endowment for the Humanities (NEH) for providing us with a Digital Humanities Start-Up Grant (#HD-51851-14), and especially to Jennifer Serventi and Perry Collins for their invaluable assistance through the application process and beyond. Without the financial support from this grant the workshop and this publication would not have been possible. We would also like to thank Susan Alcock (Special Counsel for Institutional Outreach and Engagement, University of Michigan) for supporting our grant application and workshop.

The workshop was graciously hosted by Wentworth Institute of Technology (Boston, MA). For help with hosting we would like to thank in particular Zorica Pantić (President), Russell Pinizzotto (Provost), Charlene Roy (Director of Business Services), Patrick Hafford (Dean, College of Arts and Sciences), Ronald Bernier (Chair, Humanities and Social Sciences), Charles Wiseman (Chair, Computer Science and Networking), Tristan Cary (Manager of User Services, Media Services), and Claudio Santiago (Utility Coordinator, Physical Plant).

Invaluable financial and logistical support was also generously provided by the Department of Fine and Performing Arts and Sponsored Programs Administration at Creighton University (Omaha, NE). In particular, we are grateful to Fred Hanna (Chair, Fine and Performing Arts) and J. Buresh (Program Manager, Fine and Performing Arts), and to Beth Herr (Director, Sponsored Programs Administration) and Barbara Bittner (Senior Communications Management, Sponsored Programs Administration) for assistance managing the NEH grant and more. Additional support was provided by The University of Wisconsin-Milwaukee; in particular, David Clark (Associate Dean, College of Letters and Science), and Kate Negri (Academic Department Assistant, Department of Art History). Further support was provided by Davidson College and, most importantly, we express our gratitude to Michael K. Toumazou (Director, Athienou Archaeological Project) for believing in and supporting our research and for allowing us to integrate mobile devices and digital workflows in the field.

The workshop itself benefitted from the help of Kathryn Grossman (Massachusetts Institute of Technology) and Tate Paulette (Brown University) for on-site registration and much more. Special thanks goes to Daniel Coslett (University of Washington) for graphic design work for both the workshop materials and this volume. We would also like to thank Scott Moore (Indiana University of Pennsylvania) for managing our workshop social media presence and his support throughout this project from workshop to publication.

This publication was a pleasure to edit, thanks in no small part to Bill Caraher (Director and Publisher, The Digital Press at the University of North Dakota), who provided us with an outstanding collaborative publishing experience. We would also like to thank Jennifer Sacher (Managing Editor, INSTAP Academic Press) for her conscientious copyediting and Brandon Olson for his careful reading of the final proofs. Moreover, we sincerely appreciate the efforts of this volume's anonymous reviewers, who provided detailed, thought-provoking, and timely feedback on the papers; their insights greatly improved this publication. We are also grateful to Michael Ashley and his team at the Center for Digital Archaeology for their help setting up the accompanying Mobilizing the Past Mukurtu site and Kristin M. Woodward of the University of Wisconsin-Milwaukee Libraries for assistance with publishing and archiving this project through UWM Digital Commons. In addition, we are grateful to the volume's two respondents, Morag Kersel (DePaul University) and Adam Rabinowitz (University of Texas at Austin), who generated erudite responses to the chapters in the volume. Last but not least, we owe our gratitude to all of the presenters who attended the workshop in Boston, our audience from the Boston area, and our colleagues on Twitter (and most notably, Shawn Graham of Carlton University for his word clouds) who keenly "tuned in" via the workshop's livestream. Finally, we extend our warmest thanks to the contributors of this volume for their excellent and timely chapters. This volume, of course, would not have been possible without such excellent papers.

As this list of collaborators demonstrates, the discipline of archaeology and its digital future remains a vital area of interest for people who value the past's ability to inform the present, and who

recognize our ethical responsibility to consider technology's role in contemporary society. For our part, we hope that the experiences and issues presented in this volume help to shape new intra-disciplinary and critical ways of mobilizing the past so that human knowledge can continue to develop ethically at the intersection of archaeology and technology.

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October 1, 2016

How To Use This Book

The Digital Press at the University of North Dakota is a collaborative press and *Mobilizing the Past for a Digital Future* is an open, collaborative project. The synergistic nature of this project manifests itself in the two links that appear in a box at the end of every chapter.

The first link directs the reader to a site dedicated to the book, which is powered and hosted by the Center for Digital Archaeology's (CoDA) Mukurtu.net. The Murkutu application was designed to help indigenous communities share and manage their cultural heritage, but we have adapted it to share the digital heritage produced at the "Mobilizing the Past" workshop and during the course of making this book. Michael Ashley, the Director of Technology at CoDA, participated in the "Mobilizing the Past" workshop and facilitated our collaboration. The Mukurtu.net site (https://mobilizingthepast.mukurtu.net) has space dedicated to every chapter that includes a PDF of the chapter, a video of the paper presented at the workshop, and any supplemental material supplied by the authors. The QR code in the box directs readers to the same space and is designed to streamline the digital integration of the paper book.

The second link in the box provides open access to the individual chapter archived within University of Wisconsin-Milwaukee's installation of Digital Commons, where the entire volume can also be downloaded. Kristin M. Woodward (UWM Libraries) facilitated the creation of these pages and ensured that the book and individual chapters included proper metadata.

Our hope is that these collaborations, in addition to the open license under which this book is published, expose the book to a wider audience and provide a platform that ensures the continued availability of the digital complements and supplements to the text. Partnerships with CoDA and the University of Wisconsin-Milwaukee reflect the collaborative spirit of The Digital Press, this project, and digital archaeology in general.

Abbreviations

AAI	Alexandria Archive Institute
AAP	Athienou Archaeological Project
ABS	acrylonitrile butadiene styrene (plastic)
ADS	Archaeological Data Service
Alt-Acs	Alternative Academics
API	application programming interface
ARA	archaeological resource assessment
ARC	Australian Research Council
ARIS	adaptive resolution imaging sonar
ASV	autonomous surface vehicle
BLM	Bureau of Land Management
BLOB	Binary Large Object
BOR	Bureau of Reclamation
BYOD	bring your own device
CAD	computer-aided design
CDL	California Digital Library
CHDK	Canon Hack Development Kit
cm	centimeter/s
CMOS	complementary metal-oxide semiconductor
CoDA	Center for Digital Archaeology
COLLADA	COLLAborative Design Activity
CRM	cultural resource management
CSS	Cascading Style Sheet
CSV	comma separated values
DBMS	desktop database management system
DEM	digital elevation model
DINAA	Digital Index of North American Archaeology
DIY	do-it-yourself
DoD	Department of Defense
DVL	doppler velocity log
EAV	entity-attribute-value
EDM	electronic distance measurement
EU	excavation unit/s
FAIMS	Federated Archaeological Information Management System
fMRI	functional magnetic resonance imaging
GIS	geographical information system
GCP	ground control point
GNSS	global navigation satellite system
GPR	ground-penetrating radar

GUI	graphic user interface
ha	hectare/s
hr	hour/s
Hz	Hertz
HDSM	high-density survey and measurement
ICE	Image Composite Editor (Microsoft)
iOS	iPhone operating system
INS	inertial motion sensor
IPinCH	Intellectual Property in Cultural Heritage
IT	information technology
KAP	Kaymakçı Archaeological Project
KARS	Keos Archaeological Regional Survey
km	kilometer/s
LABUST	Laboratory for Underwater Systems and Technologies (University of Zagreb)
LAN	local area network
LIEF	Linkage Infrastructure Equipment and Facilities
LOD	linked open data
LTE	Long-Term Evolution
m	meter/s
masl	meters above sea level
MEMSAP	Malawi Earlier-Middle Stone Age Project
MOA	memoranda of agreement
MOOC	Massive Online Open Course
NGWSP	Navajo-Gallup Water Supply Project
NeCTAR	National eResearch Collaboration Tools and Resources
NEH	National Endowment for the Humanities
NHPA	National Historic Preservation Act
NPS	National Park Service
NRHP	National Register of Historic Places
NSF	National Science Foundation
OCR	optical character reader
OS	operating system
PA	programmatic agreement
PAP	pole aerial photography
PARP:PS	Pompeii Archaeological Research Project: Porta Stabia
PATA	Proyecto Arqueológico Tuti Antiguo
PBMP	Pompeii Bibliography and Mapping Project
PDA	personal digital assistant

PIARA	Proyecto de Investigación Arqueológico Regional Ancash
PKAP	Pyla-Koutsopetra Archaeological Project
Pladypos	PLAtform for DYnamic POSitioning
PLoS	Public Library of Science
PQP	Pompeii Quadriporticus Project
PZAC	Proyecto Arqueológico Zaña Colonial
QA	quality assurance
QC	quality control
QR	quick response
REVEAL	Reconstruction and Exploratory Visualization: Engineering meets ArchaeoLogy
ROS	robot operating system
ROV	remotely operated vehicle
RRN	Reciprocal Research Network
RSS	Rich Site Summary
RTK	real-time kinetic global navigation satellite system
SfM	structure from motion
SHPO	State Historic Preservation Office
SKAP	Say Kah Archaeological Project
SLAM	simultaneous localization and mapping
SMU	square meter unit/s
SU	stratigraphic unit/s
SVP	Sangro Valley Project
TCP	traditional cultural properties
tDAR	the Digital Archaeological Record
UAV	unmanned aerial vehicle
UNASAM	National University of Ancash, Santiago Antúnez de Mayolo
UQ	University of Queensland
USACE	U.S. Army Corp of Engineers
USBL	ultra-short baseline
USFS	U.S. Forest Service
USV	unmanned surface vehicle
UTM	universal transverse mercator
XML	Extensible Markup Language

3.4.
The Development of the *PaleoWay*: Digital Workflows in the Context of Archaeological Consulting

Matthew Spigelman, Ted Roberts, and Shawn Fehrenbach

In this chapter we present the development of our *PaleoWay* digital workflows, designed in-house by PaleoWest Archaeology, and offer insight into the development of digital archaeology within the private sector in the hope that our solutions may serve as an exemplar and model for academic and non-academic projects alike. PaleoWest Archaeology is a full-service cultural resources consulting firm, with offices across the United States. PaleoWest's archaeological services include archaeological resource assessments (ARAs); literature and site file searches (Phase 1A); reconnaissance and intensive archaeological surveys (Phase 1B); preservation and treatment plans; programmatic agreements (PAs); memoranda of agreements (MOAs); historic architectural documentation, site testing, and evaluations (Phase 2); full-scale excavation for data recovery and mitigation (Phase 3); and construction monitoring. We offer surveys using the full suite of geophysical instruments commonly used in archaeological surveys: ground-penetrating radar (GPR), gradiometry, electromagnetic induction (both magnetic susceptibility and conductivity), and resistivity. PaleoWest leverages the latest positioning technologies such as real-time kinetic (RTK) geographic positioning system (GPS) and robotic survey stations to collect subsurface imaging surveys quickly with precise spatial positioning. We also employ low altitude aerial photography for the creation of high-resolution orthomosaics, as well as digital elevation models (DEM). In fact, PaleoWest is the only archaeological firm nationwide to commercially hold a FAA 333 exemption permit to collect unmanned aereal vehicle (UAV), or drone, data. Our goal is, more broadly, to create an approach to archaeology focused on born-digital data and built-in quality assurance and quality control that provides clear and logical paths for turning field observations into client-ready deliverables.

Our needs in developing the *PaleoWay* digital workflows demanded they be scalable, customizable, and able to operate both with and without cellular connectivity. Scalability, which for our purposes was the ability to field multiple crews working simultaneously, was important because the size of our projects vary widely. A typical survey could be as small as a single plot being developed for residential or commercial use, a few miles of pipeline being added to a natural gas-collection network, or as large as a hundred-thousand-acre military base or a several-hundred-mile long water distribution system. Customizability was important because our work is variable and occurs across the 50 states and beyond. The goals for projects differ widely based on client needs, and the project deliverables vary across states and between government agencies. We therefore stress that *PaleoWay* is a system of digital workflows (plural) because the variety of our projects, geographic locations, and regulatory requirements make the development of a single, one-size-fits-all, system impractical.

The great benefit of being a successful archaeology-only consulting firm is that we have had a large number of projects through which to develop and refine the *PaleoWay* digital workflows. Since our founding in 2006, we have successfully completed over 1,100 cultural resource investigations. In this paper we present an overview of the process of developing the *PaleoWay* digital workflows, provide several projects as case studies to highlight the strengths of a digital data system, and reflect on how the position of the data and mapping specialist has become a key position in the firm. First, however, since we are the only contributors to the volume speaking from a cultural resource management (CRM) perspective, we provide a brief overview of the environment in which archaeological consulting is practiced within the United States. This context informs all of the decisions we have made, and continue to make, in developing and implementing the *PaleoWay* digital workflows.

Archaeological Consulting

As archaeological consultants our job is to help local, state, federal, and private entities manage the cultural resources under their care. The largest of these entities are federal organizations and agencies, such as the Bureau of Reclamation (BOR), the U.S. Forest Service (USFS), the National Park Service (NPS), Department of Defense (DoD), Army Corps of Engineers (USACE), and the Bureau of Land Management (BLM), each responsible for millions of acres of land and the management of millions of archaeological sites and other historic properties located on public land. The smallest entities are developers or other landowners embarking on a project that requires a federal, state, or municipal permit and therefore triggers historic review. The cultural resources we are hired to record and evaluate include, but are not limited to, archaeological sites. We are also charged with identifying other historic features on the landscape, such as petroglyphs, irrigation canals, roads, fences, and historic buildings. Also falling within the category are less tangible cultural resources, such as ethnographic knowledge, natural resources of cultural significance, and traditional cultural properties (TCPs) where important activities continue to take place.

Much of this work is federally mandated by section 106 of the National Historic Preservation Act (NHPA), but also other parallel pieces of legislation (King 2013: fig. 1.1). This work is mandated at the federal level but regulated at the state level. Each state maintains a State Historic Preservation Office (SHPO), which is responsible, among other things, for reviewing work done to satisfy the section 106 legislation, for maintaining a statewide inventory of historic properties, and for nominating historic properties to the National Register of Historic Places (NRHP). Historic properties are typically defined as anything greater than 50 years of age and are considered significant for what they can tell us about our collective history, both before and after the founding of the Unites States of America (for an overview of the relevant legislation, see King 2013: 1–54).

This work typically proceeds along a three-step process of (1) identifying cultural resources, (2) an evaluation of their eligibility for inclusion on the NRHP, and (3) determining if construction or other events will have a negative impact on those resources and proposing mechanisms to avoid or mitigate those impacts (King 2013: 55–82).

In practical terms, this process results in our being hired to survey archaeologically the proposed project areas (hundreds or thousands of acres), identify archaeological sites, and assess the impacts of any proposed activities on those sites and other identified historic properties. When negative impacts to a significant cultural resource are unavoidable, one method of mitigating those impacts is to research and record the cultural resource in order to gather information of importance to human and American history. Again, in practical terms, mitigation often results in extensive site excavation, the purpose of which is to gather data from an archaeological site or other cultural resource before it will be destroyed or made inaccessible by construction, mining, or other activities. For this reason, these projects are typically referred to as "data recovery" excavations.

As archaeological consultants, each project we complete results in a set of deliverables that are reviewed by the SHPO. For surface (pedestrian) surveys, these deliverables will typically include a report on the work conducted and an inventory form for each archaeological site or other historic property identified. The report allows the SHPO to evaluate if the appropriate federal requirements have been met, while the inventory forms contain all of the information necessary for the SHPO to update their statewide inventory of historic places. For data recovery excavations, the deliverables also include the thousands or millions of artifacts and other material recovered during the work, all of which must be cataloged and processed for long-term storage. Our job is, therefore, to conduct archaeological research in the service of managing the historic resources of our nation. Effective and efficient work is central to this process, to meet both the management needs of the resource and our own needs as a private company working on competitively priced projects with low profit margins and little tolerance of inefficiencies.

The *PaleoWay* Digital Workflows

The goals for the *PaleoWay* digital workflows are twofold: to produce higher quality data and to do so in a more efficient and cost effective manner. The creation of all digital workflows requires the reimagining of how we prepare for fieldwork, conduct fieldwork, collect data, analyze data, and produce deliverables for our clients. We developed the *PaleoWay* as a suite of tools that removes paper maps, paper records, and paper forms, replacing them with digital devices and digital data.

The first phase of developing the *PaleoWay* digital workflows was one of research and experimentation, as new hardware (most notably the first and second generation iPads) and a host of new applications became available. The challenge in this phase was to create a culture shift within our organization and industry similar to paradigm shifts occurring in academic archaeology (Dufton, Ch. 3.3; Gordon *et al*., Ch. 1.4; Wallrodt, Ch. 1.1). This culture shift included encouraging and empowering project managers, crew chiefs, and field technicians to find new way to conduct fieldwork and produce deliverables. In doing so, we were forced to confront deeply engrained practices, many of which dated back to the early years of CRM in the 1970s and 1980s. These paper-based workflows were well honed, but they were also increasingly inefficient due to the need to digitize eventually all data for final computerized report production, map drawing, and production of client-specified deliverables (see Caraher, Ch. 4.1).

The second phase of development was product development. In conjunction with a period of rapid growth in the company, many of the workflows that had been established in the first phase using a host of standalone applications were consolidated into a single, centralized database. While many options were explored, the solution chosen was to build a customized database within the FileMaker Pro program. This choice of an established software package has proven successful, allowing us to focus on the development and improvement of the database itself (and to do more archaeology), without having to worry about the fundamental software reengineering associated with each and every hardware and operating system release (for perspectives on proprietary vs off-the-shelf solutions, see: Fee, Ch 2.1; Motz, Ch. 1.3; Sobotkova *et al*., Ch. 3.2; Wallrodt, Ch. 1.1). The resulting software is now utilized in all of our projects, ranging from survey, through testing, to large-scale excavation.

The Old Way

The old way of conducting archaeological consulting was developed as a paper-based workflow, with computers and other digital devices uncomfortably inserted after the fact (Eiteljorg 2007). Field data was recorded on paper, in a manner that has changed little since the devel-

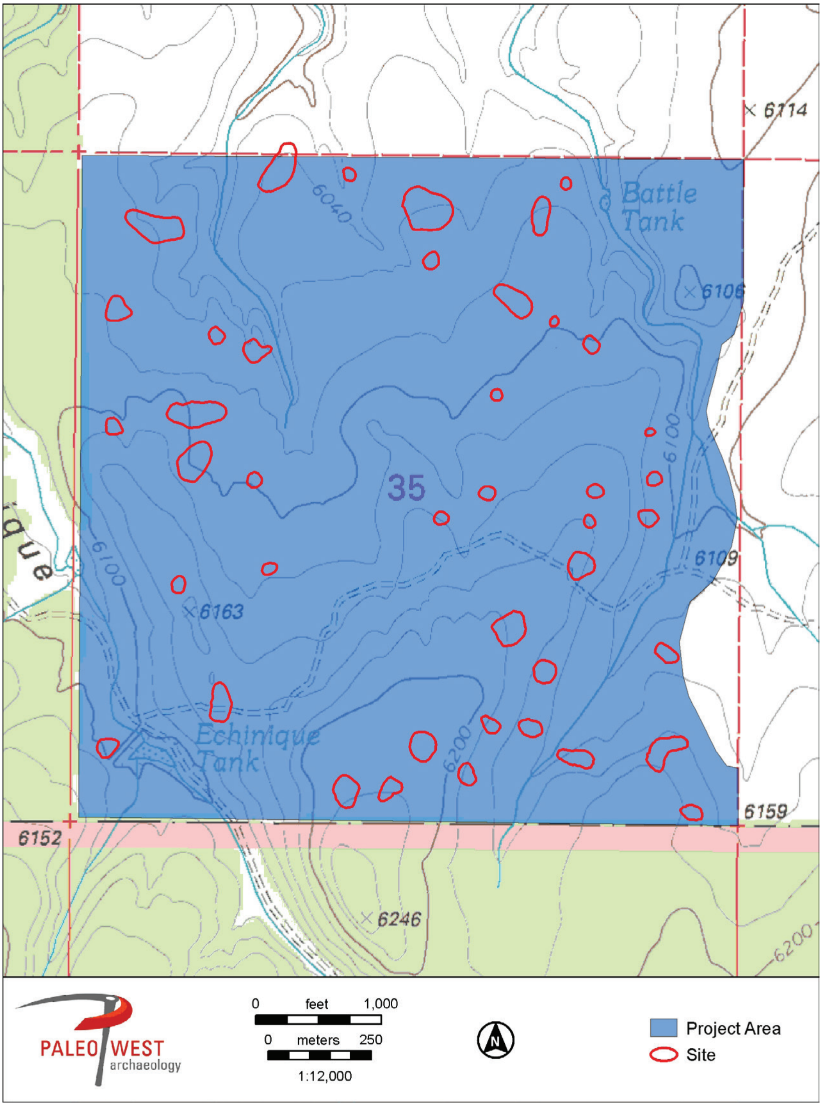

Figure 1: Map of typical site density (does not depict actual site locations).

opment of CRM in the 1970s. Deliverables were also paper-based, with printed reports and site forms filled out by hand or using a typewriter. Archaeological consulting companies introduced computers into this workflow as a means to organize data as it returned from the field and produce better looking maps, but as of 2010, computers had not meaningfully changed how fieldwork was conducted. Similarly, multi-thousand-dollar GPS units (most made by Trimble™) and high-quality digital cameras had been introduced into fieldwork, but both were inserted into the traditional methodology (see Ellis, Ch. 1.2). The crew chief, who previously recorded site and isolated artifact locations by hand on a paper map, now recorded those locations using the GPS unit. This initial insertion of technology only served to reinforce the hierarchical nature of field crews, creating greater distance (and at times animosity) between field crews and their crew chiefs and project managers.

As of 2010, computers were allowing archaeological consultants to organize better data, render high-quality maps, and record more accurate spatial data. These benefits, however, came at a cost. Fieldwork now required several pieces of expensive equipment, while still producing only paper records and hand-drawn maps as a result. Upon leaving the field, paper records now needed to be typed into the computer before data could be tabulated and included in reports. Hand-drawn maps needed to be scanned and loaded into Adobe Illustrator or AutoCAD, where they were then re-drawn again. Higher-quality data was being collected and higher-quality deliverables were being produced, but there were, as of yet, only efficiency losses and no efficiency gains.

The Development of Digital Workflows for Pedestrian Survey and Site Recording (2010–2011)

The development of the *PaleoWay* digital workflows took place in 2010 and 2011, a period of tough economic times. Commercial property development had ground to a halt, taking away a formerly lucrative source of archaeological contracts. The work that remained was largely generated by government agencies, such as the USFS, BLM, BOR, and various branches of the military. These projects were publicly advertised and highly competitive, susceptible to low bids by those willing to cut corners. The goal of PaleoWest was therefore to leverage technology not just in an attempt to maintain and improve the quality of the data coming out of the field, but also to increase efficiency and lower costs in this competitive environment.

PaleoWest bid aggressively on contracts during this time and won work throughout the American Southwest and West on large projects in Arizona, New Mexico, Utah, Wyoming, and Colorado. These projects were largely extensive surveys in archaeologically rich landscapes (FIG. 1). Projects were usually non-collect surveys, meaning that all artifact analysis was conducted in the field, and that only photographs, records, and maps returned to the lab. The deliverables for these projects were a final report and the completion of Agency-specific inventory forms, typically accompanied by appropriate pictures and maps. While core staff members (project manager, field director, and some crew chiefs) remained fairly consistent from project to project, field crews were typically hired on a per-project basis. Most projects covered 500 to 1,000 acres, had crews of 4 to 12 people, and lasted anywhere from 10 days to a month. This was an ideal environment to test and innovate new solutions, allowing for near continuous iterative development.

The economic downturn of 2010 and 2011 simultaneously ushered in a period of rapid technological development and lowering costs of hardware and software (see Ellis, Ch. 1.2; Motz, Ch. 1.3; Poehler, Ch. 1.7; Wallrodt, Ch. 1.1). While the launch of the iPad was an important piece of this process, so too were the appearance of lower-cost and higher-quality GPS units and digital cameras. During this beta testing period, a concerted effort was made to engage all members of the field crew to adopt the technologies and embrace the changes in the personnel dynamic associated with going digital in all stages of the archaeological process. The goal was to give everyone access to the technology and to empower everyone to identify problems, find solutions, and spread these results throughout the field crews and the greater company. This was an exciting time: new technology was being adopted in real time while under constant pressure to bring projects in under budget and on schedule.

The main task in going digital was to convince everyone from the top down, and the bottom up, to buy into the process. Previously, when new technology had been introduced, it had been jealously guarded by the crew chief (see Sayre, Ch. 1.6), with the unfortunate consequence of creating both hierarchy and resentment, but also of introducing inefficiency, as able crew members sat idle while the crew chief recorded coordinates, drew maps, filled out paperwork, or took pictures. Our goal, instead, was to put technology in each crew member's hands, giving everyone a job to do in parallel to one another, thereby increasing efficiency in the process. This approach was directed at all stages of the archaeological process, replacing the traditional archaeological toolkit with a digital one.

The system that developed to further this approach was a suite of technology and software (see Motz, Ch. 1.3; Wallrodt, Ch. 1.1). A crew of four now went to the field with four Garmin handheld GPS units, three iPads, and one Trimble high-precision GPS unit. Each crew member had their own GPS, which was pre-programed with their designated survey lines. That all crew members had a GPS made field walking more efficient, and it also streamlined the process of recording isolated artifact occurrences. Crew members, upon spotting an isolated artifact, could now quickly and efficiently make their identification, note the coordinates, and call out the information to be recorded. Paper site-recording forms were now digitized into fillable PDFs that were pre-loaded with applicable information and ready for digital data collection. Because these were the same forms that would later be printed and submitted to the client, fieldwork was directly producing the project deliverables, thereby removing all of the digitization and typing that used to be required. Similarly, site plan maps were produced directly on the iPad, using off-the-shelf vector mapping programs. By pre-loading a template with an appropriate symbology, field vector mapping increased efficiency by removing the need for the post-field digitization of paper maps, and it also produced higher-quality data by standardizing symbology, layout, and other aspects of the map between team members and across field crews (see Bria and DeTore, Ch. 1.5; Motz, Ch. 1.3; Ellis, Ch. 1.2).

With the introduction of the second generation iPad, it became possible to bring site and artifact photography fully into the digital realm as well. Whereas previously it was necessary to juggle a camera, a GPS unit, and a paper photo log, now these three lines of data were brought together within a single device (see Ellis, Ch. 1.2; Fee, Ch. 2.1; Gordon *et al*., Ch. 1.4). In this first phase of development the solution was an off-the-shelf application that digitally marked photographs with all of the necessary information: location, direction, time, and space for a note, thereby removing the need for a separate photo log.

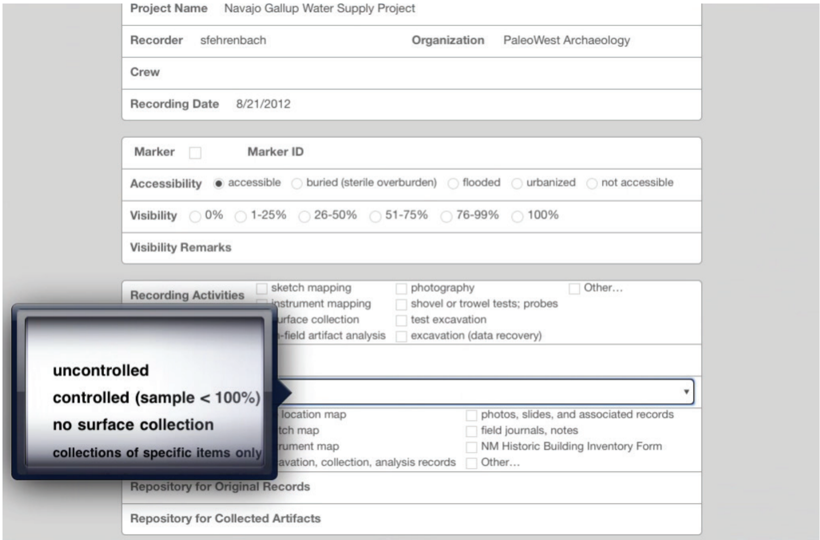

Figure 2: Screen shot of the NGWSP database.

The Development of an Integrated Database Solution (2011–2012)

We transitioned from a phase of research and development during 2010 and 2011 to the creation of an integrated database solution in 2011 and 2012. This transition occurred when PaleoWest was awarded the cultural resource management component of the Navajo-Gallup Water Supply Project (NGWSP). The NGWSP is a $1.3 billion undertaking, consisting of a 280-mile-long system of pipelines and pumping stations that will bring water to parts of the Navajo Nation that are currently without a clean and sustainable water supply. This cultural resource management contract was, at the time, the largest federally funded CRM contract ever awarded in the United States. The NGWSP is a complex and demanding project, requiring a digital data solution that could accommodate archaeological survey, testing, and excavation, as well as ethnographic research (Potter *et al.* 2013). The cultural resource portion of the project is also slated to take at least a decade to complete, and construction is estimated to extend through 2024. This complex project with an extended timeline required the creation of a robust system that could handle all of the diverse project needs, but it also necessitated a flexible system that can be adapted and altered over time. This solution was developed in the context of the NGWSP (cf. Chuipka 2015), and in the years since, it has been implemented by PaleoWest on that project and other survey and excavations projects, both large and small.

The *PaleoWay* digital workflows designed and implemented for the NGWSP are based around a collection of nested modules in a FileMaker Pro database (FIG. 2; see also Gordon *et al*., Ch. 1.4; Motz, Ch. 1.3; Wallrodt, Ch. 1.1). These modules create guided pathways for collecting data for survey, excavation, and other regularized tasks. While we explored many different software options, including customized app development and other solutions, the decision to utilize commercial database software was made to avoid the time and expense of re-engineering software for each hardware or operating system upgrade. We also needed the ability to work without cellular connectivity, as much of the NGWSP runs through rural areas, and it was also necessary to have the ability to integrate and coordinate data in real time, such as on large and complex excavation sites.

This too resulted in higher-quality data because it eliminated the all-too-common occurrence of the photo log and the camera falling out of sync, thus ensuring that the location, direction, and subject of every photo was always recorded.

Lastly, going digital allowed crews to take whole libraries of information with them to the field, and to organize that information in a usable manner. Having digital libraries in the field pays dividends both in recording newly discovered artifacts and sites and in re-visiting and re-recording previously identified cultural resources. Having identification libraries at hand is key for maximizing productivity among field crews, members of which might be working one week in Utah and the next week in Arizona; they might find a prehistoric lithic scatter in the morning and an early 20th-century campsite in the afternoon. When revisiting sites, the digital library for that site could be easily consulted, forms could be pre-filled with known information, and the old site map consulted to see if subsequent changes required the drawing of a new one.

This research and development phase continued through 2010 and 2011 and reached a mature state with the capabilities of the second generation iPads with their onboard cameras. Using off-the-shelf hardware and applications we achieved notable productivity gains, both in the field and in the time it took to go from field to deliverables. Utilizing all team members, each with their own role in the process and each inputting data to their own device, the recording of a lithic scatter went from over an hour in the paper era to under 15 minutes using the *PaleoWay* digital workflow. The time spent recording an isolated artifact went from 10 minutes to less than a minute. Major productivity gains and quality control was gained by removing digitization entirely from the process. The move from field records to deliverables went from two weeks to two days. This period of research and development required overcoming technological changes, but, more importantly, it required a cultural shift as people learned to trust the technology and see the benefits of collecting digital data directly in the field (see Ellis, Ch. 1.2; Poehler, Ch. 1.7).

National Registrer of Historical Places Eligibility Evaluations at Fort Irwin, California

A major opportunity for testing the *PaleoWay* as implemented in the FileMaker Pro database was a large survey project carried out at Fort Irwin, California. We were hired to evaluate 731 previously identified archaeological sites, located within a 642,000 acre active military facility (Roberts *et al.* 2012, 2013). This project was ideally suited to a digital approach: the archaeological sites were previously identified, so the task was to re-locate, re-record, and evaluate their eligibility for the NRHP in the most efficient manner possible. A digital workflow utilizing a four-person team, with three iPads and Trimble GPS unit, was devised. One team member surveyed the site, tallied artifacts, marked artifact positions and the site boundaries with survey flags, and recorded coordinates with the Trimble GPS. The remaining team members all used iPads. One member took photos and completed the integrated photo log, a second filled out the site form, and the third used a vector mapping application to draw a site map. The vector map template was populated with current project information, thus eliminating the need for redundant and repetitive efforts. This workflow engaged all team members in the site-recording process, with data integrated after the fact through the centralized database. This digital approach also allowed for unprecedented flexibility at Fort Irwin, as necessitated by the demands of working in an active military facility. Field crews were empowered to shift to new sites or new areas of the base seamlessly, as all of their background research and all necessary field forms and maps were carried with them digitally at all times.

Large-Scale Excavation at the Ironwood Village Site, Arizona

The *PaleoWay* digital workflows have proven particularly successful at managing the large volumes of physical and digital data produced by large-scale excavation projects. In 2013 and 2014, PaleoWest was hired to excavate the Ironwood Village site, a ca. seven acre (2.8 ha) Hohokam settlement, located midway between Phoenix and Tucson, Arizona (Bostwick *et al.* 2015). The project represents the first all-digital large-scale excavation in the nation. Excavation was conducted on an extremely tight schedule, with the goal of gaining clearance for

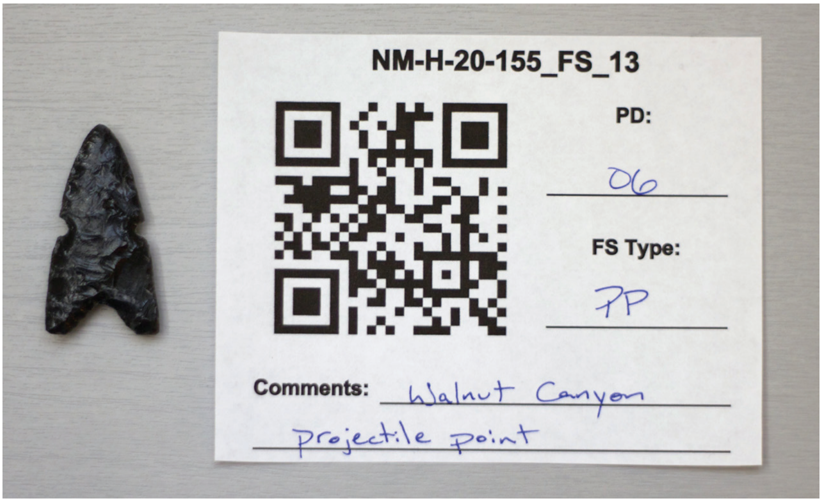

Figure 3: QR code for artifact and sample tracking.

the construction of the Marana Center commercial development in advance of the 2015 holiday shopping season. The goals of the project were therefore efficient and high-quality excavation, followed quickly thereafter by reporting and clearance for the project to proceed. These demands required that the excavation, data analysis, and initial technical report assembly phases be conducted coincident with one another. The project was successful, with the technical report submitted the day after fieldwork was complete, due to the capabilities of the *PaleoWay* digital data workflows. Two aspects were particularly important: access to a centralized database from both the field and the lab, and the use of artifact and sample tracking using quick response (QR) codes.

The excavation of the Ironwood Village site utilized a centralized database hosted in the company's Phoenix headquarters and was accessed in the field over cellular networks in real time. This allowed full access to all field records, photographs, and other information by all members of the project team as soon as they were created. Most importantly, records were being continuously checked and cleaned by a full-time data manager. The data manager was responsible for maintaining standardization and identifying potential issues that could be addressed while features, contexts, and artifacts were still fresh in excavators' memories and crews were still in the field. Over 500 distinct archaeological features were excavated at the site, including a ball court and numerous houses, roasting pits, and burials. Each feature was digitally mapped in the field using a vector drawing app and coordinates taken from the site grid. These maps were revised in the lab using control points taken with a total station.

A large and diverse artifact assemblage was recovered from the Ironwood Village site, and samples for flotation, pollen, botanical, and C^{14} analysis were also collected. In total, nearly 4,000 bags of artifacts were recovered in the field and transferred to the lab for analysis. Each artifact bag was tracked throughout this journey using a unique QR code (FIG. 3; see also Castro López *et al.*, Ch. 3.1). Representing a distinct advancement over traditional barcode systems (see, e.g., McPherron and Dibble 2002), QR codes require no special equipment to produce or read them—they simply are printed on regular paper (or waterproof Tyvek) and then attached or included in sample bags in the field. The codes can be read quickly and accurately using the camera on any smartphone or tablet. The use of QR codes within a centralized database also allows for efficient custody tracking.

The tracking of artifacts and other samples as they leave the site, enter the lab, and move from conservation, through analysis, to storage is critical to the success of a large project. Custody tracking is, however, mandatory and essential when dealing with human remains. Human remains and associated funerary objects were discovered as both distinct cemeteries and isolated occurrences at the Ironwood Village site. The methods for excavating, housing, and repatriation of these remains were determined in consultation with the Tohono O'odham Nation and described in the project's Burial Agreement. A member of the Tohono O'odham Nation was on-site during fieldwork and participated in the excavation of many burial features. A core part of the burial agreement is an establishment of trust between PaleoWest and the Tohono O'odham Nation that the material recovered from burial features will be handled and housed respectfully at all times. The use of a centralized custody tracking system was an essential part of this process. Within the framework of appropriate treatment and transport of these highly significant and sensitive items (as outlined in the Burial Agreement), the chain of custody could be demonstrated immediately wherever and whenever the need for access to this information arose.

The *PaleoWay* digital workflows proved particularly useful in the context of large-scale data recovery excavations, such as the Ironwood Village site. The use of a centralized system allowed for the real-time coordination and control over the digital data and physical artifacts that was impossible using paper records alone. Key to these efforts is not just the construction of a functional and efficient database system, it is also the assignment of personnel to the maintenance and use of such a system, thereby establishing the role of the data manager within the archaeological consulting firm.

The Data Manager

The development, implementation, and maintenance of the *PaleoWay* digital data workflows positions the data manager (and mapping specialist) as a core member of any project team. In the paper era, data collection was the responsibility of the field director, data processing the responsibility of the lab director, and the production of the project deliverables was the responsibility of the principal investigator. The data manager and mapping specialist now play key roles at each stage of a project's lifecycle. In preparation for fieldwork they conduct site file searches of already identified sites within the project area, compile these data in ArcGIS, and output geoPDFs for use in the field. They are also responsible for preparing a blank database for fieldwork by customizing fields, dropdown menus, and other aspects as necessary for the specific project. During large and complex projects they are responsible for database integration and quality control, often allowing problems to be identified and corrected while the team is still in the field. After fieldwork is complete they are responsible for moving data out of the database in which it was collected and into the various formats of the project deliverables. These typically include the project report, site forms, and associated maps and photographs. It is becoming increasingly common for SHPOs to require that spatial data be delivered as shapefiles, which necessitates site coordinates and other information to be brought back into ArcGIS for export. All of this is to say that while we have created digital data workflows and removed paper from the system, we have not removed people from the system.

Conclusions

Our goal in developing the *PaleoWay* digital data workflows was to produce higher-quality data and to do so in a more efficient and cost effective manner. We have found that collecting digital data in the field produces higher-quality data due to the quality assurance and quality control (QA/QC) mechanisms built into the process. As a result, this QA/QC process improves archaeological interpretation by eliminating redundant or bad data. For database input we can limit choices to a predefined set of values, thereby standardizing recording across personnel and field crews, and we can also create required fields, thereby ensuring that all data is collected before leaving a given archaeological site. Vector mapping in the field also produces a higher-quality work product because map symbology, scale, and conventions are all built directly into the pre-loaded template. Perhaps the greatest efficiency gains, however, have been achieved by removing the need to digitize large volumes of field forms, decipher the handwriting of multiple field crew members, and reconstruct missing data after the fact. We now move directly from fieldwork to the production of deliverables. This closer linking of fieldwork and reporting allows the synthesis of results to occur much closer to when the work actually took place, again resulting in a high-quality product and efficiency gains.

The irony of our current efforts is that while our data workflows are entirely digital, our project deliverables remain largely paper-based. State and federal laws are built around the archival stability and permanence of paper records. The SHPOs are just beginning to bring site databases online and integrated with spatial data. We expect, therefore, that the shift from paper to digital deliverables is at hand, and we will soon be accompanying our digital spatial data deliverables with digital databases of our results as well. Our *PaleoWay* digital workflows position us well to adapt to these changes.

The development of the *PaleoWay* digital workflows benefited in its early phases from our high project throughput, allowing many new technologies to be employed. The successful technologies were developed and refined, while the onerous or inefficient were culled. The development of a more effective and efficient paperless system was particularly advantageous as we operate in many areas of the country that are densely populated with a rich diversity of archaeological sites, thereby compounding even small efficiency gains into sizeable benefits. And more recently it has benefited from our participation in large and complex projects, which provided the time and budget to build more integrated and robust systems and capabilities. We have found, however, that it is not possible or desirable to produce a single application or database that contains all the necessary functionality our system requires. Vector mapping remains most efficiently done in an external application, and we continue to utilize handheld GPS units and total stations running their own proprietary software. Recreation-grade GPS units remain the most rugged and economical option for providing surveyors with their routes through the project area, while we turn to professional-grade GPS units for recording tasks requiring greater accuracy.

In this paper we have reviewed the development *PaleoWay* digital workflows and highlighted several projects in which they have proven particularly effective. The NGWSP highlights the ability of the *PaleoWay* digital workflows to utilize a centralized database to integrate a highly varied set of project tasks, which are simultaneously taking place over hundreds of miles of archaeologically rich land, and which will extend over more than a decade of work. The re-recording and evaluation of previously identified archaeological sites at Fort Irwin highlights the ability of digital data workflows to efficiently collect data while maintaining high quality over time. Efficiency was produced by designing a workflow in which all team members were actively engaged in site recording for the duration of the time spent at each site. Lastly, the Marana Data Recovery Project (the Ironwood Village Site) was a large-scale excavation of a Hohokam Village site conducted in advance of commercial development. This project was executed on an extremely tight timeline, and its successful deployment highlights the ability of the *PaleoWay* digital workflows to create an active flow of information between the field and the lab.

https://mobilizingthepast.mukurtu.net/collection/34-development-paleoway-digital-workflows-context-archaeological-consulting

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