

Implementing Participatory Site Stewardship through Citizen Science and Mobile Apps

The Case of Bodie, California

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ABSTRACT

Historic archaeological resources in the American West are increasingly at risk of loss because of prolonged droughts, wildfires, earthquakes, general deterioration, and the negative impact of increasing visitation. Casual visitors regularly remove objects from their original contexts in the landscape, either taking them home as souvenirs or bringing them to local staff because they are concerned about the items disappearing. As a result, many sites of cultural significance are losing the ability to convey the information required for scholarly interpretation and for drafting community and life histories of their past residents. We argue that citizen science and mobile apps specifically designed for site stewardship are viable tools for alleviating negative human impacts on cultural landscapes and enhancing our capacity to record and monitor sites of cultural heritage. We contend that our approach uses an innovative interface, the Citizen Preservationist app, an open-source hybrid mobile/desktop software we developed to foster both current use and protection of archaeological sites and historic parks. We demonstrated the viability of our app by conducting a user study at Bodie, California (ca. 1859–1942), that assessed how this software promotes a sense of stewardship and appreciation for the archaeological heritage of this beloved California State Historic Park.

Keywords: Bodie, California, heritage preservation, participatory site stewardship, citizen science, mobile apps, collaborative site monitoring, digital archaeology

Los recursos arqueológicos históricos en el oeste de los Estados Unidos corren cada vez más riesgo de pérdida debido a sequías prolongadas, incendios forestales, terremotos, deterioro general y el impacto negativo del aumento de las visitas. Ocasionalmente, los visitantes de un parque arqueológico remueven artefactos de sus contextos originales en el paisaje, llevándolos a casa como recuerdos o llevándolos al personal local porque les preocupa que desaparezcan. Como resultado, muchos sitios de patrimonio cultural están perdiendo la capacidad de transmitir la información requerida para la interpretación académica y para redactar historias de la comunidad y la vida de sus residentes anteriores. Argumentamos que la ciencia ciudadana y las aplicaciones móviles específicamente diseñadas para el monitoreo de sitios son herramientas viables para aliviar los impactos humanos negativos en los paisajes culturales y mejorar nuestra capacidad para registrar y monitorear sitios de patrimonio cultural. Sostenemos que nuestro enfoque utiliza una interfaz innovadora, la aplicación Citizen Preservationist, un software híbrido de escritorio/móvil de código abierto que desarrollamos para fomentar el uso actual y la protección de sitios arqueológicos y parques históricos. Demostramos la viabilidad de nuestra aplicación al realizar un estudio de usuarios en Bodie, CA (1859–1942) que evaluó cómo este software promueve un sentido de cuidado y apreciación del patrimonio arqueológico de este amado Parque Histórico del Estado de California.

Palabras clave: Bodie, California, preservación del patrimonio cultural, cuidado colaborativo de sitio, ciencia ciudadana, aplicación móvil, monitoreo colaborativo de sitio, arqueología digital

PARTICIPATORY SITE STEWARDSHIP AS A COMPLEX AND EVOLVING SCENARIO

For decades, the Gold Rush town of Bodie has been a popular destination, visited by more than 100,000 visitors annually since

1990 (DeLyser 1999). Between 2011 and 2014, visitor counts increased steadily at a rate of an additional 1,000 visitors each year, a trend that has continued into recent years (DPR 2018; Figure 1). Although most visitors tend to focus on Bodie's 150 remaining structures, the built environment that exists today represents only 10% of the original 1870s settlement (Anthropological Studies Center 2015; Figure 2a).

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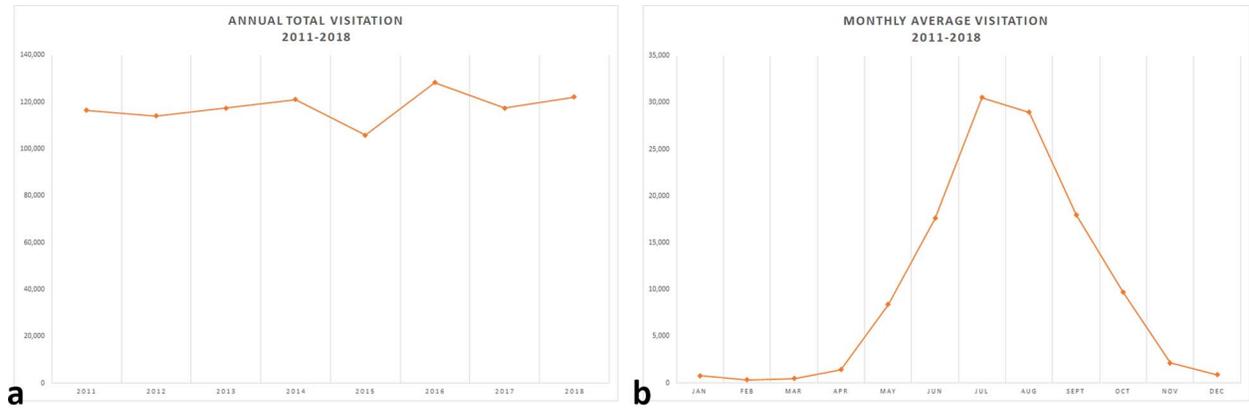


FIGURE 1. (a) Annual total visitation 2011–2018 and (b) monthly average visitation 2011–2018 at Bodie using data collected via DPR449 Form (Bodie State Historic Park Monthly Visitor Attendance Reports). Visitation data for April, May, October, and December 2015 is missing or was not recorded.

Like many sites of cultural significance, most of the information about Bodie exists in the form of scattered archaeological artifacts that, together with other features and ruins, collectively tell the stories of its past inhabitants. Evidence of Bodie’s past, however, is fast deteriorating because of the site’s increasing popularity. Visitors regularly remove objects from their original contexts, either taking them home as souvenirs or bringing them to park staff because they are concerned about the items disappearing. These actions incrementally remove important pieces of Bodie’s history, limiting our understanding of its past community and former residents. Moreover, prolonged drought, related wildfires, and a series of earthquakes in recent years have further exacerbated the site’s preservation, sustainability, and resilience issues.

These conservation concerns compound the complexities of balancing cultural tourism at Bodie and protecting its resources for generations to come, which is a ubiquitous problem affecting the management of sites of cultural significance worldwide.

We argue that citizen science and mobile apps specifically designed for site stewardship are viable tools for alleviating negative human impacts on cultural landscapes and enhancing our capacity to record and monitor sites of cultural heritage. To further the preservation and educational goals for sites and parks, in this study we apply the above-mentioned principles through the creation of the Citizen Preservationist (CitPres) app. CitPres is an open-source hybrid mobile/desktop software that can be utilized to engage visitors with training on the importance of preservation in place and community participation in site investigation and monitoring.

CITIZEN SCIENCE AS A TOOL FOR THE STUDY AND PRESERVATION OF THE PAST

Citizen science is a method of scientific inquiry in which a group of nonprofessional scientists volunteers time and effort in data collection, analysis, and dissemination at a scale that is not viable in traditional research (Haklay 2013:106). The recent exponential

growth in the number and scope of citizen science projects has been attributed to the increasing availability and affordability of mobile internet connections and location-aware devices that have enabled citizen scientists to collect field data that otherwise would be too time intensive, expensive, or outright impossible to research (Kim et al. 2013; Pew Research Center 2019; Pew Research Center’s Global Attitudes Project 2019).

Archaeological and heritage preservation projects have positively implemented citizen science and participatory activities to expand existing commitments to volunteer-based data collection and public engagement. Smith (2014:754–757) has identified four key spheres of application:

- (1) Large-scale participatory fieldwork research or mass heritage surveying/recording initiatives, including the numerous site stewardship programs developed by universities, nonprofit organizations and public agencies, such as the [Arizona Site Stewards Volunteer Program](#), [Nevada Site Stewardship Program](#), [California Archaeological Site Stewardship Program](#), [Texas Archeological Stewards](#), [Maine Midden Minders](#), and [Heritage Monitoring Scouts \(HMS Florida\)](#) projects in the United States (Kelly 2007; Musser-Lopez 2010); the [Rock Art CARE](#), [Portable Antiquities Scheme](#), and [CITIZAN](#) projects and the [SCAPE Trust](#) in the United Kingdom; or the various coastal archaeology programs that have worked with non-professional divers or beach visitors to conduct shoreline surveys and report on the state of preservation of underwater remains or the opportunistic exposure of shipwrecks (Dawson et al. 2020; Scott-Ireton and Moates 2019).
- (2) Web-based crowdsourced analysis, such as the web platforms [GlobalXplorer](#) and [TerraWatchers](#), which enable remote discovery of archaeological sites or the monitoring of at-risk cultural heritage in case of conflict, looting, or other anthropogenic hazards (Parcak 2019:219–222; Savage et al. 2017), or [Heritage Quest](#), which leverages crowd analysis of lidar data for site reconnaissance in forested landscapes.
- (3) Archaeological research enabled by crowdfunding, consisting of numerous archaeological projects worldwide receiving micro-donations through citizen science platforms, such as [Experiment](#), [SciStarter](#), and [Zooniverse](#); or purpose-built



FIGURE 2. (a) Drone-based view of the core of Bodie townsite, (b) view of the Standard Stamp Mill and nearby wooden structures on the hillside, and (c) view of remains associated with mining activities near the Roseclip Mine located in a hazardous zone closed to the public. Photograph (a) by Nicola Lercari; photographs (b) and (c) courtesy of Anaïs Guillem.

archaeological crowdfunding platforms, such as [Crowdfunding for Archaeology](#) and [DigVentures](#) (Piscitelli 2013).

- (4) Crowdsourced creation or annotation of digital collections and repositories of geotemporal, archaeological, cultural, and curatorial data in the cloud, such as [ARIADNEplus](#), the [Finnish Archaeological Finds Recording Linked Open Database \(SuALT\)](#), [MicroPasts](#), [Pleiades](#), [Google Ancient Places](#), and [Recogito](#) projects among many others (Bagnall et al. 2006; Harris 2012; Kansa 2012; Simon et al. 2017:20).

SITE STEWARDSHIP AND CITIZEN SCIENCE: COMMON GOALS AND PROBLEMATICS

Even though citizen science presents numerous benefits to site preservation and appreciation, enlisting casual visitors in

participatory site stewardship activities inherently introduces potential issues for the protection of sites. A major risk is that governmental agencies entrusted with managing sites may see this approach as a way to “outsource” preservation activities to the goodwill of local organizations or citizens in order to save money and/or address government funding shortfalls. To mitigate this problem, academics, heritage professionals, and other local stakeholders involved in implementing site stewardship through mobile-app-based citizen science need to assess the effects of their initiatives, making adjustments and changes as needed, and ensure that the proposed community-based participatory frameworks are not leveraged negatively (Adair et al. 2011; Atalay 2012; Frisch 2003; High 2009). Therefore, we believe that mobile-app-based citizen science must be used as a tool to increase cooperation between archaeologists, preservation specialists, park managers, community organizations, and visitors, which has long been identified as a priority by disciplinary experts and preservation professionals (Matero et al. 1998).

Additionally, asking casual visitors to record and monitor surface artifacts may prove problematic because it might encourage visitors to remove objects from their original contexts and increase illicit collection. Although this is a legitimate concern, we must also acknowledge that this issue is neither a direct consequence of citizen science nor the usage of mobile apps. It is instead a long-lived and ongoing problem affecting sites large and small where visitors can roam freely and interact with objects and buildings scattered through the cultural landscape. Significantly, the Portable Antiquities Scheme (PAS) project, initiated in England and Wales in the mid-1990s, has successfully tackled this issue by bringing together archaeologists and the public to record archaeological finds, de facto spearheading participatory heritage management through education (Bland 2009; Lewis 2016). Similarly, the LEARN Archaeology Expedition Program has provided best practices for training the visiting public on the importance of site preservation, context, and object curation (Reeves 2015). These initiatives have demonstrated that utilizing a team-based approach in which participants use their devices (e.g., a metal detector or cell phone) to conduct site stewardship increases the success of citizen science in archaeology. We therefore argue that, instead of working retroactively to mitigate artifact loss, site managers should allow the very people who travel to enjoy an archaeological site or historic park to participate and become educated in its preservation using citizen science.

A final consideration regarding the implementation of the proposed approach is related to uninformed visitors potentially engaging in erroneous observations and introduce poor-quality data on artifacts' material, size, and state of preservation to our database. Previous studies have emphasized verification of crowdsourced data collection and analysis and indicate that for citizen science to be a viable research tool, multiple layers of control must be in place (Gardiner et al. 2012:472–475; Lintott et al. 2008; Maisonneuve and Chopard 2012:121–123; Savage et al. 2017:69–73; Sullivan et al. 2014:2284–2285). The issue of data accuracy, standardization, and quality can be solved in mobile-based citizen science by enforcing mandatory user training, conducted either in person by local staff or via in-app video tutorials before users can begin collecting data. In-app data entry forms that include drop-down menus and instantaneous filtering can be used to minimize errors (e.g., any record where an artifact is recoded being larger than a specific size triggers a warning and precludes users from saving the data). Additional quality control methods include requiring users to complete data review before an observation is saved and having domain experts and trained algorithms conduct post-collection validation before final data curation.

We believe that the above strategies make a strong argument for mobile-app-enabled citizen science to become fully operational at sites of cultural significance. This allows staff to use the digital tools and datasets made possible by citizen science to conduct periodic site monitoring and rapidly intervene and take measures to protect an archaeologically significant area, a cluster of artifacts, or individual objects.

SITE AND RESEARCH BACKGROUND

The Gold Rush town of Bodie is a significant site of state and national heritage, considered the “finest example of a mining ghost town in the West” (Snell 1964:2). Bodie was designated as a

National Historic Landmark in 1961, and it became a California State Historic Park in 1962 (Felton et al. 1977). The park is located on the western boundary of the Great Basin Region (Figure 3), a vast hydrographic area in the arid western United States (Grayson 2006), and it encompasses a 2,900-acre historical landscape dotted with reminders of an industrial era long since abandoned (ca. 1859–1942).

Industrial remains, including mine shafts, tunnels, waste rock dumps, mill sites, tailings ponds, habitation sites, and other structures and objects, cover the hillsides (Figures 2b and 2c, above). The core of the Bodie townsite, as well as the surrounding mining zone, contain hundreds of ruins in the form of collapsed wooden buildings, cellar pits, privy holes, dumps, and broadcast refuse, which constituted the commercial and residential remains of the district's 7,000–8,000 former inhabitants (Piatt 2003:44).

Bodie still exists today in large part due to the guardianship of the J. S. Cain Company, a family-owned enterprise that purchased many of the abandoned buildings and lots in and around the town (Cain 1956:75–88). A caretaker for the company protected the remaining buildings from looters and vandals during periods of low mining and exploration activity between the 1930s and 1950s. Despite their efforts, the J. S. Cain Company and CSP, which acquired Bodie in the early 1960s, could not prevent the illicit collection of artifacts large and small (DPR 1960), and this issue has persisted to the present day. Therefore, it has become a high priority for CSP and the Bodie Foundation to develop new and effective digital preservation methods that not only allow amassing comprehensive geospatial data of Bodie in case the site is damaged or destroyed in the future but that also enhance recording and monitoring of surface artifacts in ways that do not limit access to popular locations and iconic buildings within the park.

Between 2015 and 2017, as part of the Bodie 3D Project, we partnered with CSP to collect comprehensive geospatial data utilizing both terrestrial light detection and ranging (t-lidar) and structure from motion (SfM) photogrammetry. We generated ultra-precise measurements and 3D models that can be used to inform future studies, conservation efforts, or physical reconstruction of the site (Lercari and Jaffke 2017). More specifically, we flew an unmanned aerial vehicle (UAV) over the entire townsite and recorded hundreds of close-range photographs and several 4K-resolution videos. We also used t-lidar to document with high accuracy and precision eight historic buildings, including the iconic Dechambeau Hotel, Hoover House, Railroad Depot, two buildings associated with mining operations, and the residences of a Chinese family and Native American family. We shared results with park managers and created a best-practice guide for built heritage documentation that was reviewed and accepted by California State Parks as the standard operating procedure for the department (Lercari and UC Merced HIVE Lab 2017).

We are aware, however, that to develop a viable and sustainable site stewardship program at Bodie, continuous and large-scale monitoring of buildings and archaeological remains must be implemented by engaging park visitors as partners. Consequently, we implemented solutions to the challenge of balancing preservation and current use by developing a mobile-app-based enhanced version of citizen science that involves the public in on-site training and collaborative recording and monitoring of the archaeological remains that define Bodie's cultural landscape. In 2019, we developed and field-tested the CitPres app with the

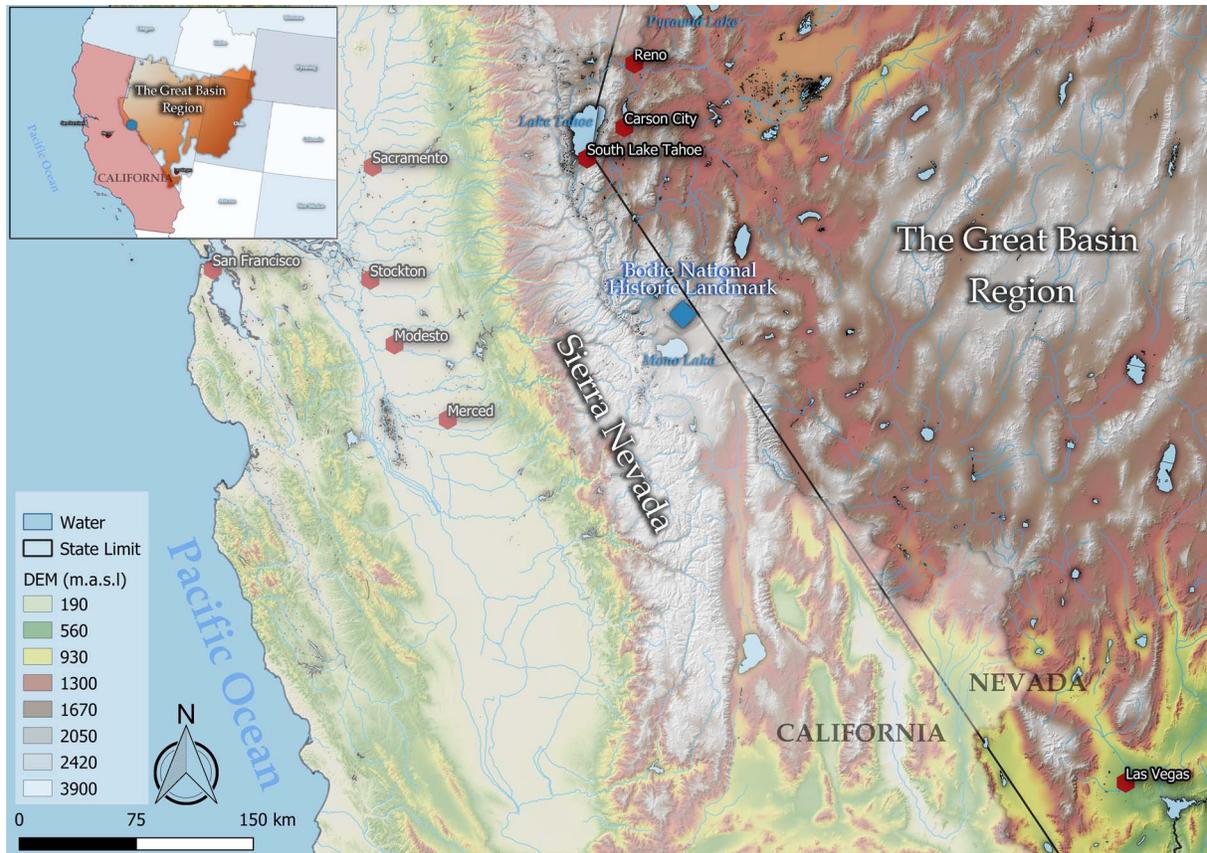


FIGURE 3. Map of eastern California showing Bodie’s location in relation to the hydrographic Great Basin Region and the western United States. Map courtesy of Manuel Dueñas Garcia.

intention of engaging an initial group of volunteers/beta testers in crowdsourced data capture and geospatial visualization of scattered artifacts. We contend that the significance of the proposed approach derives from the CitPres app’s unique ability to address the complexities of site preservation and conservation through community participation as well as its broad applicability at a variety of sites of cultural significance. To allow other scholars and heritage practitioners to test, verify, customize, and reuse the CitPres app, we released our software into the public domain via [GitHub](https://github.com).

METHODS

Implementing Site Stewardship through the Citizen Preservationist App and On-Site Training

The CitPres app is significant because it can be utilized to engage volunteers with documenting, monitoring, and visualizing surface artifacts at any site where the local staff is willing to partner with casual visitors to collectively preserve the cultural landscape (Figures 4a and 4b).

Our software supports both opportunistic data collection in the field and subsequent visual analysis through the following components:

- (1) CitPres DataCollector is a mobile app for the documentation of archaeological artifacts developed in Unity 3D using both custom C# code and Unity core functionalities. It features a high-contrast user interface to optimize outdoor use, photo taking, video training, and metadata recording capabilities.
- (2) CitPres Map is a desktop app developed in Unity for rapidly ingesting photographs, geospatial data, and metadata produced by our DataCollector that enables interactive data visualization through a monitor, TV, or touch display. The advantage of developing our software in Unity is that this cross-platform development ecosystem provided us with the financial and structural efficiency of building a single version of each component of the app and then making it easily available to multiple operating systems (i.e., Android and iOS in the case of DataCollector, and Win10 and macOS in the case of Map).

All of CitPres’s components can be downloaded from our [GitHub](https://github.com) repository and then deployed locally with the support of local staff. This approach ensures that CitPres can be used at sites where cell phone coverage or Wi-Fi is unreliable or unavailable. It also allows archaeologists and park managers to have more control over who can use the app and when, which allows them to enforce stricter rules about training users must take before they can start collecting data. More specifically in our case study,

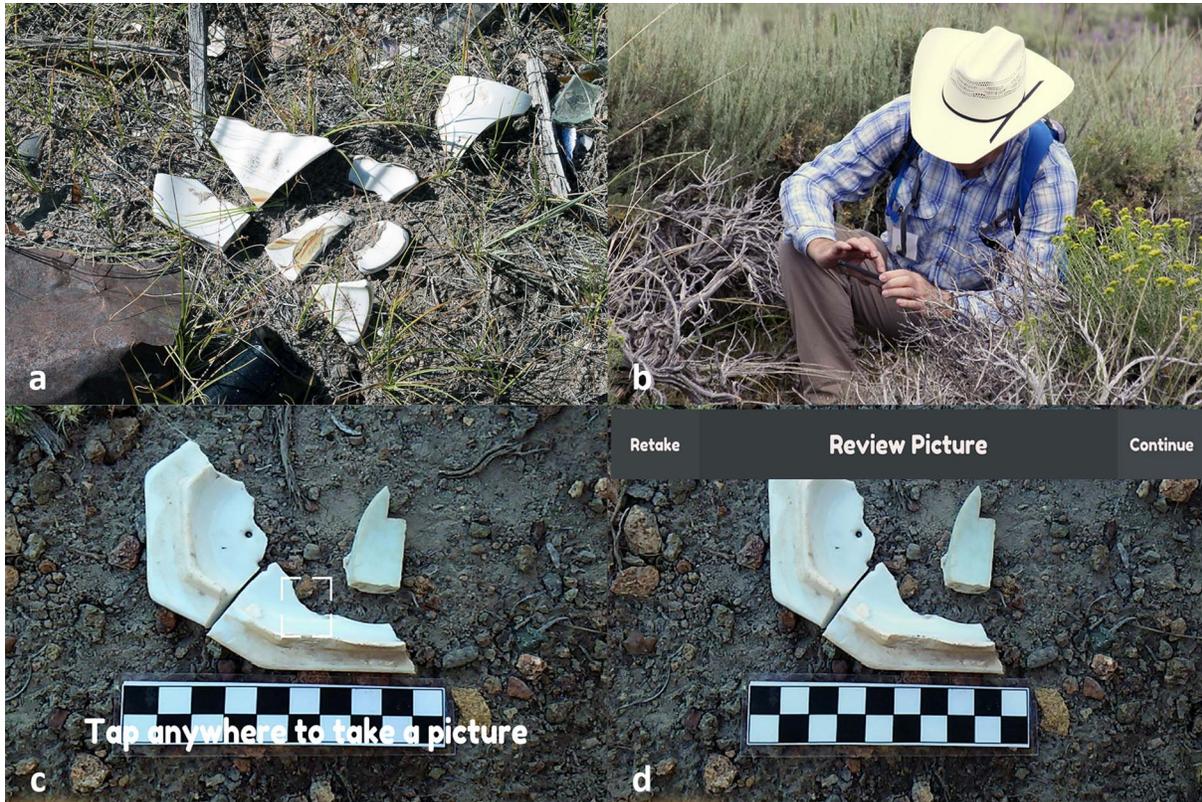


FIGURE 4. (a) Cluster of artifacts in their original context, (b) citizen preservationist using the CitPres app in 2019, (c) screenshot of the photo feature in the CitPres DataCollector app, and (d) screenshot of the photo review feature in the DataCollector app. Photographs by Nicola Lercari.

required training for volunteers is delivered via in-person sessions—but an in-app video training option is also available for volunteers to review while in the field. Our training focuses on the importance of in situ object collections to reconstruct and preserve the histories and daily lives of Bodie’s average resident, which depend on preservation in place. Then, users learn about specific historic archaeology materials at Bodie (i.e., ceramic, fabric, glass, leather, metal, etc.) as opposed to prehistoric materials (i.e., bone, stone, etc.), which would require additional consultation and permission from local tribal partners and governments and which are outside the scope of our study. Additionally, users learn the importance of providing a dimensional reference in the collected data, and they are instructed to carry multiple plastic scales while taking pictures on-site (Figures 4c and 4d).

At any location where CitPres DataCollector is deployed, trained volunteers can explore the site at their own pace and take photos of artifacts they find on the surface. Volunteers are also tasked with describing each photographed artifact directly in the app and adding additional metadata (Figure 5a and 5b, below). The final data-capture step requires volunteers to review, validate, and submit each record (Figures 5c and 5d). After this step is complete, our DataCollector securely stores the photos and metadata on the device without the need of an internet connection. At the end of each data collection session, volunteers must report back to local staff, who collect and ingest recorded pictures and

metadata into a local geographic information system (GIS) or database of surface artifacts.

Data Entry Form, Metadata, and Geotagging

CitPres DataCollector facilitates artifacts’ description through an in-app data entry form consisting of several drop-down menus that ensures standardization for most of the metadata and minimizes errors (Figure 5). To ensure data conformance with widely adopted standards for artifacts from the mid-nineteenth to early twentieth century, we utilized fields, categories, and terminology listed in the Sonoma Historic Artifact Research Database (SHARD; Gibson and Praetzellis 2009). Additionally, our app features metadata elements codified by the Dublin Core Metadata Initiative (DCMI) to ensure easier ingestion in digital asset management and curation platforms such as Nuxeo or long-term preservation in online repositories. Importantly, the DataCollector’s entry form and metadata schema can be customized to any specific case study by modifying the app’s source code in Unity. Table 1 lists the metadata elements we used at Bodie.

Most significantly, to support preservation in place, CitPres DataCollector geotags and dates the collected photos. To ensure confidentiality, an artifact’s location and metadata are recorded in a JavaScript Object Notation (JSON) file not visible to the users. At any time, local staff can bulk download these JSON files

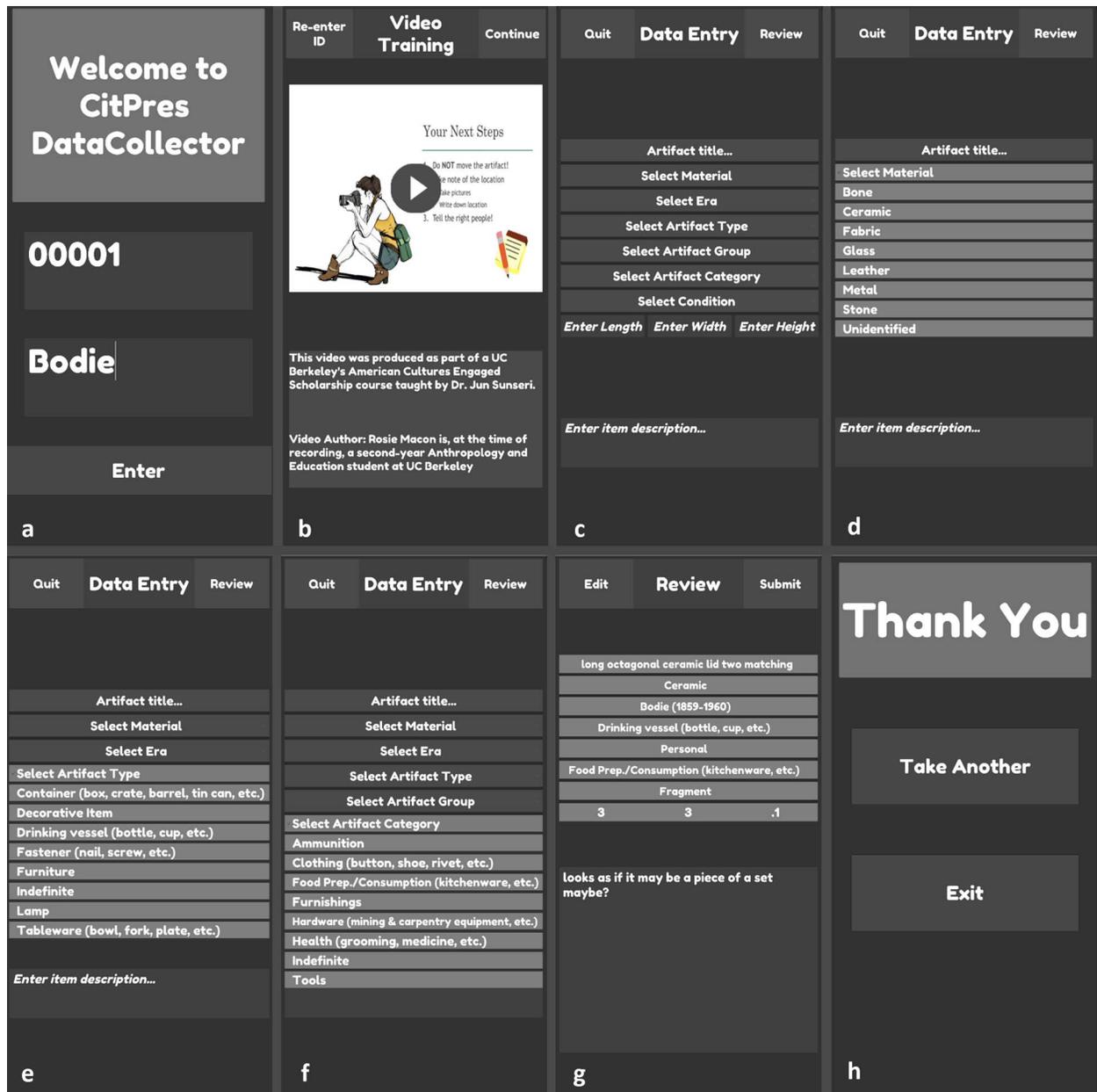


FIGURE 5. Screenshots of the DataCollector app displaying (a) filled-out welcome page showing volunteer ID and place name, (b) video training page, (c) empty data entry form, (d) data entry form showing material drop-down menu, (e) data entry form showing artifact type drop-down menu, (f) data entry form showing artifact category drop-down menu, (g) metadata review page, and (h) data-saving confirmation page.

organized by the recording date. Each JSON includes a binary version of the artifact’s photograph as well as metadata. Recordings can then be batch converted into images (e.g., JPEG) and spreadsheets (e.g., CSV) using our Convert and Save Python script, which is also downloadable from our GitHub. After the conversion is completed, local staff can analyze the collected data using a GIS or our CitPres Map desktop application. Volunteers can keep copies of the photos in their own device’s default picture gallery, but any location data or metadata is excluded.

Through the Convert and Save script and CitPres Map app, we aim to provide archaeologists and preservationists with viable tools to create a geodatabase that grows through time and records a dynamic map of a site’s cultural landscape, made possible through the analysis of the data captured by citizen preservationists (Figures 6a–6c). Significantly for participatory site stewardship, CitPres Map can be also used for public-facing visualization and outreach at a site’s visitor center to increase public engagement and potentially recruit

Table 1. List of the SHARD, Dublin Core, and Nuxeo Metadata Elements Used in CitPres DataCollector.

Metadata Element	Type	Hidden from User	Entry Example
Access Restrictions	Nuxeo	Y	UC Merced only
Campus/Unit	Nuxeo	Y	UC Merced Library and Special Collections
Rights	Dublin Core	Y	Material in the public domain: This work has been created by citizen preservationists under a joint project developed by the University of California, Merced and the California Department of Parks and Recreation. No modifications should be made. Users of this work should not remove any public domain mark or this rights statement. The trademarks, name, or logos of the University of California, Merced and/or the California Department of Parks and Recreation should not be used to endorse (or imply origin of) the public domain work without written consent. Suggesting tagging, annotation, or commenting on this work is welcome.
Copyright Status	Nuxeo	Y	Public domain
Creator	Dublin Core	Y	Anonymous
Date	Dublin Core	Y	2020-05-18
Description 1	Dublin Core	N	This is a small glass bottle, which I found broken in two parts. Color is dark green. There is a small label engraved in the larger fragment saying Pierce Bros., which may refer to the bottle manufacturer.
Description 1 Type	Nuxeo	Y	scopecontent
Description 2	Nuxeo	Y	This artifact was recorded by citizen preservationists via the CitPres app with the authorization of California State Parks.
Description 2 Type	Nuxeo	Y	Acquisitions
Extent	Nuxeo	N	3 × 4 × 10 × cm
Identifier	Dublin Core	Y	v0005_83ae1e74bace943b955a55980b112a07
Language	Dublin Core	Y	English
Language Code	Nuxeo	Y	eng
Place 1 Authority ID	Nuxeo	Y	LCNAF
Place 1 Coordinates	Nuxeo	Y	Coordinates hidden to protect location confidentiality
Place 1 Name	Nuxeo	N	Bodie (Calif.)
Subject	Dublin Core	Y	This artifact is property of California Department of Parks and Recreation
Subject (Name) 1 Name Type	Nuxeo	Y	Local
Coverage	Dublin Core	N	Bodie (1859–1960)
Title	Dublin Core	N	Glass bottle
Type	Dublin Core	Y	Image
Artifact Group	SHARD	N	Domestic
Artifact Type	SHARD	N	Drinking vessel
Condition	SHARD	N	Complete/Fragment
Artifact Category	SHARD	N	Food Prep./Consumption
Material	SHARD	N	Glass

new volunteers while protecting the exact position of the artifacts.

Supplemental Text 1 provides high-level pseudocode as a reader’s guide for nonprogrammers to understand the distinct functionalities of the CitPres app.

RESULTS

We conducted beta testing of the CitPres app in the summer of 2018 and verified the viability of the participatory data collection and visualization features. After this research received institutional review board (IRB) approval in 2019, we developed an on-site

preservation and awareness program, in collaboration with California State Parks and the CSP Foundation’s Volunteer Program, that involved participants in testing the CitPres app and assessing the effectiveness of this initiative.

Participants consented to data capture and survey/focus group activities that were utilized to assess the CitPres app and the on-site training. Ten volunteers were randomly recruited via the CSP Foundation’s [website](#). They participated in a two-day program that tasked citizen preservationists with surveying a portion of the Bodie townsite and collecting data using our app (Figure 6). All participants were 18 years old or older. None were professional archaeologists or heritage practitioners, but all expressed great interest in California heritage and site



FIGURE 6. The CitPres Map desktop application allows park managers, archaeologists, and visitors to visualize data captured via CitPres DataCollector app: (a) shows data collected by citizen preservationists on the first day of a two-day session at Bodie in 2019, (b) shows data collected on the second day, and (c) shows all data collected during the session.

Table 2. List of Questions Used to Assess the Site Stewardship Program and CitPres with Selected Responses.

Question	Responses
<p>1. In what ways do you think this type of citizen science activity enriches the visitor experience?</p>	<ul style="list-style-type: none"> o "It was satisfying to take photos and think about who discarded these items so long ago." o "This activity could be adapted and incorporated into school curriculums as well as the Junior Ranger Program." o "There's a disconnect between kids visiting historical sites. Using this app might bring past and present together."
<p>2. How do you feel about Parks soliciting help from visitors to document and monitor archaeological resources?</p>	<ul style="list-style-type: none"> o "Need for quality control and providing information that serves both professional and volunteer archaeologists." o "It would entail safety concerns (e.g., proper footwear, contact with mining residual chemicals and other hazards)." o "Developing partnerships with local school districts." o "Encourages people to go off trail where people don't otherwise go. Overall concern about further damaging archaeological resources."
<p>3. Suppose you had one minute to describe the purpose/benefit of this project to the preservation of Bodie, what would you say?</p>	<ul style="list-style-type: none"> o "Historical sites like Bodie should include cultural stories of all ethnic groups that once lived and worked here" [e.g., Chinese, Hispanics, Native Americans].
<p>4. Do you feel more connected to Bodie and artifacts after participating in this type of experience?</p>	<ul style="list-style-type: none"> o "I felt that when I was taking the photos of the artifacts, I was thinking about my descriptions. . . . It made the artifact itself more interesting and more personal to me." o "Kids would better engage with Bodie using this type of app. It would help to connect them to the past and in turn they would learn to care and support these historic sites." o "I feel more connected to Bodie after participating in this volunteer event." o "I got more out of the experience than what I would have if I were to take an artifact."
<p>5. There's been a long-term practice of collecting artifacts from archaeological sites to serve as mementos for visitors. What would be your recommendation to change this attitude toward cultural heritage sites?</p>	<ul style="list-style-type: none"> o "Sell [artifact] reproductions at the Visitor Center." o "Start by changing the mindset of young people. They can share their experience with others and they start to influence change." o "Taking pictures and the experience of contributing to preserve Bodie mean more than taking objects home that ultimately get thrown in the trash and end up in a landfill." o "Need to build the app so people can keep the photos without location information, including a summary of their text entries."
<p>6. What is the most important aspect you learned about preserving Bodie's Cultural Landscape?</p>	<ul style="list-style-type: none"> o "We all have our phones. Let's use that device to foster preservation." o "I take my granddaughter places and tell her about history and [with this app] she can share what she learned with friends." o "It permeates the culture." o "I'm just a big kid, a really old big kid, and to me, it was exciting. I'm part of something and can pass it on and share it." o [about using this app] "It's more engaging and it was fun." o "Our phones are personal. The device bridges the gap between the user and an artifact from another century. Using your own phone as a tool connects the two." o "Exposing people to sensitive resources is risky, and you want some kind of accountability. Recommend a 'citizen watch' approach."
<p>7. Suppose you had one minute to describe the purpose/benefit of this app to the preservation of Bodie, what would you say?</p>	<ul style="list-style-type: none"> o "Connects people to the park in a new, refreshing way." o "Connects the younger generation to history." o "Teaches archaeological concepts." o "Shows value of provenance to discourage looting." o "Targets tech-savvy youth."

(Continued)

Table 2. Continued

Question	Responses
	<ul style="list-style-type: none"> o [Encourages] "Take Only Picture." o "To record, photograph, and log artifacts for a better understanding of different ethnic groups in Bodie and their locations in town." o "App would allow visitors to engage in research at the park." o "Sparks curiosity and encourages kids to explore park." o "Documentation provides depth to the Bodie story." o The app serves two distinct purposes: (1) training volunteers to map using this technology and (2) training the public and "maybe changing the relationship the public has with artifacts they're finding." The app would work well for both.
<p>8. How do you suppose this citizen science app helps (if at all) with educating the public about the importance of <u>NOT</u> collecting artifacts from archaeological sites?</p>	<ul style="list-style-type: none"> o "I do not see it accomplishing the goal. It might increase temptation to take items." o "Ability to take pictures rewards the user" [compared to taking artifacts]. o "It makes me feel more involved in preserving historic sites and probably more accountable as a result." o "Allows you to focus on individual items and their importance to the preservation of a site." o "Permits visitors to keep an image instead of being tempted to take an artifact." o "Could help people appreciate and share the find but folks like to collect (gatherer instinct)." o "The excitement of finding an artifact would either cause the person to leave it for someone else to find or pick it up and put it in their pocket." o "App refocuses users to locate the artifact and creates a new behavior."
<p>9. Think about when you collected data via the app. What did you like best about it?</p>	<ul style="list-style-type: none"> o "It made me think about the past." o "Discovering new finds." o "Step-by-step workflow." o "GPS location is automatic with photo." o "Utilizes tools user is already familiar with." o "Easy to use." o "Enjoyed taking images and being able to use my smartphone to document artifacts versus using a clipboard and handwriting descriptions." o "Fairly easy to use." o "The adventure of the hunt but in a preservation setting, not extraction. Categorizing makes you think about how items were used and how we have evolved."
<p>10. Does using this app allow you to gain better insight into the nature of documenting artifacts? Can you give examples?</p>	<ul style="list-style-type: none"> o "It helps looking at the many aspects of the artifact." o "How has the century-long practice of collecting [data] distorted what we know about the past?" o "Encourages thinking about how to categorize an object." o "Various fields prompt user for relevant attributes." o "Emphasizes importance of location." o "Makes you aware of small items you may not have noticed before and realize their importance." o "Drop-down menus help." o "Having to enter the size [of an artifact] helped remind me to put the scale in the photo." o "Appreciation of small details (e.g., maker's marks)." o "Most people would have trouble identifying what they're looking at and why." o [The app] "Has increased awareness of location and how people lived."

stewardship. Notably, six participants had previously attended other site stewardship activities organized by our partners with the CSP Foundation.

The objectives of this initiative were twofold. First, we intended to evaluate public perceptions of active stewardship and protection of Bodie's cultural landscape. Second, we tested the CitPres app for overall performance and utility. The results of an end-of-program assessment conducted using group interviews and written surveys are presented in [Table 2](#).

DISCUSSION

Although limited in scope and not statistically significant, the responses collected from user study participants in 2019 corroborate our claim that the CitPres app has the potential to engage casual visitors, enabling them to collect archaeological data and contribute to site preservation ([Table 2](#), Questions 1 and 4). Responses show that, on an individual level, citizen preservationists enjoyed participating in our pilot training program at Bodie and using the CitPres app. Spending time recording artifacts using the app allowed participants to imagine the experiences of people who once lived and worked in this mining town, and volunteers expressed a deeper awareness of the value of archaeology and appreciation for the history its practice conveys.

Although several participants voiced concerns that the app would encourage illegal artifact collection ([Table 2](#), responses to Questions 6 and 8), most expressed overall support and emphasized the benefits of asking visitors to assist with building an archaeological database of the site for future interpretation and monitoring efforts. In most cases, they explicitly stated they felt more personally connected to Bodie after using our DataCollector to collect archaeological data ([Table 2](#), responses to Questions 4 and 6). Importantly, the participatory approach proposed here has the potential to foster a more inclusive way of encouraging the visiting public to explore ethnically diverse histories of the past. Many interpretations of U.S. West mining sites like Bodie have overlooked the experiences of its Chinese, Hispanic, and Native American inhabitants ([Table 2](#), Question 3). When citizen science-based initiatives become available to all visitors, we believe this exposure will present more opportunities to involve participants from diverse backgrounds in exploring the stories about Bodie's past that can usually only be researched and appreciated through direct archaeological investigation.

These observations highlight some of the most important aspects of our approach: making heritage preservation more personal, engaging, and inclusive, along with using readily available technologies, establishes a stronger bond between the public and the cultural and archaeological landscapes we wish to preserve. More broadly, responses show that participants felt a sense of pride knowing that they contributed to the preservation of a significant cultural heritage site. They might share their participation and artifact pictures on social media, which not only informs their friends and family of their trip to the site but also carries the message of site preservation and stewardship beyond the park and its visitors. In other words, inviting the public to participate actively creates a win-win situation for managers and visitors alike.

Furthermore, to make participatory site stewardship more transparent and highlight the value of participants' contributions, we plan to make the data collected by our volunteers at Bodie publicly available via dynamic visualizations inside the park's visitor center through CitPres Map. Finally, to guarantee use, preservation, and broader access to the data produced by citizen preservationists at Bodie, we are also considering the possibility of publishing a curated digital collection of the site's historical archaeology artifacts collected by our volunteers—including all validated data but the location—in an open access repository such as [Calisphere](#). This is an online gateway to California's digital collections powered by the California Digital Library, which also automatically feeds data into the national online open-access repository of the Digital Public Library of America and which will ultimately guarantee long-term sustainability to our archaeological record.

CONCLUSIONS

This article reviewed the implementation of a pilot outreach and training program focusing on participatory site stewardship at Bodie that uses the Citizen Preservationist app. We demonstrated that the proposed approach plays a vital role in increasing awareness and civic engagement around heritage preservation and helps produce participatory documentation with the goal of monitoring vast cultural landscapes.

The initial field testing of the CitPres app shows that volunteers found our software easy and fun to use, contributing to the app's potential to enable participatory preservation of Bodie's archaeological resources and further application to other sites presenting similar preservation issues. Because the first iteration of our on-site training program with volunteers yielded positive results, we believe that the next step is to further evaluate and optimize the CitPres app by involving a larger number of volunteers at Bodie. Consequently, we are currently developing a partnership with local organizations such as the [Tahoe Center of the California Conservation Corps](#) to expand and diversify the pool of interested volunteers and advance our understanding of mobile-app-based citizen science specifically designed for advancing participatory documentation and monitoring of historical archaeology sites.

Our results suggest that visitors can use smartphones loaded with the CitPres DataCollector app to collaborate with park managers and provide an increased number of observations and data at a scale that would otherwise be difficult or impossible to acquire. Therefore, we believe that the proposed approach has the potential to further increase cooperation between archaeologists, park managers, and visitors in reducing the complexities of balancing cultural tourism at Bodie and protecting its resources for generations to come.

We found that the critical component that guarantees the success of the proposed mobile-app-based participatory site stewardship and of any archaeological citizen science project is educating the public about heritage preservation ethics and the methods used by professional and academic archaeologists. It is fundamental that visitors understand the value of archaeological context and preservation in place and the importance of sustainable conservation of a site's cultural landscape to preserve its historic fabric or archaeological signature. Participatory efforts that build a long-term research dataset will create a legacy of information about

Bodie that will help future visitors, researchers, and managers to explore, preserve, and interpret this unique site. More broadly, it is hoped that the CitPres app can provide an innovative model for site stewardship and heritage preservation that engages the public in both the preservation and appreciation of cultural heritage sites in the western United States as well as other cultural areas presenting similar issues of illicit artifact collection and complex site monitoring.

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Data Availability Statement

No original data were presented in this article beyond a selection of participants' responses listed in Table 2.

Supplemental Material

For supplemental material accompanying this article, visit <https://doi.org/10.1017/aap.2020.29>.

Supplemental Text 1. High-level pseudocode for nonprogrammers.

REFERENCES CITED

Adair, Bill, Benjamin Filene, and Laura Koloski
 2011 *Letting Go? Sharing Historical Authority in a User-Generated World*. Pew Center for Arts and Heritage, Philadelphia, Pennsylvania.
 Anthropological Studies Center
 2015 *Cultural Resources Inventory of Bodie Townsite*. California Department of Parks and Recreation, Sierra District, Sacramento.
 Atalay, Sonya
 2012 *Community-Based Archaeology: Research with, by, and for Indigenous and Local Communities*. University of California Press, Berkeley.

Bagnall, Roger, Richard Talbert, Sarah Bond, Jeffrey Becker, Tom Elliott, Sean Gillies, Ryan Horne, Michael McCormick, Adam Rabinowitz, Elizabeth Robinson, and Brian Turner
 2006 *Pleiades: A Community-Built Gazetteer and Graph of Ancient Places*. Electronic document, <http://pleiades.stoa.org>, accessed August 2, 2019.
 Bland, Roger
 2009 *The Development and Future of the Treasure Act and Portable Antiquities Scheme*. In *Metal Detecting and Archaeology*, edited by Suzie Thomas and Peter G. Stone, 2:63–86. Heritage Matters Series. Boydell Press, Woodbridge, UK.
 Cain, Ella M. Cody
 1956 *The Story of Bodie*. Fearon, San Francisco, in cooperation with Mother Lode Press, Sonora, California.
 Dawson, Tom, Joanna Hambly, Alice Kelley, William Lees, and Sarah Miller
 2020 Coastal Heritage, Global Climate Change, Public Engagement, and Citizen Science. *Proceedings of the National Academy of Sciences of the United States of America* 117:8280–8286.
 DeLyser, Dydia
 1999 Authenticity on the Ground: Engaging the Past in a California Ghost Town. *Annals of the Association of American Geographers* 89:602–632.
 DPR
 1960 *Appraisal Survey of Bodie Property Prior to Acquisition*. California Department of Parks and Recreation, Sacramento.
 2018 Bodie SHP Monthly Attendance Records - DPR Form 449 - Internal Document. California Department of Parks and Recreation, Sacramento.
 Felton, David L., Francis Lortie, Kathleen Davis, and Leslie Lewis
 1977 *The Cultural Resources of Bodie State Historic Park*. California Department of Parks and Recreation, Sacramento.
 Frisch, Michael
 2003 Commentary: Sharing Authority: Oral History and the Collaborative Process. *Oral History Review* 30(1):111–113.
 Gardiner, Mary M., Leslie L. Allee, Peter M. J. Brown, John E. Losey, Helen E. Roy, and Rebecca Rice Smyth
 2012 Lessons from Lady Beetles: Accuracy of Monitoring Data from US and UK Citizen-Science Programs. *Frontiers in Ecology and the Environment* 10:471–476.
 Gibson, Erica, and Mary Praetzelis
 2009 *Sonoma Historic Artifact Research Database (SHARD)*. Anthropological Studies Center (ASC), Sonoma State University, Sonoma, California.
 Grayson, Donald K.
 2006 The Late Quaternary Biogeographic Histories of Some Great Basin Mammals (Western USA). *Quaternary Science Reviews* 25:2964–2991.
 Haklay, Muki
 2013 Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation. In *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*, edited by Daniel Sui, Sarah Elwood, and Michael Goodchild, pp. 105–122. Springer, Dordrecht, Netherlands.
 Harris, Trevor M.
 2012 Interfacing Archaeology and the World of Citizen Sensors: Exploring the Impact of Neogeography and Volunteered Geographic Information on an Authenticated Archaeology. *World Archaeology* 44:580–591.
 High, Steven
 2009 Sharing Authority: An Introduction. *Journal of Canadian Studies* 43(1):12–34. DOI:10.3138/jcs.43.1.12.
 Kansa, Eric
 2012 Openness and Archaeology's Information Ecosystem. *World Archaeology* 44:498–520.
 Kelly, Sophia
 2007 *Technical Brief 22: Developing and Implementing Archeological Site Stewardship Programs*. DOI Departmental Consulting Archeologist/NPS Archeology Program, National Park Service, Washington, DC.
 Kim, Sunyoung, Jennifer Mankoff, and Eric Paulos
 2013 Sensr: Evaluating a Flexible Framework for Authoring Mobile Data-Collection Tools for Citizen Science. In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*, pp. 1453–1462. CSCW '13. ACM, New York.

- Lercari, Nicola, and UC Merced HIVE Lab
2017 *Heritage Digital Documentation: Guides to Good Practices*. California Department of Parks and Recreation, Sacramento.
- Lercari, Nicola, and Denise Jaffke
2017 Bodie 3D Project: Best Practices for Heritage Digital Documentation at Bodie SHP. Paper presented at the Society for California Archaeology 2017 Annual Meeting, Fish Camp, California.
- Lewis, Michael
2016 A Detectorist's Utopia? Archaeology and Metal-Detecting in England and Wales. *Open Archaeology* 1. DOI: [10.1515/opar-2016-0009](https://doi.org/10.1515/opar-2016-0009).
- Lintott, Chris J., Kevin Schawinski, Anže Slosar, Kate Land, Steven Bamford, Daniel Thomas, M. Jordan Raddick, Robert C. Nichol, Alex Szalay, Dan Andreescu, Phil Murray, and Jan Vandenberg
2008 Galaxy Zoo: Morphologies Derived from Visual Inspection of Galaxies from the Sloan Digital Sky Survey. *Monthly Notices of the Royal Astronomical Society* 389:1179–1189.
- Maisonneuve, Nicolas, and Bastien Chopard
2012 Crowdsourcing Satellite Imagery Analysis: Study of Parallel and Iterative Models. In *Geographic Information Science*, edited by Ningchuan Xiao, Mei-Po Kwan, Michael F. Goodchild, and Shashi Shekhar, pp. 116–131. Lecture Notes in Computer Science. Springer Science+Business Media, Berlin.
- Matero, Frank, Kecia L. Fong, Elisa Del Bono, Mark Goodman, Evan Kopelson, Lorraine McVey, Jessica Sloop, and Catherine Turton
1998 Archaeological Site Conservation and Management: An Appraisal of Recent Trends. *Conservation and Management of Archaeological Sites* 2:129–142.
- Musser-Lopez, Ruth Arlene
2010 Ancestral and Modern Site Stewardship in the Mojave Desert. In *Proceedings of the Society for California Archaeology Volume 24: Papers presented at the 44th Annual Meeting of the Society for California Archaeology, Riverside, California, March 17–20, 2010*, pp. 1–13. Society for California Archaeology, Chico.
- Parcak, Sarah H.
2019 *Archaeology from Space: How the Future Shapes Our Past*. Henry Holt, New York.
- Pew Research Center
2019 Demographics of Mobile Device Ownership and Adoption in the United States. Electronic document, <https://www.pewinternet.org/fact-sheet/mobile/>, accessed August 2, 2019.
- Pew Research Center's Global Attitudes Project
2019 Smartphone Ownership Is Growing Rapidly around the World, but Not Always Equally. Electronic document, <https://www.pewresearch.org/global/2019/02/05/smartphone-ownership-is-growing-rapidly-around-the-world-but-not-always-equally/>, accessed August 2, 2019.
- Piatt, Michael H.
2003 *Bodie: "The Mines Are Looking Well . . .": The History of the Bodie Mining District, Mono County, California*. North Bay, El Sobrante, California.
- Piscitelli, Matthew
2013 Using Social Networks to Fundraise: Crowdfunding for the Archaeologist. *SAA Archaeological Record* 13(4):36–39.
- Reeves, Matthew
2015 Sleeping with the "Enemy": Metal Detecting Hobbyists and Archaeologists. *Advances in Archaeological Practice* 3:263–274.
- Savage, Stephen H., Andrew Johnson, and Thomas E. Levy
2017 TerraWatchers, Crowdsourcing, and At-Risk World Heritage in the Middle East. In *Heritage and Archaeology in the Digital Age*, edited by Matthew L. Vincent, Víctor Manuel López-Menchero Bendicho, Marinos Ioannides, and Thomas E. Levy, pp. 67–77. Quantitative Methods in the Humanities and Social Sciences. Springer International, Cham, Switzerland.
- Scott-Ireton, Della A., and Jeffrey T. Moates
2019 Shipwrecks and Sport Divers: Florida's Programs in Participatory Preservation Underwater. In *Transforming Heritage Practice in the 21st Century: Contributions from Community Archaeology*, edited by John H. Jameson and Sergiu Musteață, pp. 161–171. One World Archaeology. Springer International, Cham, Switzerland.
- Simon, Rainer, Elton Barker, Leif Isaksen, and Pau De Soto Cañamares
2017 Linked Data Annotation without the Pointy Brackets: Introducing Recogito 2. *Journal of Map & Geography Libraries* 13:111–132.
- Smith, Monica L.
2014 Citizen Science in Archaeology. *American Antiquity* 79:749–762.
- Snell, John Bernard
1964 *Early Railways*. Putnam, New York
- Sullivan, Brian L., Jocelyn L. Aycrigg, Jessie H. Barry, Rick E. Bonney, Nicholas Bruns, Caren B. Cooper, Theo Damoulas, André A. Dhondt, Tom Dietterich, Andrew Farnsworth, Daniel Fink, John W. Fitzpatrick, Thomas Fredericks, Jeff Gerbracht, Carla Gomes, Wesley M. Hochachka, Marshall J. Iloff, Carl Lagoze, Frank A. La Sorte, Matthew Merrifield, Will Morris, Tina B. Phillips, Mark Reynolds, Amanda D. Rodewald, Kenneth V. Rosenberg, Nancy M. Trautmann, Andrea Wiggins, David W. Winkler, Weng-Keen Wong, Christopher L. Wood, Jun Yu, and Steve Kelling
2014 The eBird Enterprise: An Integrated Approach to Development and Application of Citizen Science. *Biological Conservation* 169:31–40.

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