This text is the script of a webinar program that was presented on February 8, 2018, as part of the "Climate Change in America's National Parks Webinar Series" from the National Park Service's Climate Change Response Program.

Slides to accompany the script are available here: http://ux.opencontext.org/wp-content/uploads/2018/02/Anderson-etal-DINAA-NPS-Webinar-08Feb-2018-slides.pdf

The full video of the webinar is available here: https://youtu.be/r_yMpq7X3qU

Learn more about the Digital Index of North American Archaeology (DINAA) project here: http://ux.opencontext.org/archaeology-site-data/

SLIDE *TITLE

Protecting American Heritage through Linked Data: Using DINAA as a Guide in a Changing World

David G. Anderson, Eric C. Kansa, Sarah W. Kansa, Joshua J. Wells, and Stephen J. Yerka

Hi… I'm Dave Anderson, speaking on behalf of our DINAA project team… Eric and Sarah Kansa are here with us online and will be available to jump in as needed, and for the Q&A session after the formal part of the talk. Two of our team send regrets… Josh Wells had to teach and Steve Yerka is in a tribal consultation meeting as we speak. The five of us, furthermore, are just the tip of an iceberg that involves many people, a team effort, involving the help and support of many state, federal and tribal partners, and many researchers.

Finally, we'd like to thank our colleagues at the National Park Service, and Marcy Rockman and Matt Holly in particular, for the invitation to participate in this series, and for technical help with our research and this presentation.

SLIDE *SEA LEVEL RISE GOOGLE MAPS

In recent years, concerns about the damaging effects of anthropogenic global climate change have been amplified by the increasing frequency of destructive weather events, including large-scale wildfires and droughts, hurricanes and storm surges, and flooding.

The vast preponderance of scientific evidence, furthermore, indicates sea levels will rise appreciably over the next several centuries, by ca. 1 meter by the end of this century, by at least 3-5 meters or more in the 22nd century, and by unknown but potentially very large amounts thereafter, in the absence of effective efforts to ameliorate the underlying causes.

SLIDE* DINAA ORANGE MAP OF EASTERN US

In this presentation we show how linking together archaeological and historic data at a large scale can be a powerful tool, not only for studying human life in the past, but also for evaluating possible developments in the future, and planning for their mitigation.

SLIDE *REPORT COVERS

While the importance of climate change has been questioned in some quarters, many private organizations as well as state and federal agencies like the National Park Service and the Department of Defense, to name a few, are taking the matter seriously, with significant effort directed to exploring how to preserve and protect our country's heritage and infrastructure from climate-related effects.

SLIDE *GRAND CHALLENGES

The archaeological record in the United States is one of the most extensive in the world, with millions of sites and historic properties professionally reported, many with extensive associated collections, records, and reports. Some of the top archaeologists in the profession have argued that compiling and linking this information digitally, for research, resource management, and public education purposes, is one of the truly great challenges facing our profession.

SLIDE *GEORGIA MIDDLE WOODLAND SITES

As this map of Georgia Middle Woodland sites and mounds shows, some individual states and land managing agencies have done a superb job of compiling and integrating these records, many in sophisticated GIS linked databases.

SLIDE *GEORGIA LATE WOODLAND SITES

Such data are invaluable for examining settlement change in the past, as these examples from Georgia show, documenting the changes that can occur in settlement over just a few hundred years, sometimes in response to changes in climate, vegetation, or in technology and social organization.

Vast archaeological and historic datasets are maintained by state and federal agencies and individual installations,

SLIDE *FORT POLK SITE MAP

like this example from Fort Polk, Louisiana, where over 4000 sites have been recorded. Only rarely, however, has this data been combined, that is, rendered interoperable at larger geographic scales. Typically such efforts have been research driven, documenting the occurrence of special site types, feature, or artifact categories, like mound groups, or pottery or projectile point types, and only rarely beyond the state level. Likewise rare have been detailed quantitatively-based analyses documenting human responses to environmental change that encompass broad geographic and temporal scales. Here we show that this situation is rapidly changing for the better.

SLIDE *SITE FILE MANAGEMENT VOLUME

An early effort involving archaeological site file managers in the mid-1990s led to the recognition that important information on settlement and land use could be found in the combined and mapped data,

SLIDE *EARLY ARCHAIC SITES

showing settlement concentrations during specific time periods, like this example showing Early Archaic sites in the Southeast.

Unfortunately, the effort languished due to the technology of the time, characterized by limited data storage and comparatively crude mapping procedures, and the fact that many states were only beginning to digitize their data and link it into GIS frameworks.

A generation later we are no longer bounded by such restrictions. Computer technology and programming and storage capabilities have come a long way.

SLIDE*NATURE DATA SHARING

Cyberinfrastructure development and data sharing is considered a critical part of 21st century science, including in archaeology and historic preservation.

Here we discuss efforts underway to make archaeological data increasingly useful to research, management, and public educational efforts at a large scale, and in the process help us better understand past human settlement in the United States and beyond, as well as plan for changes in the future.

SLIDE *DINAA 2017 'Google it'

With a wide array of colleagues in state and federal agencies, tribal nations, and a number of universities, a project linking disparate cultural and environmental datasets is currently underway. Linked archaeological data, as we shall demonstrate, can provide unparalleled insights into long-term human-environmental interactions, and is crucial to making well informed forecasts and policy decisions about the consequences of rapid climate change, extreme weather events, and displaced populations, factors that will shape our civilization profoundly in the coming decades.

SLIDE *DINAA 2017 web hosting

The Digital Index of North American Archaeology, or DINAA, was established in 2012 with the goal of integrating or, more accurately, rendering interoperable archaeological site file data, while providing links to information about specific sites in other databases, collections, and publications, using the formal site number as the common referent, or indexing tool. These site data are also linked with natural systems data sets encompassing physiography, biota, and climate in the past, present, and projected into the future.

SLIDE *DINAA PARTNERSHIPS

DINAA is currently working with data from 20 states primarily in Eastern North America, with roughly half a million sites from 15 states currently rendered interoperable. This work has been done in consultation and cooperation with government, academic, and tribal stakeholders, and with funding from the National Science Foundation, and the Institute of Museum and Library Services.

SLIDE *SAA, SHA, AAA AD LETTERS OF SUPPORT

In 2017, we are pleased to note, the DINAA project was endorsed by the leadership of the Society for American Archaeology, the Society for Historical Archaeology, and the Archaeology Division of the American Anthropological Association. The SAA's Climate Change Strategies and the Archaeological Record committee under the leadership of Thomas H. McGovern has been particularly helpful as well.

SLIDE *WORKSHOPS

Four workshops have been held to date involving site file and resource managers, researchers, public educators, and informatics specialists, with more planned this year. Just bringing people together from differing states and agencies has helped us all see the strengths and weaknesses in existing data and recording standards. In the process we are examining what an archaeological site or historic property means to differing groups, how people perceived and used landscapes in the past, and the kinds of information that should be consistently recorded in every system. Perhaps the greatest benefit is the networking that occurs, and the sharing of skills and data. We've had booths at the last three SAA meetings and the last two NATHPO meetings, and will have another one at the SAAs this April in Washington. Feel free to stop by and chat!

SLIDE *DINAA SITE DOT MAP (Open Source…)

So what is DINAA? Quite simply, it is a publicly accessible compilation of existing archaeological site file, collection, and report data from multiple regional, state, and local repositories. DINAA uses the site number as a basic identifier, linking archaeological datasets together, and the site locational data can then be used to link with paleoenvironmental datasets of varied geographic scale and temporal resolution, encompassing physiography, climate, and biota, in the past, present, and as projected for the future.

SLIDE *EARLY ARCHAIC MAP

Standardized temporal metadata—using calibrated or calendar years—serves as a relational control between data sets, to permit analyses by selected time intervals. As such, DINAA is emerging as a tool of unprecedented power for understanding the causes and effects of co-evolutionary change in human societies and the natural environment over the 15,000 years of human occupation in the New World.

SLIDE*DINAA TEXT MINING

Information in state archaeological site files, artifacts and records in museum collections or curation repositories, or information in reports or journal articles can be linked using DINAA, provided a site number is one of the characteristics. A recent text mining effort undertaken in cooperation with JSTOR demonstrated the feasibility of finding sites in online journals such as *American Antiquity*.

SLIDE*ALL DINAA LINKAGES
Site data in DINAA is being linked to, or rather points to, information in a wide range of online data repositories, using site numbers as the common denominator. DINAA directs users to these outlets, but access and content control remains on their systems. Repositories with information currently indexed in DINAA include

SLIDE tDAR LINKAGE
tDAR (the Digital Archaeological Record), a major curation repository of reports, data, and bibliographic references related to archaeology,

SLIDE *CARD LINKAGE

radiocarbon dates in CARD (the Canadian/Comprehensive Radiocarbon Database),

SLIDE *PALEOINDIAN DATABSE OF THE AMERICAS
Data in PIDBA, the Paleoindian Database of the Americas, a compilation of Pleistocene site and artifact data from across the continent, and

SLIDE *EASTERN WOODLAND HOUSEHOLD DATABASE
information in the Eastern Woodlands Household Archaeology Data Project, a record of thousands of prehistoric structures built by first peoples. These are just a few of the data types we are currently working with.

SLIDE*DINAA HEMISPHERE MAP WITH EASTERN US CLOSEUP

DINAA can be used to generate maps or search results with a few simple queries or clicks, giving the results in a useful digital format, and of great value for research and public education when examining distributions encompassing large areas or time periods.

DINAA strictly conforms to legal requirements regarding the maintenance and use of cultural resources data. Precise site coordinates are neither published nor stored online, and the project redacts other sensitive attributes such as artifact or property ownership, specific directions to sites or find spots, or the presence of associated sacred objects or human remains—in consultation with our partners, which include SHPO, agency, and other interested parties, including tribal nations.

Only coarse grained locational information is given for site and artifact locations, with a resolution no finer than the county level or a 0.176 degree (ca. 20x20km) grid cell in DINAA. Specific geospatial data and the permission to use it must be obtained from the agencies maintaining the information. Directions to offices to contact to obtain such information are provided with output, but DINAA itself does not maintain or release such data.

While we are currently focusing on the 49 continental United States, similar systems can be adopted just anywhere and, indeed, our team members have worked with colleagues in Australia and Europe on similar efforts.

A distributed network, DINAA provides some of the benefits of centralization without requiring different—and typically financially strapped—state and federal agencies, site file managers, or individual researchers to change their own systems. As such, our approach fosters independent development and experimentation, while allowing researchers, resource managers, and interested members of the public online access to linked heritage and environmental data at broad scales.

Open Source translational protocols thus allow integration of datasets from many different and otherwise incompatible data sources into a single interface. DINAA thus embraces current best practices in scientific data-management including open standards and open licensing, transparent version control of both data and source code, Linked Data, and iterative development.

SLIDE *OPEN CONTEXT WEB SITE
DINAA digital data, including all constituent software, are maintained online by Open Context and archived with the California Digital Library a world leader in digital preservation. The data are also mirrored in a number of repositories in the US and internationally, to ensure the long term survival of the information. While presently focused on the United States, the DINAA informatics structure can be adopted anywhere, something we encourage by the use of open source/open access programming and data. We are always seeking new data providers and others willing to provide assistance.

SLIDE *PELAGIOS WEB SITE
DINAA information are also recorded by the Pelagios project a community and infrastructure for Linked Open Geodata in the Humanities. Pelagios links historical materials through their common reference to particular places.

What this example illustrates is that making nonsensitive data openly available, with no login, and no intellectual property strings, means it can be easily accessed and used by many people. DINAA is being used because it employs open standards that other systems can understand. Pelagios periodically harvests data from Open Context, where DINAA is housed, and DINAA has become one of its largest data contributors.

SLIDE*DINAA HEMISPHERICAL MAP WITH EASTERN US CLOSEUP
As of February 2018, personnel from 20 states are actively participating in DINAA development, and the project has initiated discussions with many of the site file managers and governing authorities in the remaining 29 states in continental North America, and in other countries, with the goal of developing a truly continental database.

Somewhat surprisingly, developing partnerships has proven a far greater challenge than the technical aspects of creating the linked database and online infrastructure. Some administrators have been reluctant to make information available, with reasons given such as a lack of staff time, a belief that their data is of poor quality, concerns about data security or, in a few cases, an unwillingness to share any information.

These concerns are usually overcome when the potential partner sees that the DINAA team infuses responsible legal and ethical practices regarding information management into everything we do. Every DINAA team member working with site data is a Registered Professional Archaeologist, for example.

Participation in DINAA is likewise not hard. To integrate state data into the national effort, a single database table, spreadsheet, or even text file of site numbers and associated information is all that is needed, a transfer that can be accomplished in minutes, with secure file transfer protocols used. The DINAA team cleans the file using tools like OpenRefine, and then randomly places the sites into 20x20 km grid cells for public mapping purposes.

Primary locational data, which is only maintained in offline computers and encrypted files during this phase, is then permanently deleted. DINAA does not maintain specific locational data… anyone interested in such data has to contact the agencies maintaining it. Our partnership agreements are commonly formal documents detailing terms of data access and use, and how state authorities are to be contacted.

DINAA indexing thus does not supplant but rather assists and enhances agency information management, access, and regulatory authority. DINAA is neither designed nor capable of serving as a primary source for compliance activities. However, because of its flexibility and ease of access, some states are already using it for public education purposes.

The DINAA team has taken a long view and a positive approach to working with those researchers, states, tribal nations, and federal agencies partnering with us, although we are always hoping to persuade more to join in the effort. We have no doubt that as DINAA's capabilities become better known and used, the blank spots on maps and in data searches will be increasingly filled in.

SLIDE *PALEOINDIAN DINAA SITE MAP

In the remainder of this talk, we examine how data like this can be used to examine population trends over time, and the effects of climate change on archaeological and historic properties.

Information in DINAA offers the opportunity to determine how many components and artifacts, possible proxy measures of human population, have been found and recorded to date by time period.

SLIDE *DINAA SITES BY CENTURY (ARROW TO PALEO)

Of 166,550 components in DINAA that could be dated to a specific Native American period of occupation; only 4,014, less than 3 percent of the total, have Pleistocene or Paleoindian components, suggesting population density was quite low, at least when compared with later periods. The top bar graph shows the total number of sites per major time period, and the bottom bar graph shows these same data standardized giving numbers of sites per century, since the major periods differ considerably in length.

SLIDE *DINAA SITES BY CENTURY (ARROW TO MISSISSIPPIAN)

Thus, while the total *number* of sites drops in the Mississippian following the Woodland period, when these numbers standardized per century a major *increase* is actually occurring, since the Mississippian period is only 600 years long, while the Woodland period is over 2000 years.

SLIDE *DINAA SITES BY CENTURY (ARROWS SHOWING GROWTH)

Overall, the numbers of components grew very quickly in the Early Holocene, slowed in the Mid Holocene, and then grew dramatically over the course of the Late Holocene. Indeed, nearly an order of magnitude increase in components per century is evident between Paleoindian and Early Archaic periods, followed by little change in the Middle Archaic, after which there is a near doubling or tripling in each of the subsequent Late Archaic, Woodland, and Mississippian periods. These trends show human population grew rapidly following the initial colonization of the Americas, slowed their growth for several millennia, and then grew rapidly as local populations developed increasingly intensive agriculture and more and more complex forms of social organizational.

Large artifact datasets as well as summed probability distributions of radiocarbon dates are other ways to examine population tends at a regional scales; the recent linkage of the PIDBA and CARD database with DINAA means this form of analysis should become more common in the future.

SLIDE *PLOS ONE PAPER
Using DINAA, site locational information was also plotted against elevation to predict losses to our common heritage due to sea level rise in the coming years. In November 2017 our project team published a paper on this subject in PLOS ONE, an open access journal, in keeping with our philosophy of sharing information freely, and not putting it behind paywalls. In this paper, we examined the effects of sea-level rise and human population relocation using a sample from nine states encompassing much of the Gulf and Atlantic coasts of the southeastern United States. The paper caused a bit of a stir, with articles about it appearing in dozens of media outlets around the world. The online technical paper has had over 25,000 views, indicating considerable the interest in the work.

SLIDE *DINAA SEA LEVEL 129K SITE SAMPLE
Data from nearly 130,000 sites were examined, extending from the Texas-Louisiana line to the Maryland Virginia area, and encompassing all sites within 200 km from the modern coastline. The 200km buffer was used to assess the numbers of recorded properties at various elevations further inland, where populations may be forced to relocate, or along portions of the coast where construction of seawalls might be considered.

SLIDE *SOUTHEASTERN SITES 1-5 M SEA LEVEL RISE
A 10 m horizontal resolution digital elevation model from publically available USGS datasets was spatially joined with the archaeological data to determine site elevations, and hence how many would be effected by sea level rises at 1 m intervals.

SLIDE *SOUTHEASTERN SITES NUMBERS BY STATE TABLE
It is clear that small increases in sea level will have great consequences on the coastal archaeological record. Projected sea level rise within the coming century, as well as in the centuries after, will result in the loss of a substantial portion of the record of both pre-Contact and historic human habitation of the coastal margin. This information, by the way, is available in the published paper, and these tables will be available to those requesting this talk afterwards.

SLIDE *SOUTHEASTERN SITES NUMBERS BY STATE TABLE ARROW TO TOP
Large numbers of recorded sites are within 1m vertical elevation of modern sea level and generally to within 1 to 3m,

SLIDE *SOUTHEASTERN SITES NUMBERS BY STATE TABLE ARROW TO >3M

Interestingly, the numbers drop off markedly above 3m across the region. Large numbers of people in the Southeast thus appear to have lived in close proximity to the coast in recent millennia, at least in terms of elevation. The same trends are true, as we shall see, with modern populations.

SLIDE *SOUTHEASTERN SITES STAR TREK 1-5 M SEA LEVEL RISE
In the study area ca. 19,000 known archaeological sites will be covered given a 1 m rise, which is projected for the next century, and nearly 30,000 if sea level rise continues as predicted, to between 3 to 5 m in the century or two after that. These numbers, of course, are only for known and recorded sites. Since survey coverage is incomplete, the numbers of actual sites impacted will be much higher.

SLIDE *NRHP SITES MAP 200 KM BUFFER TABLE

The National Register of Historic Places (NRHP) is another online database encompassing archaeological sites, standing structures, battlefields, landscapes, sacred sites, and other cultural properties that have been determined to be significant in American history.

SLIDE *NRHP SITES TABLE WITH ARROW

Over 1000 locations already listed as eligible on the National Register of Historic Places will be submerged given a 1 m rise, with nearly another 1000 lost given a 3 to 5 m rise. These numbers include many iconic places in American history, such as St. Augustine, portions of Jamestown, the Battery in Charleston, and many sites created by first peoples. Many of these, of course, are national parks or national monuments.

SLIDE *SOUTHEASTERN NRHP SITES STAR TREK 1-5 M SEA LEVEL RISE

While some archaeological sites are included in the eligible properties, many historic buildings and landscapes are also present.

SLIDE *LAND AREA LOSS DUE TO SEA LEVEL RISE (FIGURE)
Sea level rise will also inundate large areas on the eastern and Gulf coasts of the United States and displace large numbers of people, even if major construction projects occur to protect critical population and economic centers. Even if dike and dam building does occur, it can only encompass small areas, and will itself damage cultural resources in the areas fill comes from.

SLIDE *LAND AREA LOSS DUE TO SEA LEVEL RISE (TABLE)
Data on the amount of land lost per state by 1m increments of sea level rise was derived from 1-arc second (30 square meter) resolution digital elevation models provided by the United States Geological Survey.
SLIDE *LAND AREA LOSS DUE TO SEA LEVEL RISE (TABLE ARROW TO FLORIDA)
For states like Florida, with extensive low-lying terrain and lengthy coastal margins, the area that could be lost is quite substantial.

SLIDE *POPULATION RELOCATION DUE TO SEA LEVEL RISE (TABLE)

Finally, the numbers of people impacted can also be calculated. Population data are derived from 2013 estimates produced as part of the ongoing Land Scan initiative undertaken by the Oak Ridge National Laboratory. Over 3 million people in the Southeast currently live in areas at or below 1 mAMSL, and hence are likely to be displaced in the next century given current projections for sea level rise. The displacement of millions of people due to rising seas will cause additional impacts on historic resources where these populations resettle.

SLIDE *LATE PLEISTOCENE SEA LEVEL TRANSECTS
Our species has, however, witnessed comparable periods of dramatic sea level change in the past. At at the end of the last ice age, as the vast ice sheets on land were melting, much as is happening in Greenland today, shorelines were moving inland at a kilometer or more a decade. These resulted in population movements throughout the region, with interior areas becoming more densely settled than before. We can expect no less to occur in the years to come.

SLIDE * SEA LEVEL RISE SITE SAMPLE 129k SITES WITHIN 200KM
To conclude, given the large numbers of cultural resources threatened by sea level rise, as well as other effects of climate change, using big datasets to develop protection and mitigation strategies should proceed and, indeed, many researchers and government agencies within the United States and beyond are doing just this, including many of you listening.

One method of proceeding, we believe, is to use the entire known sample of cultural resources to document the kinds, numbers, and assessed importance of properties to that will be lost overall and within specific areas.

Developing such a comprehensive database is what we are trying to do with DINAA. Such information can help to develop systems for survey, triage, and mitigation of cultural resources in coastal regions, including identifying areas and site types currently under examined.

SLIDE * DINAA EASTERN US SITE MAP ORANGE DOTS
How humanity faces the loss of its coastal history concurrent with the displacement of millions of people will test national capabilities and global civilization generally by creating vast numbers of culturally displaced refugees, and placing great pressures on existing social fabrics. Cultural resources are a critical factor to consider when planning mitigation

strategies… they are essential to our sense of self and well-being, and a continuing source of inspiration.

The importance of continental scale archaeological datasets will only grow in the future, as archaeological data are increasingly used to address human response to changes in climate, biota, sea level, and physiography. Fostering networking and data integration among multiple partners will transform the practice of resource management. How we address these challenges can provide valuable lessons, and hope, for the future as we move forward into an increasingly uncertain world. Please urge your agency leaders as well as state SHPOs, archaeologists, and site file managers to join us, if they haven't already.

Thank you!
SLIDE *ACKNOWLEDGMENTS