Mapping and the future of caring for the past: Using GIS as a tool to understand the risk of emergencies to cultural heritage collections

Madeline Cooper

ABSTRACT

Natural and human-caused disasters have always been a risk to museums, libraries, archives, and all types of cultural heritage collections. The increase in frequency and intensity of extreme weather events brought about by climate change indicate that risk assessment and emergency preparedness and response will become even more important in caring for these collections in the future. Since the beginning of the 20th century, the art conservation and heritage preservation communities in the United States have worked to develop tools and networks for organizations preparing for and responding to collections emergencies. Some of these initiatives, including an interactive map called *Active Weather Risks for Museums, Libraries, and Archives,* have included the integration of Geographic Information Systems (GIS) in mapping cultural heritage assets and identifying location-specific risks. Continued research into the applications for GIS in responsive risk assessment and emergency planning, and the utilization of publicly available hazard data from emergency management organizations and climate scientists, will help prevent catastrophic damage to our nation's collections.

INTRODUCTION

As communities learn to prepare for and respond to the effects of climate change, so do cultural heritage institutions. This is a tall order for any organization, but especially those small and mid-sized institutions that make up 96% of the archives, historical societies, libraries, museums, and scientific collections in the United States.[1] The effects of extreme weather and natural disasters have always been a risk to collections. This will continue to be true as extreme weather events increase in frequency and intensity with the rise in global surface temperature.[2]

Risk assessment and its integration into emergency preparedness and response planning is widely recognized in the art conservation community as an effective way to protect collections from harm caused by disasters. While there are a number of emergency planning tools and networks available to cultural heritage organizations, the art conservation community has not fully explored the use of Geographic Information Systems (GIS) for risk assessment and response.

The following is an abbreviated history of cultural emergency response by art conservators in the United States and an exploration of the current uses for GIS in cultural heritage preservation. The development of a map designed to aid cultural heritage institutions in risk assessment is described, and areas of future research are proposed.

FOUNDATIONS OF COLLECTION EMERGENCY PREPAREDNESS AND RISK ASSESSMENT IN CULTURAL HERITAGE CONSERVATION

The contemporary practice of collection emergency preparedness and response in the United States is

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deeply intertwined with the natural and human-caused disasters of Western Europe in the 20th century. The development of the museum laboratory at the British Museum followed damage caused to collections that were evacuated during World War I.[3] This acknowledgement of the role of external factors in the deterioration of cultural heritage shifted focus from restoration to prevention. The targeting of cultural heritage for theft and destruction by the Nazis in World War II and the 1966 flooding of the Arno River in Florence were large-scale disasters that garnered a lot of media attention and required conservators to develop new strategies for dealing with huge quantities of heavily damaged collections (Figure 1). Those American conservators involved in the responses to those events would go on to, among other things, head conservation labs, found professional organizations, and teach a generation of conservators who were galvanized by what they had seen and heard about the cultural response to the wars and the flooding.[4]

A string of stateside disasters in the late 1980s and early 1990s, including the Loma Prieta Earthquake along California's Central Coast, Hurricane Hugo across the Caribbean and southeastern US, and the Midwest Floods along the Mississippi and Missouri Rivers and their tributaries led to a recognition from the American art conservation community that collections stewards needed help preparing for and recovering from these types of events. A meeting jointly organized in 1994 by the Getty Conservation Institute (GCI), a non-profit organization called Heritage Preservation, and the Federal Emergency Management Agency (FEMA) led to a collaboration between the preservation community and FEMA called the Taskforce on Emergency Response,[5] which is now known as the Heritage Emergency National Taskforce (HENTF).[6]

FIGURE 1. **Manuscripts from the National Library being washed and dried after the flood.** UNESCO/DOMINIQUE ROGER, CC BY-SA 3.0

The conservation community was introduced to the concept of risk assessment at around the same time as the formation of the task force. In his 1995 paper on the subject, Robert Waller defined risk assessment as "the analysis of the magnitude of each and all risks affecting some entity," and argued that it could be used to strategically make decisions about how to allocate limited resources when caring for collections.[7] While risk assessment can be used to make a range of decisions about collections care outside of emergencies, the identification of risk and vulnerability has become widely accepted as one of the first steps in writing a good emergency preparedness and response plan.[8] Since the 1990s, there have been a number of quantitative risk assessment models developed specifically for cultural heritage collections. These include the Cultural Property Risk Analysis Model (CPRAM), which is Waller's model,[9] and the ABC Method, adapted for cultural heritage in the 2016 book *A Guide to Risk Management of Cultural Heritage*.[10]

As the risk of natural disasters shifts with climate change, so too should the emergency planning process for cultural heritage institutions.

In addition to those risk assessment models, there are also a number of networks that support emergency preparedness and response. Alliance for Response (AFR) is an initiative started by Heritage Preservation and absorbed by the Foundation for the American Institute for Conservation (FAIC) that works to support the formation of regional networks of cultural heritage workers and emergency responders. According to FAIC, there are currently 32 active AFR networks that span the United States and the US Virgin Islands.[11] One function of these networks is to direct members to the many resources that are available covering every aspect of the emergency preparedness and response process. The Risk Evaluation and Planning Program (REPP),[12] Collections Emergency Preparedness Benchmarks,[13] and the dPlan|ArtsReady 2.0[14] are just three resources of many that are recommended by HENTF. A group called Resources for Emergencies Affecting Cultural Heritage (REACH) maintains a peer-reviewed list of resources broken down by category that is hosted on the American Institute for Conservation's Emergency Committee Wiki page to help users find what they need without getting bogged down by all that's available.[15]

There is some evidence that cultural heritage institutions are using the available tools to develop emergency preparedness and response plans. The Heritage Health Information Survey (2014) reported that 42% of collecting institutions in the US had engaged in emergency planning, which was up from 20% in 2006. This is an improvement, but still leaves the majority of collections without emergency plans as the frequency and intensity of extreme weather events increase.[16] As the risk of natural disasters shifts with climate change, so too should the emergency planning process for cultural heritage institutions. There is potential in the use of GIS as a tool for emergency preparedness and response planning that hasn't been fully explored by the art conservation community.

THE APPLICATION OF GIS TO RISK ASSESSMENT FOR CULTURAL HERITAGE CONSERVATION

Geographic Information Systems, or GIS, is the connection of information to a specific point on a map. In the world of cultural heritage, the use of GIS, itself, is not new. GIS is widely used to map archaeological sites, historic structures, and public art collections.[17] The technology has even been used to map cultural institutions specifically for the purpose of emergency response. GaNCH is a publicly editable directory and map of cultural organizations located in the state of Georgia that allows responders to quickly find and contact those organizations affected by an emergency.[18] HENTF is working towards a similar cultural inventory through their Asset Mapping Working Group.[19] These projects focus on building an accurate picture of the cultural heritage organizations that are currently active in the United States. This is a tall order given that there is no central list of museums, libraries, archives, and other collecting institutions. It is, however, a critical task. Small museums, libraries, and archives are less likely than larger organizations to have emergency plans in place. They are also less likely to be in contact with emergency response organizations like HENTF or their local AFR network. To help the collections with the greatest need, response organizations need to have accurate location and contact information for as many affected institutions as possible.

The use of GIS specifically for risk assessment in American cultural heritage institutions is less explored, though it's a commonly used application for federal, state, and local emergency management agencies. FEMA strongly recommends the use of maps when states are developing hazard mitigation plans, which are required by law,[20] and reliable GIS data on hazards including flood, avalanche, wildfire, drought, landslides, earthquakes, coastal erosion, hurricanes, and more are maintained by a variety of federal and non-governmental agencies.[21] These data are publicly available, meaning that they could be pulled into mapped cultural heritage assets to identify specific risks to specific collections using a process called exposure analysis. One example of this kind of analysis applied to cultural heritage is a 2016 study that identified vulnerable sites in a region of Romania called the Sucevita catchment by layering a map of sites over a map of flood risk. Researchers on that project found that 47% of the heritage monuments they mapped were located in a "very high flood susceptibility" region.[22] Similar studies have been performed in Taiwan[23] and Italy[24] with a focus on historic structures.

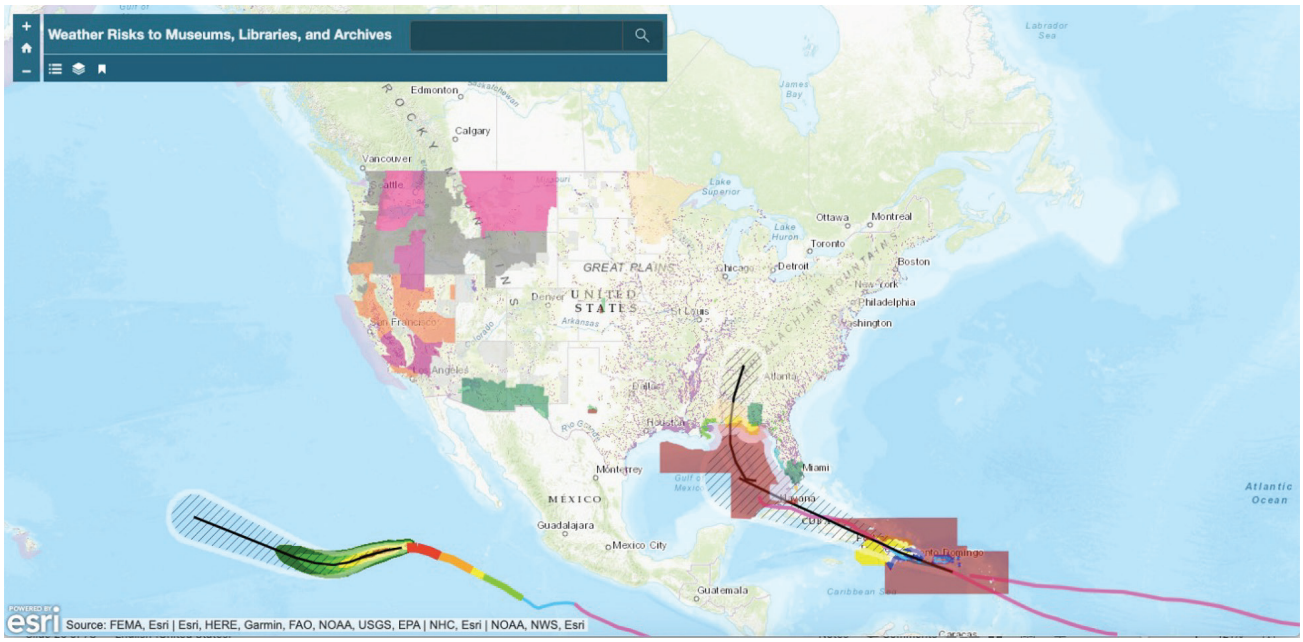
A multidisciplinary European project called the *Atlas of Climate Change Impact on European Cultural Heritage* took the concept of exposure analysis a step further. The 2012 publication used modeled climate data for the near future (2010–2039) and the far future (2070–2099) to show how climate change may specifically affect cultural heritage collections. Maps of phenomena like biomass accumulation on monuments and metal corrosion translate the changing climate into terms that art conservators and other collection stewards can understand.[25] There hasn't been a comparable study of the ramifications of climate change models on American cultural heritage collections.

ACTIVE WEATHER RISKS FOR MUSEUMS, LIBRARIES, AND ARCHIVES

"Active Weather Risks for Museums, Libraries, and Archives" is an early exploration of the use of GIS for risk assessment in American cultural heritage organizations. The map (Figure 2), which was built using the ArcGIS platform in September 2020, is an amalgamation of static data layers, including flood risk information and the location of cultural heritage institutions in Delaware, Maryland, and Washington, DC, and dynamic data layers covering severe weather events in the United States. The map allows users to turn on and off data layers to assess the risk of damage caused by severe weather on a specific location.

The only data layer that was developed specifically for this project was "Museums and Historic Places in MD, DE, and DC." Location data for Delaware and Maryland cultural heritage institutions were generated and uploaded

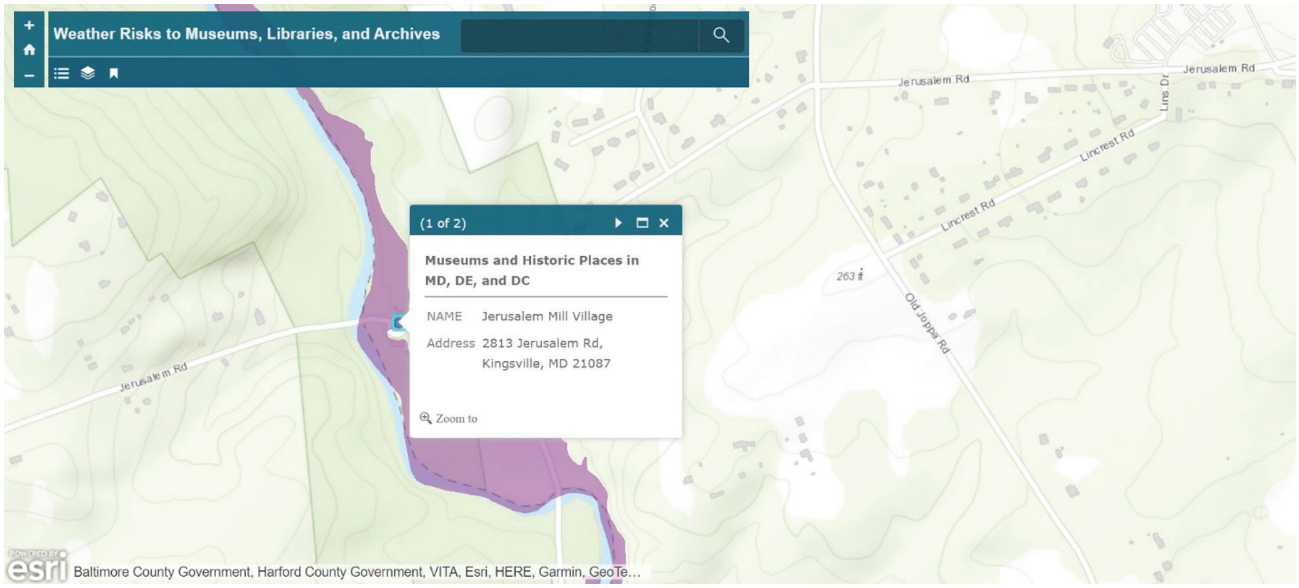
FIGURE 2. Active Weather Risks for Museums, Libraries, and Archives. MADELINE COOPER

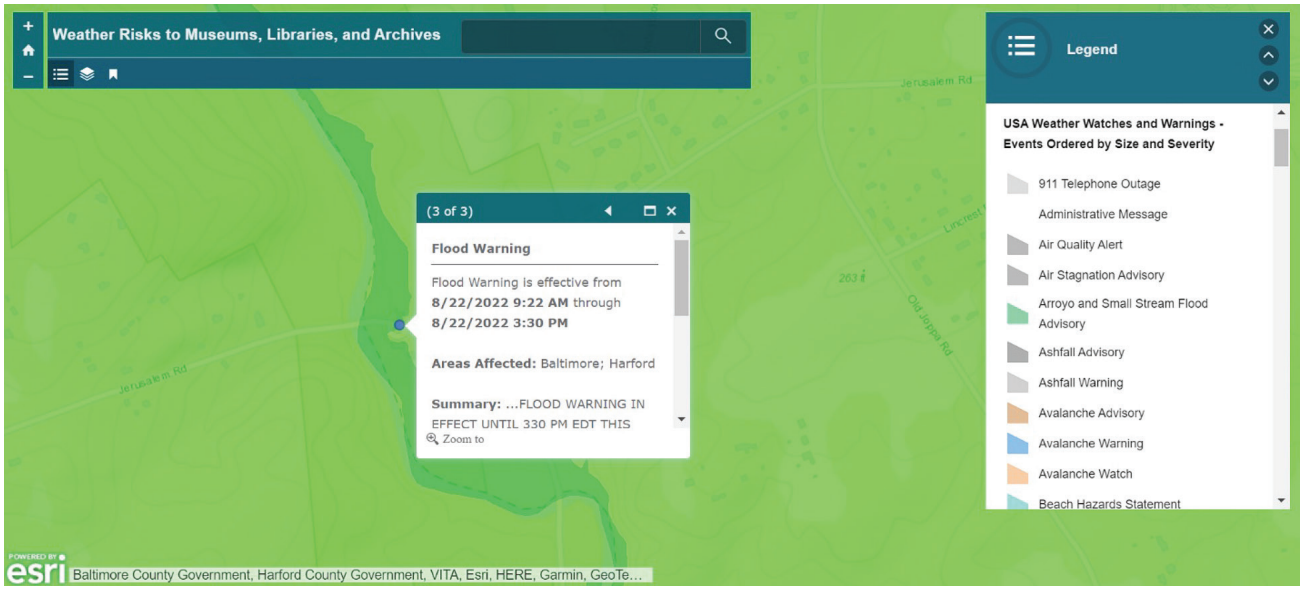


into the ArcGIS software the form of a spreadsheet. The Wikipedia pages, "List of museums in Delaware"[26] and "List of museums in Maryland"[27] were used as a reference. Name, street address, latitude, and longitude were collected for 72 institutions in Delaware and 309 in Maryland. These data points were combined with a map of cultural heritage institutions in Washington, DC, that was available through Open Data DC, which is the repository for public data from the District of Columbia.[28] "Museums and Historic Places in MD, DE, and DC" is a static data layer, meaning that it must be manually updated.

The other static data layer on the map is "USA Flood Hazard Areas," which displays data from FEMA's Flood Insurance Rate Map (Figure 3). Areas that lie within the 1% annual flood hazard area (100-year flood plain) are shaded in purple. Though this data layer is referred to as "static" in this context, it is updated yearly by FEMA.[29] The dynamic datasets on the map are related to severe weather. A group of layers showing active hurricanes, typhoons, and cyclones comes from the National Hurricane Center and the Joint Typhoon Warning Center. These layers are updated every fifteen minutes.[30] The final dynamic data layer shows weather watches and warnings in the United States from the National Weather Service (Figure 4). This layer is updated every five minutes.[31]

FIGURE 3 (top). Static data layers showing historic site within 100-year flood plain. FIGURE 4 (bottom). Static and dynamic data layers showing active flood warning affecting historic site within 100-year flood plain. MADELINE COOPER



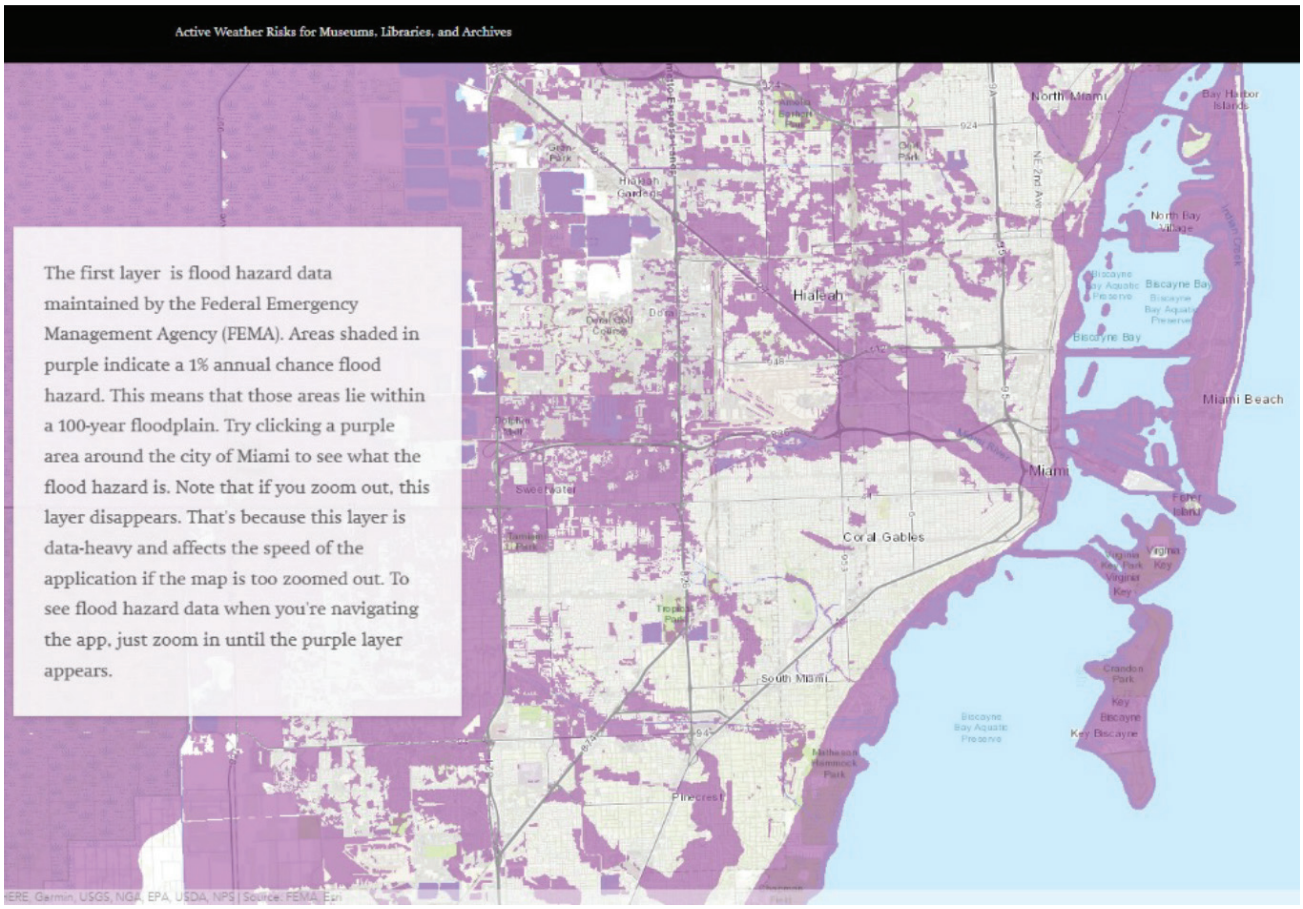


To help users understand the map and how to use it, a tutorial in the form of a Story Map was developed (Figure 5). Story Mapping is a function of ArcGIS that allows spatial data to be integrated into presentations. The Story Map, which shares a title with the map it describes, introduces users to "Active Weather Risks" and then walks them through the functionality of the different data layers. At the end of the Story Map, users are prompted to search for a cultural institution of their choice and use the data layers to think about the risk of severe weather events affecting that site.

Cultural heritage institutions can use publicly available GIS data to think about risk, but there is potential for much more work in this area.

"Active Weather Risks" was built as a tool for individual organizations to use when performing risk assessments. While this application is viable, particularly for understanding flood risk, the map and the Story Map that explains it are likely more useful as educational tools. To date, the map has been shared with the Alliance for Response Minnesota, the Winterthur/University of Delaware Program in Art Conservation, and the Northwest Museum Services Center of the National Park Service. The Story Map prompts users to think in terms of risk assessment, and the map has enough data layers to encourage exploration, but not enough to cover the full range of hazards. For example, there are no data on earthquake hazard nor projected climate risk. In terms of sustainability, the use of dynamic data layers from trusted sources means that upkeep of risk data is minimal. "Museums and Historic Places in MD, DE, and DC.," however, is static and based on Wikipedia data that are likely not completely accurate or current. At the time of this submission, there have been 466 views of the Story Map and 644 views of the map itself.

FIGURE 5. The Story Map walks users through the data layers and prompts them with questions. MADELINE COOPER



LOOKING FORWARD

"Active Weather Risks" is a cursory look at how cultural heritage institutions can use publicly available GIS data to think about risk, but its applications are limited. There is potential for much more work in this area, particularly looking at US collections. Research into the following two topics would benefit an art conservation community that is dealing with low emergency preparedness *and* the effects of climate change:

- Climate modeling to predict future collections risk, and
- Quantitative analysis using location-specific data.

Emergency preparedness and response will almost certainly need to become a bigger priority for museums, libraries, archives, public art, and other cultural heritage collections.

While it is conceptually clear that climate change will continue to affect cultural heritage organizations in a myriad of ways, there isn't a clear picture of what that will mean practically for art conservators in the United States. There is a fair amount of publicly available data modeling future sea level rise, precipitation, and temperature based on greenhouse gas concentrations.[32] These modeling data could be layered with cultural heritage asset maps to identify at-risk collections and help organizations do more accurate risk assessments that take the effects of climate change into account. For example, collections in areas projected to see less cumulative rainfall, but more severe rainstorms, may choose to prioritize flood prevention through strategies like sustainable landscaping or the development of a flood response plan. A climate modeling project like this would require accuracy in cultural asset mapping, which highlights the importance of projects like GaNCH and the work of HENTF. Taking the use of climate modeling a step further might look like a version of the *Atlas of Climate Change Impact on European Cultural Heritage*, using data for US climate and collections. This type of project could guide art conservation research based on what conditions may become more prevalent in the future.

In addition to taking advantage of the climate modeling data that are publicly available, research should be done into integrating GIS into quantitative risk assessment models (like CPRAM) to help cultural heritage organizations with decision-making. The benefit of a quantitative approach to risk assessment is that it assigns a numerical figure to specific risks, which is beneficial when making decisions and advocating for funding and other support. An example of this type of project is a current NEH-funded effort by the Midwest Art Conservation Center to develop GIS-based remote risk assessment tools for geographically diverse public art collections, using a portion of Washington's State Art Collection as a pilot.[33] This type of project combines non-public-facing collections data, like a history of previous damage, with the climate and risk data produced by trusted sources for more accurate and in-depth risk assessment.

CONCLUSION

The changing climate indicates that emergency preparedness and response will almost certainly need to become a bigger priority for museums, libraries, archives, public art, and other cultural heritage collections in the future. There is a history in the United States of conservators and other preservation professionals reacting to natural and human-caused disasters to create new tools and networks. We have drawn on the lessons of disasters in the past and will continue to do so as we work towards the preservation of cultural heritage into the future. There is so much work being done by emergency management agencies and climate scientists that has the potential to aid cultural heritage organizations in producing better risk assessments and emergency plans. GIS is an effective way for cultural heritage institutions to visualize and utilize this location-specific information. More research into the utilization of GIS will serve those dedicated to the prevention of catastrophic damage to our nation's collections.

ENDNOTES

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29. "USA Flood Hazard Areas—Overview."
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