Digital Preservation in Museums:

Cultural Heritage Institutions in Last Place

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Author's Statement

Working as a technician in Harvard Library Imaging Services, formerly a division of digital preservation, the desire to learn about digital preservation in cultural heritage institutions grew. Dismayed by the lack of current literature available about museum digital preservation in the United States, it was obvious that museum digital preservation was a subject in need of research and became the focus of this project.

Kathy Jones, former MCN board member, generously provided time and meaningful feedback on this project; shared relevant insights from her career working in museum computer technology, provided historic context to the subject; and arranged access to a Harvard community digital preservation expert.

Stephen Abrams, Head of digital preservation at Harvard University Library, provided expert knowledge about digital preservation; answered all of my questions, facilitated my learning of relevant topics, provided current information and directed me towards appropriate sources. Without their guidance and these important resources, this project would not have been feasible. Additionally, Cathy Payne provided much-needed direction in task management, and answered questions about academic writing.

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Introduction to museum digital preservation

Museums are the caretakers of our cultural heritage, and therefore, bear the responsibility to protect and make available the well-preserved details and history of their collections, in accordance with their mission. As digital technology progresses, an increasingly heavy reliance is placed on it by museums, for information of all kinds. This increases the museum's vulnerability for errors and potential loss of fragile digital information. Reasons for this include a lack of education about digital preservation by museum professionals and a lack of resources to actively manage these assets as is required for digital data. Information professionals have also expressed related concerns including inevitable obsolescence; the lack of knowledge about the needs of future users; and a pending storage capacity issue in the future. Museum digital preservation includes many steps, intertwined and connected by the use and reliance on digital technology. As a nod to the importance of digital assets and digital access to collections, the American Alliance of Museums (AAM) includes accreditation eligibility stipulations, within its collections management policy, requiring digitization of materials (Paqua). Ideally, museums' capabilities to digitally steward their cultural heritage should be on equal footing with the rest of the cultural heritage field in this country. Statistically, museums are the cultural heritage institutions least able to handle these challenges and have the least amount of resources to do so, as the information within this paper will show.

This capstone paper will examine the overarching problem of a lack of digital preservation and digital preservation policy-writing in US museums, juxtaposed to other cultural heritage institutions, mainly libraries. It will begin with a brief introduction to some key terms that will be used throughout and include an orientation of international perspectives supporting and prioritizing digital preservation in cultural heritage, for comparison. This will be followed by

a snapshot of the digital cultural heritage environment in the US. Within this brief overview, the background and position of digital preservation within museums will be discussed, as well as possible risks resulting from digital heritage neglect. Evidence reflecting a lack of digital preservation activity and policy-writing in museums will be presented; including the results of the museum digital preservation survey done in conjunction with this research paper, and information about what should be in a digital preservation policy will be addressed. Following will be a summary of current challenges to museum digital preservation and digital preservation policy-writing, including a lack of policy examples; a lack of funding and staff; and inadequate museum studies education. Before offering a conclusion, insights about possible opportunities for museums to progress will be suggested in a short discussion of cross-collaboration, the role of open access data in collaboration, and technology solutions as first steps. Museums play an important role in protecting, preserving and presenting our history. For this reason, it is important that the appropriate resources, attention and actions be applied to the care of our digital cultural heritage for now and for future generations. Within the cultural heritage sector, libraries, archives and museums (LAMs) account for a majority of cultural heritage institutions (Allen et al. 8). Of them, museums struggle the most with digital preservation and digital preservation policy-writing (Sheldon "Towards DPP"). However, the burden of digital preservation is shared by all cultural heritage institutions, creating a point of convergence where they might meet to work together toward new possibilities and solutions.

Understanding the language – digitization, digital preservation etc.

Library professionals began discussion about terms and language used to talk about the care of digital media in the 1980s (Bastian et al. 608). Around that same time, consideration began to be paid to topics related to digital preservation, most notably by the National Archives

and the Commission on Preservation and Access (CPA) (Bastian et al. 608). "Preservation" was the supported term for "broad-based administrative aspects of caring for collections" (Bastian et al. 608). In recent times, a variety of different phrases have been used to talk about the care of digital assets and digital objects. Some of these key terms are included in the text below and in figure 1. These terms are often used interchangeably, and sometimes are not fully understood. One respondent to this project's survey noted that museum professionals at their institution did not understand what the term "digital preservation" means. Some researchers have concluded that digital preservation "has not yet reached maturity" (Chanod et al. 2) to a level of consistent theory. The definitions are still debated, throughout the cultural heritage fields, depending on institution and discipline (library, archives, or museums). However, despite overlap between the usage of these terms, subtle distinctions about the areas each extends to have been made.

Digital Preservation

According to a report about digital curation by Tyler Walters and Katherine Skinner, digital preservation focuses on the "series of managed activities necessary to ensure continued access to digital materials for as long as necessary" (5). It fits under the umbrella of digital curation, which also covers, but is sometimes used as a synonym for, digital stewardship (Botticelli 5; Ray 32, 33). Digital preservation, as a part of digital curation, requires a distinct foundation (Bastian et al. 609).

Digitization

The term digitization refers to the actions taken by cultural heritage professionals to digitally reformat an object, to create surrogate files and images from analog objects. The New England Document Conservation Center (NEDCC) defines digitization in the following way: "digitization is the process of making a digital copy of a non-digital object, or the conversion of analog

information to digital information" ("Session 7"). This is done with audio, text documents, images and more. This is only a fraction of the materials that require digital preservation, curation and stewardship. Materials that are created digitally are referred to as "born digital" files. ("Term").

Digital Curation

The middle English and old French origins of the word "curator" designate overseer or legal guardian and mean to "take care of" (Bastian et al. 610). Digital curation refers to the actions taken "to maintain and add value to digital information over its lifecycle" (Walters and Skinner 5). Each object lifecycle phase produces information, which needs to be documented and stored, including acquisition, cataloguing, conservation, exhibition, publication, education, interpretation and photography (Zorich 54). Collections information is incredibly important, but other digital information in an institution holds value as well, and therefore needs to be kept accessible. This includes information about human resources; facilities; finances and administration; institutional histories; and public and community relationships (Zorich 53). The Digital Data Curation Task Force (DDCT) in the United Kingdom (UK) has highlighted that important digital curation activities extend to "discovery and access, planning, appraisal, creating added value, active management, maintenance of provenance information and curation research" (Ray 33). The process begins before data creation, in the planning and standards setting stage. An emphasis is placed on the addition of metadata, per the key digital curation standard, in the Open Archival Information System reference model ISO 14721: 2003 (Bastian et al. 609). The Open Archival Information System (OAIS) reference model is a freely distributed, widely adopted framework for archival systems "dedicated to preserving and maintaining access to digital information over the long term" (Lavoie).

Digital Stewardship

When discussing digital pedagogy, Simmons College faculty and library information professional Jeanette Bastian, and her colleagues, define digital stewardship as a process that: "encompasses, but is not limited to, the creation, maintenance, preservation, dissemination, and exhibition of a trusted body of digital information for current and future use" (Bastian et al. 607). "Steward" is derived from old English and indicates a less extensive cultural responsibility, including "the administration of collections", in contemporary use, its reach extends to larger topics within the community and signals a fuller awareness of "historical influences of social and policy issues" and the user community needs (Bastian et al. 610, 615). At the same time, digital stewardship includes technical components such as the use of "information structures, database technology and metadata [use]" (Bastian et al. 615).

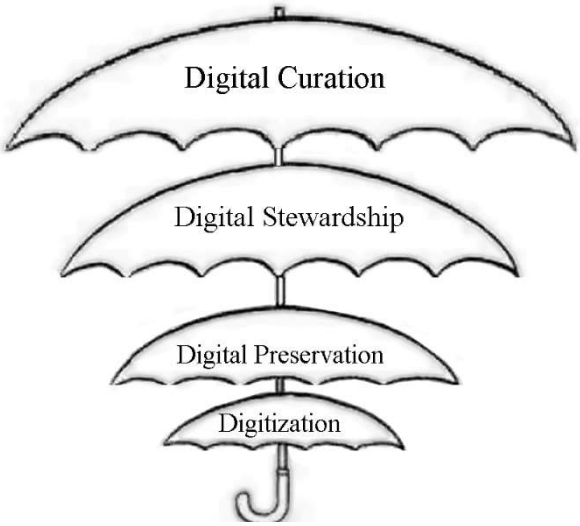

Figure 1 Umbrella of Terms. Gesek.

International perspectives on digital preservation of cultural heritage

Digital preservation transcends national borders and is essential for protecting cultural heritage around the globe (Bastian et al. 613). As part of the global community, the position or lack thereof that the United States takes is influential and can be viewed in contrast to other nations. Jeanette Bastian, briefly mentioned on page five, believes that educational programs should include information about the international insights about digital preservation, such as the position of UNESCO, "international standards and existing accords and treaties" (Bastian et al. 613). This would encourage future digital preservation professionals to "think about preservation in a global context" (Bastian et al. 613).

UNESCO

UNESCO created a charter for digital heritage in 2003 that is still in use and since has been updated, in support of digital preservation within the global cultural heritage community. It was an important milestone, providing definition to concepts they had not previously considered. UNESCO is made up of one hundred and ninety-five-member states (Van Gorsel et al. 6). The importance of collaboration cannot be understated, and advocation for it has been echoed in cultural heritage literature from the Netherlands; Scotland, the UK; and UNESCO (Hofman 33; Economou; Van Gorsel et al. 6; UNESCO 3, 4). The aforementioned charter document reads:

> strategies and policies to preserve digital heritage need to be developed, taking into account the level of urgency, local circumstances, available means and future projections. The cooperation of holders of copyright and related rights, and other stakeholders, in setting common standards and compatibilities, and resource sharing, will facilitate this. (Sanett 147)

In collaboration with other international partners, UNESCO created PERSIST at the 2012 Memory of the World conference (Van Gorsel 1). This project included a mandate that charged governments with the task of investing in "trustworthy digital infrastructure and digital preservation" (Brungs 38). It also purportedly plans to extend its guidelines to “include information on the provision of online access to digital collections” (Elford 2).

International Support and Prioritization of Digital Preservation

Officials at the National Library of Australia, like UNESCO, prioritize preservation and provide access to digital content because they believe “born-digital and digitized content and culture are paramount” (Elford 2). The 2003 Berlin Declaration is also cited as being instrumental to the digital preservation movement (Valetutti 1). In Germany, cultural heritage institutions have been providing public access to their collections since 2000 (Seifert et al. 2). Formed upon release of a 2008 Digital Data Curation Task Force (DDCT) report in the UK, the Digital Curation Centre (DCC), has been cited as a “world leader” and as a resource for digital curation alongside the British Library (Berman 53; Ray33). In the European Union, government believes preservation is their responsibility and are implementing national strategies that reflect this idea (Fresa 110). In a report funded by the European Commission in January of 2011, digital preservation was viewed as important to European institutions, prompting the creation of the Digital Curator Vocational Education Europe (DigCurV). The focus of the DigCurV is on the long-term management of digital collections, and in helping participants develop essential skills for those tasks (Sanett 143). It is also stated that in Europe, publicly funded research can be widely spread through open access publications. In the UK, research organizations were given twelve months, by the Engineering and Physical Sciences Research Council to develop plans to ensure availability and preservation of digital research for at least ten years. Generally, research council

funding applicants are required to submit data management plans with their proposals (Richards et al. 314).

While the Library of Congress and other agencies in the United States have provided support in the area of digital preservation, It has been argued that the United States lags behind other countries such as Australia, Denmark, France, Japan, Portugal, Taiwan and also the UK, in supporting digital preservation through public policy (Weber). Although "a number of preservation efforts are underway within the United States public sector" (Weber), as of January 2019, the United States reportedly does not have any public policy governing digital preservation, unlike the aforementioned countries. Matthew Scott Weber has received funding from the National Science Foundation (NSF); the Institute of Museum and Library Services (IMLS); and others, for his media research, and is Fellow of Media Management at the University of Minnesota ("Matthew S Weber"). Weber admits that the issue is complex but feels that policy is needed to preserve "the integrity of the nation's collective data" (Weber). Without a mandate, or changes to the copyright laws, preservation of digital content, becomes increasingly difficult (Weber). Laws applied to technology, in ways they were not intended to be, are said to have a detrimental impact on digital preservation in the US (Kastellec 66). Cultural heritage digital preservation researchers, Tom Evens and Laurence Hauttekeete, believe governments play an important role in providing access to cultural memory, particularly extending access to "socially vulnerable groups", and enabling them to become fully engaged (164). In another article, Executive Director of the Coalition for Networked Information (CNI), Clifford Lynch says that for the last twenty years, the US has "moved towards a licensing regime" that keeps the preservation power in the hands of the content owners (97). Most material cannot be protected without the publisher's consent. Lynch feels that the Library of Congress

should compel copyright deposit as part of copyright law. The Library of congress has yet to make any moves in that direction, which he refers to as “a stunning failure to meet a core public mission” (98).

Overview of digital preservation in cultural heritage in the US

Cultural heritage literature has debated digital media preservation for twenty-five years, according to Bastian (Bastian et al. 608). Originally, digital preservation was considered mainly a concern of libraries (Whitt 130). In the US, libraries have been carrying out digital preservation activities for at least the last thirty years (Hirtle 124). Literature of the 1990s discussed a more pointed focus on strategy and technological concerns (Bastian et al. 609). Meanwhile the importance of, funding for, and education in the preservation of digital assets, and digital preservation policy-writing, in U.S. museums has been neglected (Ray 33).

Methods and Measures in Digital Preservation

Cultural heritage institutions need to be armed with strategies and methods to care for their digital assets throughout the digital object lifecycle. Educated digital preservationists understand that providing substantial care is the way to ensure longevity and maintain usability (Bastian et al. 615). Long-term access of digital information is contingent upon a continued ability to mitigate threats to digital data (Chanod et al. 13). Some of these threats will be discussed in other sections of this paper. There have been debates about the best strategies used for digital preservation. Several of them are described briefly below, and only make up a portion of the measures that are taken in digital preservation.

Digital Data Appraisal

Amanda Rinehart’s case study on digital preservation in “resource-strapped institutions” serves as a reminder that "not all information and data are created equally" and not everything needs to

be equally preserved (37). Metadata alone can increase the volume of digital records exponentially (Carden 10). It has been noted that there can be extensive labor involved in metadata creation (Cocciolo 134). Large scale processing that can be done is often preferred, due to the number of digital files in need of processing and digital preservation in a repository (Shaw J; Bastian 613). The volume of data makes managing archives of digital data challenging (Carden 10). For this reason, digital cultural heritage resources need to be properly appraised before ingesting, when an institution accepts and imports data into their systems and databases from external sources (Niu 66).

Important appraisal criteria first includes; alignment with organizational mission, and secondarily; administrative, fiscal, legal, evidential and informational values for content producers and content users (Niu 72). Adequate attention must be dedicated to the assets when acquired or created, facilitating smooth digital curation throughout the material's "lifetime". This may include observing a period of file quarantine before ingesting, to minimize risk of file corruption or errors, as reflected in the process followed by the National Archives of Australia (NAA) (Bastian et al. 609; Carden 6). Since the labor and involvement of people is the most expensive element of the process, digital preservation researchers have concluded that, ideally, the digital preservation workflow should be "almost completely automated" (Carden 8; Chanod et al. 2). Meghan Banach Bergin found that seventy percent of respondents to her 2014 cultural heritage digital preservation survey confirmed that they actively collect metadata (29). Most respondents reported that they use a mix of automated and manual processes for metadata application (11).

In the preservation of digital assets, an emphasis is put on the importance of metadata (Dappert and Enders 6). This paper will not go into detailed depth about metadata, other than to

acknowledge its importance, and provide a brief description of it. Bastian notes that per the OAIS reference model, metadata is required because digital files alone may not be sufficient (Bastian et al. 609). The four types of metadata that accompany a digital file, needed for long term preservation include structural; descriptive; technical; and administrative, sometimes referred to as preservation metadata (Dappert and Enders 6). Most respondents in this research project's survey confirmed that their institution was collecting metadata, although there was a significant number of respondents that weren't sure, as shown in figure 2. Examples of various metadata can be seen in figures 3 and 4. Measures to ensure adequate file preservation include the use of "open file formats for data capture and storage; and applying rigorous file naming protocols, to ensure unique file identification" (Bastian et al. 610).

Figure 2 Survey Question 5. Gesek

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- <METS:structMap TYPE="citation">
  - <METS:div LABEL="Radcliffe College. Reports of the president and treasurer for..."
      ORDER="1" TYPE="serial">
    - <METS:div LABEL="1912-1914" ORDER="1" TYPE="annualReport">
        <METS:mptr LOCTYPE="OTHER" OTHERLOCTYPE="OracleID"
          xlink:type="simple" xlink:href="129277" xlink:role="part"
          xlink:title="Reports of the president and treasurer for...,1912-1914"
          />
      </METS:div>
    </METS:div>
  </METS:structMap>
</METS:mets>
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Figure 3. Generic Example of Metadata. Linkedin Learning, Jenn Riley

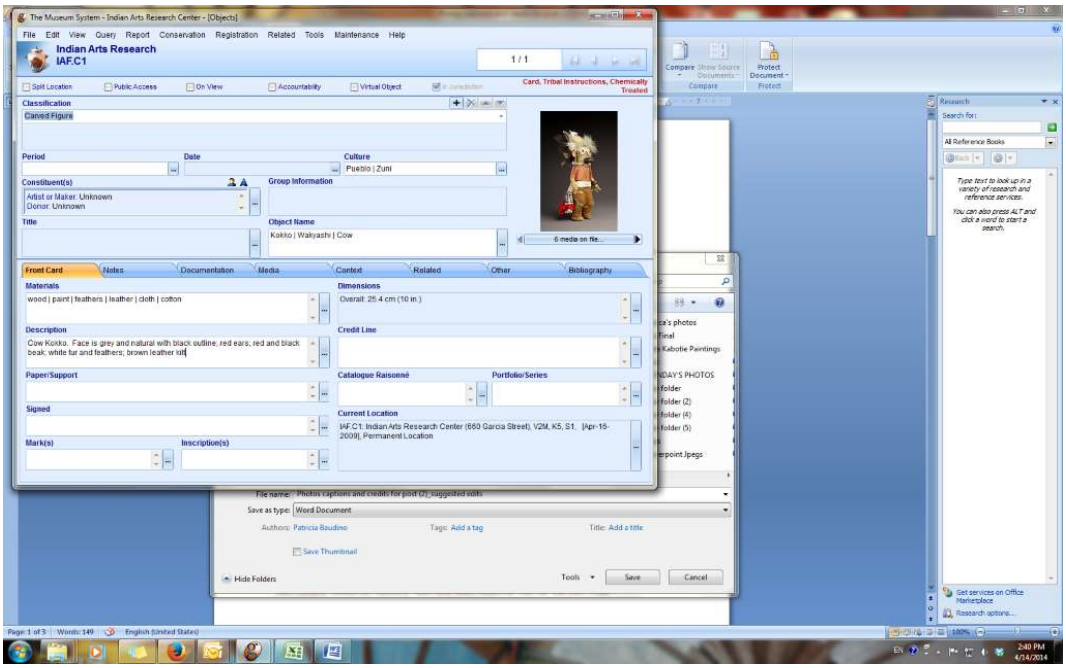

Figure 4 TMS Data Input Screen. The Incluseum. Other Strategies

Five noteworthy strategies utilized to combat possible data loss are normalization, data redundancy, virtualization, emulation and migration. These methods have been deployed in the digital preservation of cultural heritage materials, and could be used as strategies in museums, by well-trained preservation staff. Normalization, also referred to as "preemptive migration", is done by converting files to standard or common formats after ingesting (Kastellec 65; Rosenthal et al. 4). Data redundancy, also referred to as replication, duplicates and stores data in numerous locations. The goal is to ensure that the data is protected from threats that include media,

hardware and software failure; file corruption; operator error; security breaches and attacks; and other problems (Rosenthal et al. 2). Ideally, it is said that there should be media, hardware, software, system administration, vendor, geographic and funding diversity to prevent catastrophic loss in case of failure or attack (Rosenthal et al. 2). LOCKSS (Lots Of Copies Keeps Stuff Safe) serves as a good example of diversity in funding and systems administration. A LOCKSS is an international community program that utilizes open source software, as a "widely-accepted best practice in the digital preservation field and more broadly for ensuring the persistence of digital information" (Rosenthal et al. 5; LOCKSS). LOCKSS utilizes slower speeds of processing, as an example of the "sloth strategy" (Rosenthal et al. 11). This strategy allows opportunities for the system to receive warnings, minimize failure and to reduce error risks from spreading across entire storage volumes, instead accumulating only "gradual errors" (Rosenthal et al. 11). This can prevent attacks from spreading among replicas (Rosenthal et al. 11).

Emulation enables access to "original data and software" by running applications that map the technological structure of the original platform onto non-native platforms (Kastellec 64). This is what makes it possible to recall or play video games online from obsolete game systems, like the late 1970's Atari 2600 gaming system, pictured in figure 5. It is possible because the "original knowledge" can still be retrieved, as with the pictured vintage game Pacman in figure 6 (Kastellec 64; Enge 252; Whitt 158). It involves storing the digital object with its original software (Whitt 158). Emulation can contain an object's metadata, software and specifications, requiring very little from the user (Whitt 157). Emulation has been used by some German libraries and is being researched for the larger cultural heritage community in the US, including within libraries and museums (Rechert 121; "New EaaS"; Meyerson et al. ; "Fostering"). The

automated process in the Emulation of Multimedia objects in Libraries (EMiL) service collects metadata to initiate an emulation session, offering integration into web-based catalogues (Rechert 120). EMiL is a "web-based emulation service environment for library reading rooms that addresses the challenges of accessing large born-digital collections" (Rechert 120). In 2014, the Yale University library blog posted that Emulation as a Service" (EaaS) provided a solution to the technical problems associated with emulation ("New EaaS"). Later in 2014, the Library of Congress blog posted an article in which emulation was said to have "really hit its stride" (Johnston). Following the post, Library of Congress guest blog poster and digital preservation manager at Yale University Library, discussed three case studies which worked on utilizing EaaS in a research pilot program but did express licensing concerns (Cochrane). In 2017, the IMLS awarded almost two hundred and fifty thousand dollars to California Polytechnic State University and the University of Texas at Austin, for a three-year project involving six additional institutions ("RE-95-17-0058-17."; "Fostering"). The project will run from 2017-2020 and is intended to "build the skillsets of participating [library staff] individuals through hands-on experiences, as well as develop a cohort [of archivists, librarians, and curators] for broad implementation of emulation and software preservation services across the cultural heritage community [i.e. within libraries, archives and museums]" ("RE-95-17-0058-17."; Meyerson et al.; "Fostering").

Figure 5. Obsolete Hardware – Atari Gaming System.Worthpoint: the Internet of Stuff.

Figure 6. Emulated Video Game. DP Workshop.

As a strategy for digital preservation, emulation is said to meet the requirements of authenticity, defined in an archival environment (Enge 252). Concepts about authenticity have been traditionally associated with the originality of materials and process, considered to be a condition that lacks alteration (Innocenti 77). In this context, calling a digital file or object authentic may be misleading (Innocenti 77). In contrast to the previously mentioned concepts, it has been argued that authenticity is "not an original condition, but rather a dynamic process"(Innocenti 78), which allows for change and adaptation organically over time. This interpretation considers that all works are subject to an integral "transience.... not fixed in a single point in time" (Innocenti 78), meaning an object is in a constant state of change. Although the object may have undergone changes from how it existed in the beginning of its lifetime, it should still be

considered authentic. “It deteriorates, its context might change, and the way that it is conserved and re-displayed will change” (Innocenti 77). In digital preservation, when discussing the importance of file authenticity, and the careful protection of it, associations are generally focused on whether or not the object “is what it says it is” and can serve its “intended or required use”, which determines its trustworthiness (“Checking” 1; Rothenberg “Preserving”). Certification and accreditation policies; and protocols, are created to ensure digital object authenticity (Lavoie). However, concerns have been expressed regarding the availability of expert technical support to carry out emulation, since it has not been a widely understood process; and the need for metadata and artifact fidelity (Whitt 157). For this reason, migration has been a more popular technique (Whitt 158).

Migration in digital preservation refers to the transfer of data from a platform endangered by obsolescence to a newer platform. Migration can be done between servers, repositories and platforms, as pictured in the illustration, figure 7 (Whitt 156). File format may be changed. Data can then be moved to a more stable location (Whitt 158). This has risks, such as loss of data and intellectual content; and platform functionality or service function loss, which can occur when file formats are altered (Grainger). The process of migration is complex, time consuming, expensive and requires more human involvement and inevitably, deterioration (Whitt 158). Legal concerns, barriers and expenses are contributing factors when choosing among these strategies. In volume, data redundancy is probably the most frequently used technique due to its simplicity, low effort and lower risk nature (Whitt 157). The accompanying survey to this paper showed the same result, as replication was the most used strategy, followed by migration, as shown in figure 8. Very few respondents chose emulation as a strategy in use at their institution, which is unsurprising based on other research for this paper.

Figure 7. Migration Media. Computerworld.

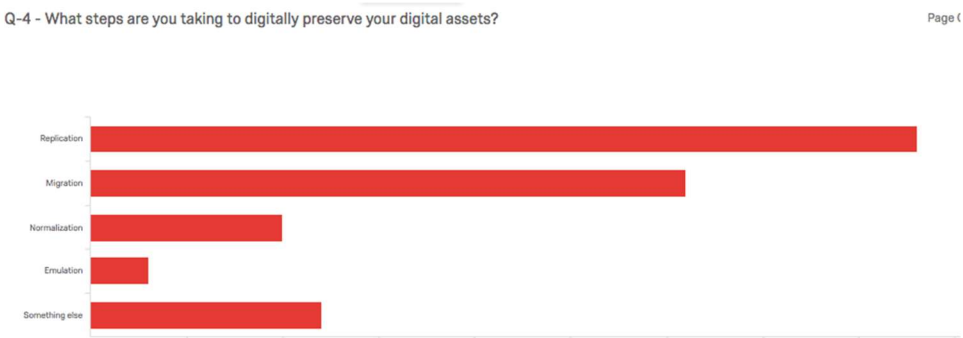

Figure 8. Survey Question 4. Gesek.

Virtualization is related to emulation, but "does not incur the software overhead of emulation" (Rosenthal "Emulation" 22). Additionally, processing speeds are said to be less accommodating to emulation than virtualization (Rosenthal "Emulation" 22). Digital content in virtualization is partitioned among multiple computer servers and machines, sometimes in different physical locations as seen in Figure 9 (Kastellec 64; Kay). In storage virtualization, the server can "regard multiple physical devices as a single logical unit" (Kastellec 64; Kay). This can be useful for running software from older (and sometimes outdated) operating systems, in combination with the use of cloud computing (Van Gorsels 17). The National Institute of Standards and Technology (NIST) defines cloud computing as "on demand network access to a shared pool of

configurable computing resources [via] networks, servers, storage, applications and services" (Han 262).

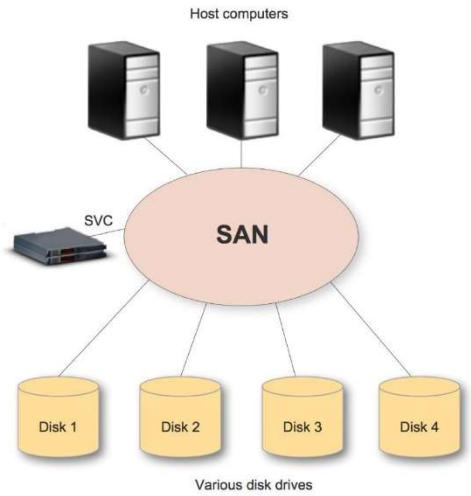

Figure 9. Virtualization Diagram. Cornerstone Information Systems.

What Happens to Digital Cultural Heritage Assets that are Neglected?

An important distinction lies between the care of museums analog materials and the care of its digital content. Benign neglect, which is the term used to describe an absence of care for cultural heritage assets, is far more detrimental to digital materials, than it would be with analog or physical materials (DeRidder 71). The term "bit rot" has also been used to describe the damage or degradation incurred by unmanaged digital data. Typically, "file fixity checks" detect errors, or bit-rot, and files can then be restored from a backup (Cocciolo 130). Physical materials might safely be left unattended for periods of time and endure only minimal affect. In Saving the Digital Record, Kondayen writes "open a book that was placed on a shelf two hundred years ago, and its pages will still provide the same information, tell the same stories." According to digital preservation experts, Ross Harvey and Martha Mahard, both formerly of Simmons College, "Most [analog] artifacts do not deteriorate rapidly if ignored, thus buying time before

preservation attention is needed which is commonly used as a management tool in preserving library, archives, and museum collections" (Harvey and Mahard 9).

In contrast, the neglect of digital materials is riskier, and can lead to corrupt files, which may be unable to be opened at all (Harvey and Mahard 9). Industry professionals have called it "a death sentence" or in less dramatic terms, Digital Preservation Europe was quoted as saying that benign neglect to digital files "is almost a guarantee that it [the data] will be inaccessible in the future" (Smith 581; Deridder 71). Digital information requires "active management" among other things, in order to ensure its accessibility and usability, no matter what type of institution holds it. As described earlier, this begins even before data creation, in the planning stages of digital curation, stewardship and before there is anything to preserve (Rosenthal et al. 4). Evens and Hauttekeete note that funding shortages are to be blamed for deterioration and obsolescence to archival materials (163).

Obsolescence

Another threat often cited in the care of digital materials is technology and media obsolescence. With the speed at which technology changes and evolves there is no guarantee how long the technology; media, or file format will remain active and usable for (Shaw, J; Rinehart et al. 30). Even when digital information is preserved properly, digital files can be rendered inaccessible and "unreadable by machines and programs in the future." (Shaw, J; Rinehart et al. 30). "Father of the internet" Vint Cerf has expressed concerns about obsolescence and a "digital dark age" in the twenty-first century "digital revolution" interfering with the technological ability to access our collective histories (Ghosh).

As an example, the failure to preserve materials from the 1975 Mars Viking Landers cost NASA irreplaceable images, and data that was only partially recoverable in the 1990s ("Mind

Gap"). The images and data, which were originally recorded to magnetic tape, in turn were unreadable by media available in the 1990s, which was when NASA discovered that the media was brittle and crumbling ("Mind Gap"). The information could be migrated to disks and stored, but not opened. This left only old printouts available, which had to be re-typed. The story does have an apparent happy ending. In 2013, a gaming startup was able to obtain these public domain images from NASA, and through a process of "reverse engineer[ing] technology", build a decoder for the data (Hui).

Jeff Rothenberg voiced fears about the longevity of digital files, disks and storage mediums in general, arguing that digital documents were fragile and cited incidents involving obsolete tapes in 1995 (Rothenberg 42). However, there are arguments made against the possibility of file format obsolescence by industry professionals. Fifteen years later, David Rosenthal disputed the argument made by Rothenberg ("Format" 208). Rosenthal concluded that the occurrence was infrequent and that more recent developments in technology had made this less of a risk ("Format" 208). Referencing several articles by Rosenthal, former DCC director, Chris Rusbridge argued that file formats actually "become obsolete much more slowly than we thought" (Rusbridge). Still, Rusbridge notes that there are clear examples of inadequate file recovery and admits flaws to his argument, involving changes in technology and the passing of time. He also acknowledges that there is significant risk of obsolescence, and risks of data loss, but views a lack of funding as the biggest risk (Rusbridge).

Funding Obstacles

The most expensive element of the digital preservation process is said to be the labor required to ingest, migrate and manage digital data over time (Richards 324). Complete collections cannot always be preserved, due to a lack of funding and data storage availability (Evens and

Hauttekeete 163). It was noted in the NEDCC survey, that a majority of the museums surveyed had devoted approximately five percent of their operating budget or less to preservation activities of any kind (Clareson 2, 3). Data recovery alone cost the United States over eighteen billion dollars alone for one year, according to Rinehart (34). Respondents to this paper's survey prodominently selected the option with lowest increment of funding, when asked how much was budgeted for digital preservation at their museum, which was ten thousand dollars or less annually, as show in figure 10.

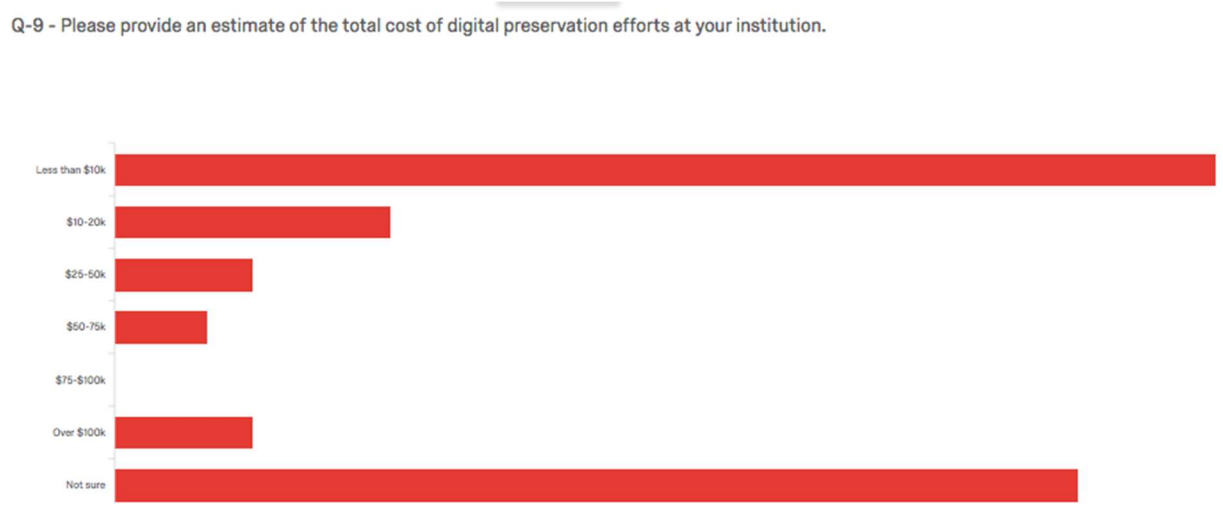

Figure 10. Survey Question 9. Gesek.

Two thirds of the museums in the IMLS survey said they lacked adequate funding, fifty-four percent said they had no funding for these activities at all, which reflected an overall drop in funding in museums, when compared to the previous IMLS survey ("Status" 6, 7, 24, 34). A majority of the museums said only half or less of their financial technology needs were met ("Status" 19). In 2006, it was found that forty percent of US museums surveyed by the IMLS did not have the funding to complete digital preservation activities. In Sanett's survey "Costs to ingest, preserve, store, deliver, and provide access to electronic records were largely unknown" (144). Sanett admitted that "securing long-term funding for digital preservation programs

remains a challenge" and recalled that long term funding was needed because "short-term project funding is not conducive to long-term viability of digital preservation" (Sanett 146, Harvey and Mahard "Preserving" 204). Rinehart found this also to be true and noted that recognition, on the part of administration, was needed, that digital preservation required programs, not projects, since ensuring institutional memory for the public good is a long-term commitment (33).

Though gaining institutional support was noted as the largest obstacle to digital preservation, in this paper's accompanying survey, funding was shown to be the second largest challenge, as shown in figure 11. Room was provided at the end of the survey, for additional input and to detail other significant challenges placed on the museums, in respondents own words and can be viewed in appendix A. Additionally challenging, is the need for adequate storage space for all of this data, which is also costly (Carden 8).

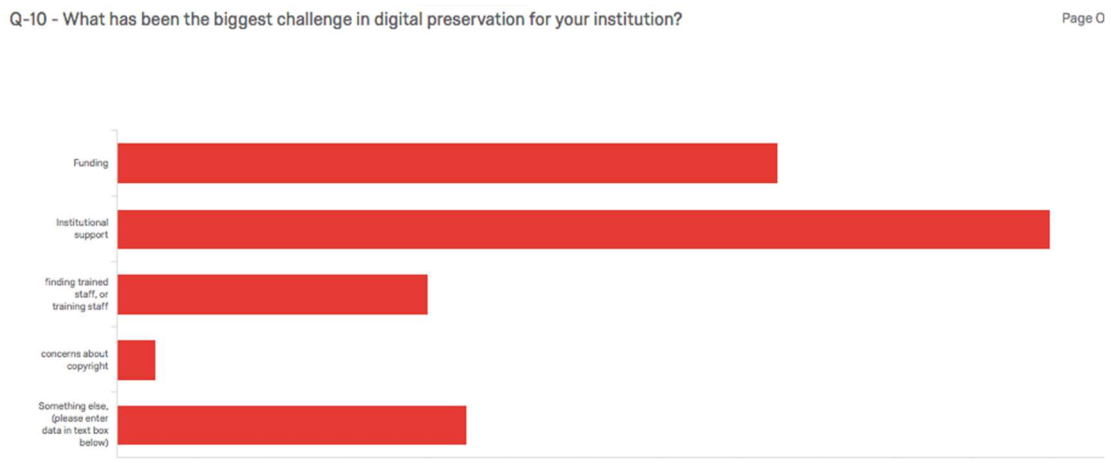

Figure 11. Survey Question 10. Gesek.

Digital Data Storage

Appraisal of digital data is predicted to increase in importance as we approach the "data capacity gap", since institutions will not be able to keep all of their data, according to "digital preservation pioneer" and former Information Chair at American Association for the Advancement of Science (AAAS), Francine Berman ("Fran"; 52). The data capacity gap is presented by information

technology professionals as a threat that we soon face of running out of digital storage space, as we amass more and more data, faster than we can create storage for it. International Data Corporation's projection is that the size of global storage capacity relative to the amount of data generated is expected to decline by half, by the year two thousand and twenty (Athow). In case efficient use of digital storage space was not already an institutional priority, this would give precedence to decision-making activities regarding digital information and storage space usage. Decisions about what will be retained, and kept accessible, and what is disposable will need to be confronted (Athow; "Running"). An appraisal process for determining priority levels of accumulated and future digital holdings should be outlined in a digital preservation policy for a museum. Research into optical data storage (ODS), holographic data storage (HDS) and DNA data storage (DDS) are offering hope for potential solutions, but storage is still an issue (Bhat 1).

Storage density, throughput and lifetime are defined as critical parameters to data storage technology. Storage density often becomes the determining factor to whether a storage method is adopted or not, and currently is in need of significant progress in order to overcome the gap (Bhat 3). ODS, DDS and HDS have been researched as possible technology solutions to the data capacity gap by adding data storage options (Bhat 2). However, none are able to stand alone as problem free, as described below. Storage technology lifetime is the time for which the technology can reliably store and retrieve data (Bhat 6). Throughput is the rate of data transfer and the time it takes to access content (Bhat 5).

Conventional ODS devices engrave information through use of a laser beam, and include Blu Ray, DVD and compact discs. The expected (though unproven) lifetime is at least one hundred years on ODS devices (Bhat 6). ODS transfer rates are said to be the fastest of the storage options, emerging or available, which may be helpful when not considering current

theory about best practices in processing speeds, as mentioned earlier, with the sloth strategy. but are still not acceptable (Bhat 6). Additionally, ODS does not contain the storage density needed to overcome the data capacity gap, which is said to need a solution that offers significant storage space (Bhat 2). Though researchers believe that by combining super-resolution techniques, potential exists to enhance the storage capacity enough that it may be possible to bridge the data capacity gap and alleviate infrastructure and operational costs (Bhat 3).

Research has been done on holographic data storage capacities dating back to the 1960s and has presented many challenges, but with the recent development of low-cost technologies, research progress has been made and is able to offer a higher storage density (Bhat 3, 4). HDS media contains information throughout the entire volume, rather than just on its surface, increasing its density (Bhat 3). Certain parts of the recording process, like mechanical positioning, are not expected to improve more, but other parts of the process that contribute to the transfer rate are expected to improve (Bhat 6). This would allow HDS to compete with one of the current technologies, Solid State Drive data storage, in cost parameters (Bhat 6). The media can be constructed in a way that significantly reduces the data footprint while "reducing the infrastructure, operational and maintenance costs" (Bhat 7).

The process of DDS encodes and decodes information onto synthesized strands of DNA, a naturally occurring (biological) molecule, that results in very high storage density (Bhat 4,7). Researchers have been interested in DNA as storage since the 1960s also and have successfully stored and retrieved data with schemes that "encoded and decoded English text, mathematical equations, Latin text and simple musical notations to DNA" (Bhat 4). This type of research has also been done at Harvard University's Wyss Institute (Athow). The technology has grown exponentially over time and the potential lifetime of DNA is speculated to be thousands of years

(Bhat 5). Related costs are declining, and its high-density capabilities can maintain a small footprint, and can lower infrastructure, operational and maintenance costs (Bhat 2,4,7). However, a study revealed that while encoded DNA is recoverable after treatment, it is vulnerable to errors, and proposed corrective techniques have shown varying success rates of full information recovery (Bhat 4,7). Other issues include limitations on its reading and writing transfer rate, which keep it from being competitive with both the existing and emerging storage technologies (Bhat 4, 5). DDS is time consuming. Research efforts made to expedite the process show promising results, and by using a specific process to amplify specific data, instead of groups of data, delays in transfer speeds can be avoided (Bhat 3, 6). Regardless, technology advocates claim that it is suitable for read only use, and long-term archival data storage. It is worth noting that the accumulation of archival materials in need of long-term storage is said to be "a big contributor to [the] data deluge" (Bhat 6) that is responsible for the data capacity gap. It has been proposed that the resulting solution may include a combination of these storage technologies, as part of a "heterogeneous and multi-tiered storage model" (Bhat 9).

Staffing

Although a lack of funding can be blamed for the absence of digital preservation and digital storage, the previously mentioned IMLS survey revealed that seventy six percent did not have adequate staffing, even if they had sufficient funding ("Status" 22). In 2005 about eighty-four percent of museums surveyed by the NEDCC regarding museum digital preservation and policymaking readiness, did support the idea of "staff development and professional education and training in the area of digital preservation" (Clareson 7). But the following year, the previously mentioned IMLS survey reported that because the museums did not have enough skilled staff for technology activities, it often relied on volunteers for digitization help (IMLS

14). In a survey seven years later, museums were found to devote the least amount of staff hours annually to digitization, of the four institutions types surveyed; museums; and college, public and special libraries (Primary Research Group 61). On average, only two people on staff were responsible for digitization activities, adding up to an average of one thousand, one hundred and fifty hours per institution annually, the least number of hours per institution of the four institution types (Primary Research Group 60). Though no information was provided about the total numbers of individuals on staff, for comparison, the average annually devoted library hours were approximately four thousand, four hundred and thirty-five hours, with approximately five employees (Primary Research Group 60). In this paper's accompanying survey, respondents most often confirmed that their institution had between one to five individuals involved in digital preservation, shown in figure 12.

Figure 12. Survey Question 7. Gesek.

Many information technology professionals agree that human error is the leading cause of up to seventy five percent of all data loss (Shaw, N). Staff who are undereducated about standards and best practices are a risk, potentially rendering efforts useless, wasting labor and preventing long-term digital preservation. (Rinehart et al. 29). This is a contributing factor to why the proper education of digital preservation and digital curation should be dispensed to museum and cultural heritage professionals working in information technology.

Digital Preservation and Curation Education in the US

As the distributors of information and mentors of the next generation of digital stewards, educators implicitly affect the future of our digital cultural heritage. It is thought that they influence "the definition, framing, and practice of digital stewardship" (Bastian et al. 619). For this reason, we cannot overlook the education of digital cultural heritage professionals as an important part of the digital preservation process. This seems to be a relatively new concept, based on the scarcity of digital preservation courses and digital curation programs available in the United States, as discussed in this paper.

Following closely behind the UK's formation of the DCC in 2008, the NSF formed an advisory board for digital curation research in the US. The NSF is a federal agency with an eight-billion-dollar budget, that provides significant financial support to non-medical research and education, through grant funding approximately twelve thousand research projects a year ("NSF Glance"). The NSF's goals include supporting "discovery, learning, research infrastructure and stewardship" ("NSF Glance").

> The NSF promotes the progress of science by investing in research to expand knowledge in science, engineering, and education, and by investing in actions that increase the capacity of the Nation to conduct and exploit science, technology, education, and mathematics research. (NSF "Building" 4)

The NSF was noted in a public finance survey, funded by the IMLS, as one of the four largest sources of federal support to US museums in 2006, providing about twenty three percent, contributing more federal dollars that year than the IMLS (Manjarrez 9, 52).

The NSF curation research panel recommended one billion dollars be dedicated to researching cyber infrastructure and investment "in data repositories [and] digital libraries" for

curation, organization, management solutions through software infrastructure and interoperability standards development (Ray 33). However, NSF's panel neglected to ask for funds "for education of the workforce that would be required to develop and manage these data repositories" (Ray 33). So, while this provided libraries with an opportunity to focus on areas involved in digital preservation, education and long-term solutions in digital preservation were not considered. Additionally, museums (science or otherwise) were not included in this funded research, even though the NSF has been cited as a significant federal funder and leader in the social sector, through its informal science education, with science centers and museums (Manjarrez 283).The lack of museum inclusion in this research widened the gap between museums and libraries' digital preservation activities (Ray 34).

The Institute of Museum and Library Services (IMLS) is also a significant federal funder of museums, having provided direct, competitive funding to museums in all fifty states for each fiscal year in the public finance survey (Manjarrez 9; Semmel and Bittner 272). Its mandate is to support the entire museum sector, unlimited by disciplinary type (Manjarrez 9). This includes supporting museum's roles in providing educational, artistic, civic, social, and economic services, and is committed to funding capacity-building projects in museums, as "keepers of the public trust" (Semmel and Bittner 285).

Leadership grants promoting the integration of new technologies in museums and museum library collaborations began in 2005, almost ten years after IMLS's inception by congress, through the merging of two older government programs (Semmel and Bittner 273). Nonetheless, when ten million dollars in funding was granted for the development of US digital curation programs in education, it was through the Laura Bush Twenty-First Century Librarian Program, and museum studies programs were not considered for the funding, and was for

Library and Information Science (LIS) programs only (Ray 33). The IMLS awarded their DigCCurr grant to several universities for digital curation education in 2006 "to define and support a graduate-level curriculum in digital curation" (Ray 33). One of the recipients of those funds was the University of North Carolina at Chapel Hill (UNCCH), appearing to be the first North American data curation program offering a master's degree (Tibbo et al. 3). UNCCH received another DigCCurr award in 2009. The program focused on preservation planning, curation and preservation activities such as migration (Ray 34). DigCCurr eventually collaborated with the previously mentioned NSF awarded program for digital curation at Virginia Tech, which was based on a model created by the DCC (Ray 34). Virginia Tech's program focused on actions that took place after data creation up to transformation, and assignment of description and representation information; metadata (Ray 34).

Out of thirty-two curriculum programs surveyed in archival and information sciences, in the US and Canada, twenty-six had a preservation course, but only one of them offered a digital preservation course in 2004 (Bastian et al. 614). Five years later the study was updated to show that three more programs began to offer a preservation course, and that an additional ten digital preservation courses had been added between the programs, a marginal improvement when you consider that seventy percent are still without any type of digital asset maintenance education, and that these statistics include four more programs that had been added to the study by the five year update (Bastian et al. 614).

With the few courses that are being run, mostly by LIS schools attempting to incorporate aspects of museum studies into their programs, rather than the other way around, there are concerns about the content being taught in the courses. In the education of digital stewardship, the strongest emphasis is placed on digital technologies and the systems that are centered around

digital stewardship (Bastian et al. 615). Relevance is placed on the importance of file types for accessibility, but fails to address usability, in a social context, for example with open access issues and the nature of digital materials (Bastian et al. 615). It is noted that while these types of courses should be observant of history, context and user, analysis provided in 2010 shows that they are not (Bastian et al. 616). By conducting the courses in this fashion, leaving out "the role of policies, demands of social issues and requirements of user communities", an educational deficit is being created in what little education already exists in this field (Bastian et al. 616).

As an "experimental digital pedagogy medium", and part of the digital cultural heritage program, marketed online as a "Cultural Heritage Concentration" in LIS, the Cultural Heritage Informatics Curriculum at Simmons College was developed with a curriculum lab and prepares future digital preservationists for their future career. The program, which features a curriculum laboratory, gives the students practical experience while still in school, rather than expecting them to eventually learn the skills on the job (Bastian et al. 616). Bastian notes that this is particularly helpful to LIS students. Since most education programs do not store "large, representative, non-proprietary digital content" (Bastian et al. 616), or virtual workspace, for students to use without damage risks, instructors are not often able to provide real world learning experiences. For this reason, this unique program has an opportunity to make a significant impact on future cultural heritage professionals.

Aside from the hands-on experience, the unique program's blending of the two disciplines (LIS and museum studies) proves rare, as well as its inclusion of digital preservation courses as a course topic at all (Bastian et al. 614). It was "specifically designed to address the digital convergence of libraries, archives, and museums" (Bastian et al. 616) and covers the convergence issue in the first course of the program, so may inadvertently help the museum

digital preservation field, but is created for an LIS student environment. Unfortunately, when discussing the program at a UNESCO conference several years later (2012), Bastian and Harvey reflected some initial disappointment, and lessons learned after the program's inception (Bastian and Harvey 10). Noting that implementation had been problematic and "not entirely successful", they learned that issues of convergence require negotiation and recognition, of the various cultural heritage issues in each discipline, but also the issues of institutions that had participated in the program projects to give students on-site training (Bastian and Harvey 10, 11). Issues cited were "lack of resources, compartmentalized and siloed mindsets; and territoriality" (Bastian and Harvey 11). Communication between the disciplines seemed to be a frequent problem (Bastian and Harvey 9).

Digital Preservation and Curation Education in Museum Studies Programs

There is a distinct lack of support for digital curation, in museums and in museum studies education programs within the US. This is reflected in surveys conducted between 2005 to 2008, by the Northeast Document Conservation Center (NEDCC); Madeline Sheldon; the IMLS; Shelby Sanett; and information professionals Helen Tibbo and Wendy Duff (Clareson 7; Sheldon "Analysis" 11, 23; Sanett 141; Tibbo et al. 3). Reports issued from the IMLS and the National Science Foundation (NSF) between 2009-2011 also offer further evidence of this (Ray 33). However, there is also a noticeable lack of cooperative relationship practice between museum studies education and LIS education, on the museum studies end (Kim 159). In recent years, LIS education has taken steps to begin inclusion of museum studies elements in their educational programs, as with the previously mentioned program at Simmons College. On the other side, museum studies education generally contains little information about digital preservation and stewardship, let alone anything to do with LIS education (Kim 159). Museum studies education

is being asked to redesign their programs to be more inclusive of digital stewardship and elements of LIS education (Kim 159). The International Council of Museums (ICOM) curricular guidelines stipulates that museum education should contain five components; museology, management, public programming, information and collections management and care (Kim 159; Tibbo et al. 17). Those guidelines were drafted in 2000. Many years later, museum professionals are still searching for a defined set of standards of what a museum studies degree holder should know, says information science professor, Jeonghyun Kim, at the University of Texas (159). This is said to have become a deterrent of growth in museum studies (Kim 159).

In a 2008 survey of professional education in North America, a "significant gap between the education of [museum] information specialists" (Ray 34) and the realities they face in the workplace was identified. Museum professionals mentioned the need for staff with digital curation skills (Ray 35). Few "museum professionals have had formal educational preparation themselves prior to their on-the-job experience" (Ray 38). Familiarity with (newly established) "standards and practices, metadata, and organizational, project management and communication skills" (Ray 35) are noted as important to museum digital preservation professionals (Han 261). It has been noted by "senior museum professionals" that the lack of these skills in museum professionals cause them to hire outside of the sector, librarians and archivists because museum professionals often lack the desired combination of "digital expertise and museum experience" (Ray "getting a handle").

An investigative report for the IMLS suggested the addition of "museum informatics" was needed in museum curricula development of repository management, to address "the full lifecycle of digital objects" (Ray 34). Only in 2008, did John Hopkins University (JHU) began to address technology in their museum studies program by adding more relevant classes to the

museum studies curriculum, and implementing a digital curation program (Ray 35). JHU felt that theory and principles that would remain valid over time should be emphasized, which is part of the reason for their delay in developing the program (Ray 35). JHU's museum studies digital curation program is based on the concept that museum employees should "know why and how digital assets were created" (Ray 36), their context of use and should have discovery information; descriptive metadata.

Overview of Museum Computer Technology

It is said that a museum professional should be able to "organize and provide access to information resources in museums" (Kim 151). But there are many current issues affecting museums and cultural heritage institutions, involving digital technology. There is a need for education, throughout the museum workforce, and for future museum professionals, regarding digital processes in preservation. Museum professionals also need to think about the sustainability of their resources, and build support within their institutions, communities and in public policy. Museums have been working on integration of information technology since the 1980s, according to previously mentioned University of Texas professor, Jeonghyun Kim (149). So, it is baffling that these issues remain unresolved, holding museums back from better stewarding their digital cultural heritage (Kim 149).

The Museum Computer Network, which signaled the beginning of machine automation in museums, has been around since in 1967. By 1998, two-thirds of institutions surveyed about digital preservation needs, by Margaret Hedstrom and Sheon Montgomary, had claimed responsibility "for preserving material in digital form" ("Timeline"; "History" MCN; Hedstrom and Montgomary V). Nonetheless, almost half lacked "the capacity to mount, read, or access files" on their storage media (Hedstrom and Montgomary V). MCN originally formed to focus

on “cultural heritage computing” and to support the greater museum community in what they considered a “growing information crisis in American museums” (Misunas and Urban 9) but would not hold its first digital preservation conference until 2005. The MCN’s creation stemmed from an electronic index project by the Computer Research in the Humanities, for the Metropolitan Museum of Art, and wanted to “provide opportunities to explore, implement, and disseminate knowledge and best practices” (Misunas and Urban 1, 2, 3, 4).

MCN exists today to “help museum information professionals advance their careers” (Misunas and Urban 2) and to use technology effectively, but once advocated for one united, national museum databank. The databank was to share information between museums nationwide, provide researchers with unprecedented access and to improve museum management (Misunas and Urban 2). The first iteration of MCN had higher aspirations of providing a multinational system of the same nature. IBM funded the first of the annual conferences in 1968, and additional grant funding from the New York Council of the Arts and the Old Dominion Foundation enabled them to create a museum databank prototype. The group developed a data dictionary to aid in descriptive practices in museum collections (Misunas and Urban 2). MCN formally incorporated in 1972, but did not offer individual, rather than organizational, memberships until 1981, prompted by the prevalence of personal computing and the obsolescence of mainframe computing systems (Misunas and Urban 3).

The shift in mission and focus onto data standards development occurred in the 1980s, once the GRIPHOS system was retired (Misunas and Urban 3). The organization underwent funding losses; grant gains from the National Endowment of the Humanities and the Pew Trust; governance changes throughout the 1980s; and held its first pre-conference workshops in 1985 (Misunas and Urban 4). MCN formed a relationship with the Smithsonian, began working

with AAM in 1987, and collaborated with Getty information Institute, Canadian Heritage Information Network, Eastman Kodak and others through their Consortium for the Interchange of Museum Information (CIMI), which would become a separate entity (Misunas and Urban 4). "Information superhighway legislation" was a priority for MCN and the museum community when, now current head of the digital preservation office at the Smithsonian, Diane Zorich was president. In 1994 the National Information Infrastructure under the Communications Act was passed (Misunas and Urban 4, 5). This allowed for museum resources to be accessible on the internet, and in 1996, MCN's website went online (Misunas et al. 4). When compared to other cultural heritage institutions, like libraries, it becomes apparent that museum digital preservation has had an exceedingly slow start, despite the history of museum computing.

The Relevance of Digital Preservation in Museums

Digital technology and digital preservation allow cultural heritage institutions to share information between each other; make available digital copies of precious and fragile items; assist researchers; and share collections on a global scale, as with the Mütter Musem's Momento medical collection, as shown in figures 13 and 14. The online collection allows for close viewing and rotation of collection objects. The digitization of analog materials offers many examples of what digital preservation can offer stakeholders.

Figure 13. Momento Collection Online, Image 1. Mütter Museum, Physicians of Philadelphia

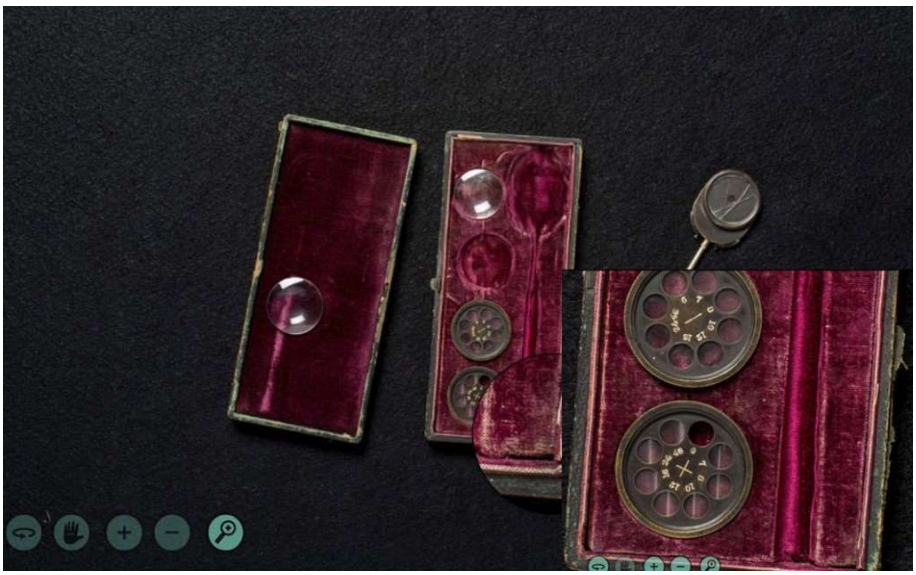

Figure 14. Momento Collection Online, Image 2. Mütter Museum, Physicians of Philadelphia.

For instance, although created by libraries, Mirador open source image viewing platform serves as a good example of what is possible, in service of the public, even on a global scale, through digital preservation. Multiple participating scholarly institutions digitally reconstructed full copies of books that are physically separated by thousands of miles (Frey). The web-based image viewing platform gives users the ability to compare manuscripts "directly from their home

institutions" (Allbritton) as seen in figure 15, with the *Canterbury tales* texts. In this case, one text is located in Los Angeles and another in Wales ("Home"; Allbritton). This collaboration between Harvard University, Stanford University and many others was made possible thanks to a grant from the Andrew Mellon Foundation ("Home"; Allbritton).

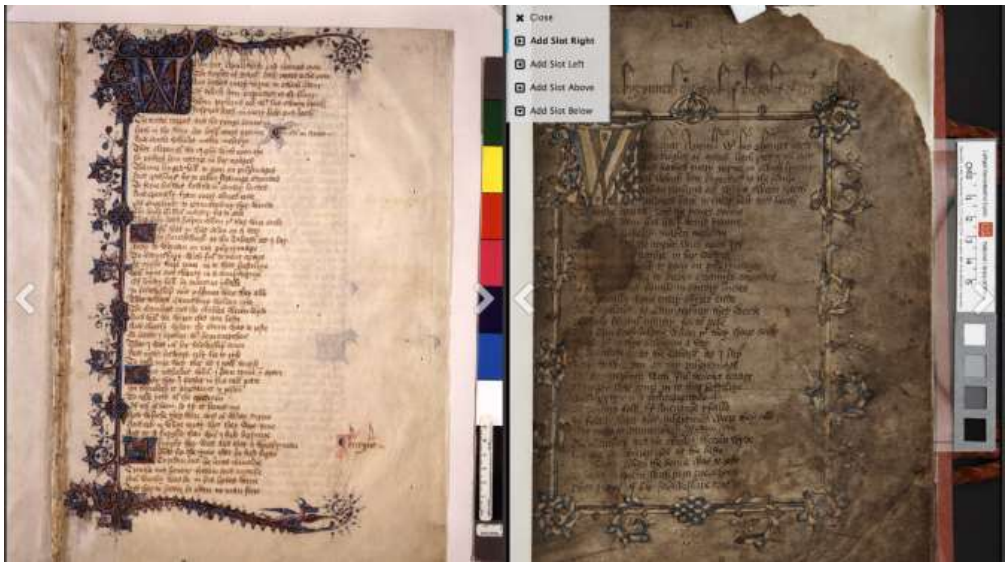

Figure 15. The Hengwert and Ellesmere Chaucer Mss. Canterbury Tales. Stanford University.

How Museums Stack up Against Other US Cultural Heritage Institutions

Of cultural heritage institutions within the United States, museums lag the most in the preservation of their digital assets and in digital preservation policy-writing (Sheldon "Towards DPP"). As the surveys and research from over the past twelve years reveal, many museums still lack digital preservation policies or fail to engage in digital preservation activities. Preserving this technology, data and the knowledge it produces is critically important for museums. Studies done from the early 2000's (up until now) reveal that even though these problems were recognized many years ago, United States archival institutions are still ill equipped and unprepared to handle the tasks of digital preservation and lack skilled staffing to undertake these tasks (Sanett 141).

In Digital Preservation

Claims were made in 2002 within the US that funding agencies were "advancing digital preservation as a serious research area" (Sanett 145) and that international collaboration had been on the rise for the past ten years. Study administrator for the National Archives and Records Administration (NARA), Shelby Sanett, took this information as an acknowledgement that institutions needed to "develop collaborative relationships, cost options, and a consensus on policies, standards, and methods in digital preservation" (145). Unfortunately, when the IMLS survey was released four years later, only approximately twenty percent of museums reported that they participate in digital preservation collaborations with other institutions and organizations ("Status" 29). A lack of museum digital preservation and a lack policymaking readiness was identified as an area of weakness in the survey Sanett conducted in 2007 (140). Over half of the respondents said that their digital assets were not insured and were only expected to last about twenty-five years. After conducting her 2014 survey, Bergin speculated that there are four main causes responsible for the lack of digital preservation and digital preservation policy-writing in cultural heritage institutions; "[the absence of] solutions, services, staff and costs" (Bailey). She found seventy three percent of respondents did not have a digital preservation policy in their institutions (Bergin 8, 21).

In an online survey about museum digital preservation that was conducted in conjunction with this research paper, a majority of respondents confirmed that they were in fact participating in digital preservation activities such as normalization, replication, migration and metadata collection. The majority of institutions reported spending under ten thousand dollars (the least amount available for a selection answer) and had between one to five employees working on digital preservation. Institutional support was cited as the biggest obstacle to digital preservation,

followed by funding needs. Most reported that they do not collaborate with other organizations on digital preservation and reported that mainly the museum library or archives was responsible for digital preservation. After museum library or archives, respondents mostly listed next that separate departments did their own digital preservation. Despite the ongoing activity, a majority of respondents said their institution did not have a digital preservation policy because it wasn't a priority. None of the respondents confirmed that their museum had another policy that covered digital preservation. Of the percentage that did have a policy, it had been adopted in the last five years. Reasons listed for not having a digital preservation policy, and other obstacles in digital preservation mentioned were not dissimilar to the other surveys mentioned in this paper. A lack of understanding and training, lack of staff, periods of transition, a lack of stakeholder support and time management issues were included as write in answers for what hampered these institutions from completing the activities and policy writing more completely.

In Policy-Writing

The development of a digital preservation policy, with regular periodic reviews, is important for the long-term sustainability of digital assets. Attempting digital preservation without one is short-sighted and can lead to loss of valuable data; wasted time in duplicated efforts; overall inefficiency and organizational chaos (Rinehart et al. 37). Though this paper's survey notes that most often a museum's archives or libraries are responsible for digital preservation, an alarming number of institution's digital preservation is being done department by department, shown in figure 16, which increases the potential for problems of inefficiency mentioned by Rinehart. At a 2015 Summit on Digital Curation, Diane Zorich said "the fragility of digital materials – be they digital collections or other museum assets in digital form - is apparent to everyone. So too is a tacit understanding that continuing with the status quo will result in unprecedented losses of

cultural heritage in our institutions" ("Report Summit" 33). Those losses could look like NASA's previously mentioned data loss, or with the chaotic disorganization that ensued between multiple departments trying to conduct the same digital preservation tasks on the same materials, as with Rinehart's case study in "Overwhelmed to Action: Digital Preservation Challenges at the under-Resourced Institution." Zorich has also lamented on the lost opportunities for collaboration as well as the costly redundancies that result, due to lack of strategic planning or oversight ("Info Policy" 56).

Figure 16. Survey Question 6. Gesek.

Researcher Anthony Cocciolo notes in his museum case study that the assumption of indefinite digital file accessibility without planning is thought of as "short-sighted" by archivists (129). When compared to the speed at which digital technology grows and alters the processes carried out in cultural heritage institutions, and also in considering that Zorich, a seasoned museum information specialist, as mentioned earlier, had called for updated museum policies over ten years ago, it is obvious that research has lagged, and continues to. She deemed new policies necessary due to the "pervasive role of information technology" ("Info Policy" 56). According to Zorich "efforts to address information policy in the context of museums [had] virtually ceased since the late 1990s" (Zorich 60).

Despite its importance, little information has been provided about the topic of digital preservation policy-writing in museums over the last twelve years, and how to create them. As a result, many museums within the United States do not have a digital preservation policy. Though the surveys referenced have been conducted over the span of twelve years, little seems to have changed, and the surveys shared similar results when noting issues relating to a lack of digital preservation policy-writing. In as survey done for the Institute of Museum and Library Services, only thirty-four percent of respondents reported having policies related to technology and digitization ("Status" 15). In 2013, Madeline Sheldon conducted a survey for the National Digital Information Infrastructure and Preservation Program (NDIIPP), a program of the Library of Congress about digital preservation ("Towards DPP"). Sheldon described museums as being "in a distant third place", compared to libraries and archives in the area of digital preservation ("Towards DPP"). The study that she conducted confirms that US libraries are, in fact, ahead of US museums when it comes to writing digital preservation policies ("Analysis" 10).

The weakest area noted in the 2005 NEDCC survey, was in the development of plans and procedures. Seventy-one percent of institutions were found to have "no written plans or procedures for the creation or management of digital resources" (Clareson 9). In Sanett's survey, two years later, weaknesses in policy development, long term fiscal planning and budgeting were evident (140). Sanett said policy development failed to be a priority of the institutions she surveyed, and therefore moved much slower than the pace of technological development (146). In this paper's survey, current trends show that the lack of digital-preservation policies in museums has not changed, as shown in figures17-19, digital preservation is going on without the use of institutionally dictated policies. When asked why a policy had not been adopted, the majority of respondents either iterated that their institution had adopted one within the last five

years reflecting a fair amount of delay on the part of the institution, or they reported that writing a digital preservation policy failed to be a priority of their institutions.

Figure 17. Survey Question 1. Gesek

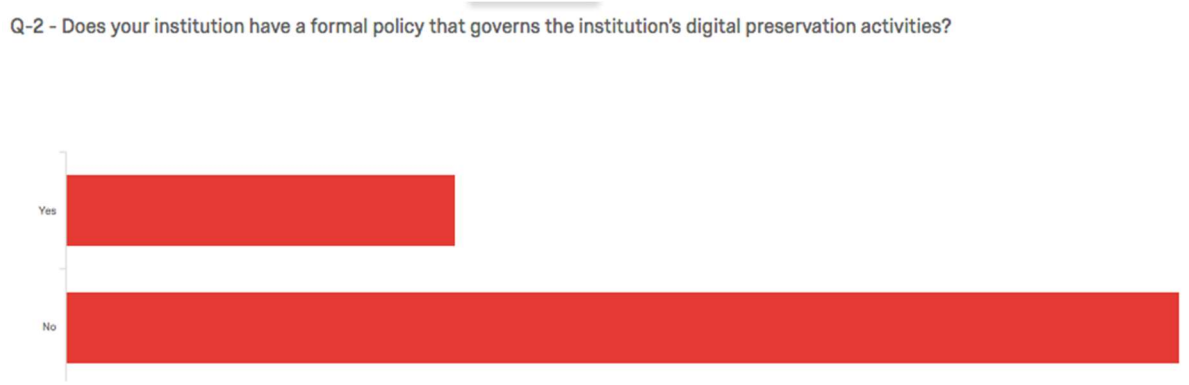

Figure 18. Survey Question 2. Gesek.

Figure 19. Survey Question 3. Gesek.

What should a digital preservation policy include?

Since an overwhelming ninety-three percent of the world's digital information is derived from born digital content, without analog equivalents, the writing of a policy that dictates how an institution will deal with that data should be a significant priority (Bawden et al. 221; Conway 76). However, Zorich acknowledges that "policy development tends to occur when an issue has reached a critical mass in terms of causing disruptions, confusion, or uncertainty within an institution" ("Info Policy" 62). Zorich says the scope of a museum policy should be "a set of principles, values, and intent that outline expectations and provide a basis for consistent decision-making and resource-allocation...derived from a museum's mission statement, goals and priorities" ("Info Policy" 53). When Bergin's institution was constructing their digital preservation policy, scope, role and responsibilities were topics they felt should be covered in the policy (Bailey). Additionally, it is thought that a digital preservation policy should consider user

needs and contain guidelines about which digital assets should be preserved and why, "a mandate which would indicate the level of commitment to digital preservation activities" and what the needs of the digital collections are (Conway "leaflet"; Henry 2000; Keene 2001; Elford 6). All processes, decisions and goals should be documented and made understandable to stakeholders and management (Sanett 147). A sample museum digital preservation policy, from the Baltimore Museum of Art (BMA), can be found in Appendix B.

Challenges and opportunities in museum digital preservation

Museum Digital Preservation Research and Policy Examples

From the NDIIPP survey, Sheldon concluded that there was a striking scarcity of museum documents relating to digital preservation, which she attributes to museum's hesitance "to apply a one size fits all" (Sheldon "Analysis" 10) strategy to collections through the creation of a digital preservation policy. Specifically, Sheldon notes that museums often contain more unique one of a kind items that are harder to streamline into one process, and library collections are often able to be conformed to one set of standards (Sheldon "Analysis" 10). For instance, "maintaining hybrid pieces, consisting of analog and digital material", require a "digital conservation" (Sheldon "Analysis" 10) approach that does not allow for conformity on a large scale. They must also take into consideration the intent of the artist. These tasks prove challenging with artwork like Nam June Paik's, which contain a combination of analog and digital material (Sheldon "Analysis" 10). Zorich expresses this same sentiment when comparing museum and library collections, citing the increased difficulty in standardizing and categorizing museum collections, which often contain many different types of items within one collection ("Info Policy" 53).

The short supply of museum digital preservation policy examples available for reference have led museums to look to libraries, archives and international counterparts for guidance (Sheldon “Analysis” 10; Pad and Rafferty 150). Of the museums surveyed by the NEDCC, the most pronounced lack of policy development was in art museums (Clareson 7). Sheldon concludes that differences between art museum collections and library collections are at least part of the reason that a gap exists between the two cultural heritage institution types in the area of digital preservation ("Analysis” 10). In addition to the struggles museums face in digital preservation and policy-writing, art museums must grapple with concerns about artist rights and unclear laws regarding copyright, object authenticity, and a lack of art museums to reference in this process (Pad and Rafferty 149).

In 2014, this was one of the obstacles that the BMA faced when the museum began the process of creating a digital preservation policy (Pad and Rafferty 157). With the help of the National Digital Stewardship Residency (NDSR) Art project, which provided expertise, and with grant funding provided by the National Historical Publications and Records Commission (NHPRC), writing of the policy became possible (Pad and Rafferty 150). It became a museum wide priority, throughout administration, thanks to grant deadlines that needed to be met (Pad and Rafferty 152,157). The goal of the NDSR is to “bridge the gap between existing, well developed classroom education and the need for more direct professional experience in the field” (“About” NDSR). Museums can seek out collaborations and financial assistance from other organizations like the BMA did, making it possible to dedicate time and resources to create their own digital preservation policy and plan for the future of their collections.

Cross-sector Collaboration and Professional Development

Following Europe's lead, about six months after the formation of DigCurV, the US Library of Congress formed the Digital Preservation Outreach & Education program (DPOE). DPOE includes a collaborative network of instructors and partners who provide training to individuals and organizations, as part of their mission to provide national outreach and digital preservation education (Sanett 143). As such, DPOE might serve as a helpful resource to museums struggling in the area of staff training and professional development. Additionally, cross sector collaboration offers important opportunities for cultural heritage organizations to work with and learn from one another with in the field, outside of formal university education programs mentioned previously. As it stands, a majority of the museums surveyed for this research paper said they had not participated in any collaborations pertaining to digital preservation, with other museums or cross-sector with other institutions, as shown in figure 20.

Figure 20 Survey Question 8. Gesek.

Through the global cooperative, Online Computer Library Center (OCLC), an effort was made to promote cross-sector collaboration in cultural heritage institutions and address convergence between the three largest cultural heritage organization types in the US. The 2016 Collective Wisdom: An Exploration of Library, Archives and Museum Cultures conference series, was a program created by the Coalition to Advance Learning in Archives, Libraries and

Museums (CALALM), and grant funded by the IMLS and Bill and Melinda Gates Foundation. CALALM works towards "professional development programs that will transform the library, archives and museum workforce" (Allen et al. 8) in order to impact existing and related national committees. Collaborations like this could be particularly helpful in adding resources to the museum field, which contain only a fraction of the member numbers in their professional organizations, than those held by professional library organizations. Specifically, AAM only has a member population of about thirty thousand, while the American Library Association (ALA) boasts numbers that at are least double that (Allen et al. B2, B3).

The eighteen selected participating cohort members of Collective Wisdom attended AAM, ALA and Society of American Archivists (SAA) meetings, engaged in discussions over nine months, and finally convened again to discuss their experiences and findings, with the help of funding that was provided for a large portion of participants in the program (Allen et al. 9). They worked together to address important "continuing education and professional development" (Allen et al. 14) issues, relevant to their organizations and were able to find common ground in multiple areas. Shared needs were discovered, for scalable strategies in; assessment and ingest of digital materials, access, audience-based engagement, property laws, privacy and publicity rights and other digital content distribution issues. An interest in working cross-sector in continuing education and professional development was reflected in the final meeting by many of the information professionals (Allen et al. 6).

Outcomes mentioned in the white paper included perspective, mentoring, exposure to new ideas, resources and models from another sector, baring relevance to their own discipline (Allen et al. 10, 11). Cohort members discovered many published resources from other sectors, relevant to their workplace (Allen et al. 11). Experiences have been shared by cohort members

presenting at the Museum Computer Network annual meeting and State Library Continuing Education Coordinators Summit (Allen et al. 11). Additionally, AAM, American Association for State and Local History (AASLH) and the Midwest Archives Conference have received project proposals, inspired by this experience (Allen et al. 12).

Areas that goals were discussed in include preservation and conservation; community engagement; cataloging protocols that reflect cultural sensitivity; shared standards; improving access and the need for strategies; and advocation of work value and for appropriate funding (Allen et al. 6, 10, 13). Additionally, practitioners felt their roles in cultural heritage tasked them with educational, democratic, freedom and information literacy-related responsibilities to the public (Allen et al. 10, 13). The cohort recognized opportunities to "pool marketing and advocacy resources in order to increase public awareness of ...heritage repositories [value], public amenities and cultural, educational resources" (Allen et al. 10). Through collaboration, grants might become accessible that would not be available to institutions independently. This could be true for institutions from any of the three sectors. Together they might be able to benefit from a national funding program.

Unfortunately, large funding agencies create collaboration barriers, and instead fuel a competitive environment between the organizations, by creating grant programs targeted to only one discipline. However, the National Endowment for the Humanities, NHPRC and the IMLS has cross-sector collaboration programs that combat the competitive funding model (Allen et al. 19). Across organizations, there has been "varying support from AAM, ALA and SAA" (Allen et al. 7) in cross sector collaboration. Because of this, the joint Committee on Archives, Libraries, and Museums (CALM), has been directly impacted by the aforementioned organizations support, or lack thereof. CALM is the only organization in the US dedicated to "addressing areas of

mutual interest across these organizations" (LAMS) (Allen et al. 7). However, the AASLH; American Institute for Conservation of Historic and Artistic Works (AIC); Association of Tribal Archives, Libraries and Museums (ATALM); and the National Council on Public History (NCPH) are currently attempting to bring LAM professionals together for cross sector training and collaborative opportunities (Allen et al. 7).

Additional barriers to cross-sector collaboration that were noted were the conference costs; and reinforced LAM silos through field specialization, in graduate school programs as well as at conferences and professional development courses (Allen et al. 6). Suggestions were made that required cross-sector collaboration between information science and museum studies graduate programs could foster an enduring connection between the fields, and the professionals working in them (Allen et al. 7). Cohort members also expressed mutual concerns that gaining administrative support from their home institutions for cross-sector training would be difficult, and that opportunities would need to be clearly incentivized (Allen et al. 14). Some of this may explain why over fifty percent of the museums surveyed in 2013 regarding digitization had not collaborated with other institutions or departments within their own institutions on digitization projects (Primary Research Group 56).

Collaboration and Open Access

Aside from conserving financial resources, another way for museums to benefit from cross-sector collaboration, raising their public profiles, is through their participation in open access collaborations with other institutions (Paqua). The Pratt Institute's Meghan Paqua advocates for making materials, and creating policies, for open access in museum institutions, a priority, "within an institution's digital strategy, whether as a separate document, or imbedded into the

strategic plan" (Paqua). Potential for collaborations with larger institutions are created by offering open access materials to the public (Paqua).

As mentioned earlier, open access of cultural heritage material has generally garnered more support outside of the US. This may be related in part to the structure of technology laws mentioned earlier, and certainly due to copyright concerns (Lynch). To provide open access implies that unrestricted or very few restrictions are put on public use of the materials in question. The level of access provided depends on each country's federal laws, intended use, and whether the materials are defined as "public domain" or copyrighted (Paqua). Some grant funders, such as the Bill and Melinda Gates Foundation, the Ford foundation, and the William and Flora Hewlett Foundation now require that projects completed with their funding be open access, further incentivizing collaboration with organizations that can offer needed resources to museums (Paqua).

Citing public engagement as the major goal, in order to maintain cultural relevancy, Paqua points to consortiums and organizations like Europeana, Wikipedia and Google Arts & Culture as examples of possible collaborators for museums to work with (Paqua). This sort of collaboration seems to be a long-term trend, Paqua noted, from NMC Horizon 2016 Museum Edition report. Even though the image collection is only available for viewing in-house, the Information Center for Israeli Art at the Israel Museum has also partnered with and provided information to Wikipedia about five thousand, eight hundred artists, in Hebrew and English (Smith 332). It is acknowledged that not all museums will have the ability to offer open access, in part because a more resource strapped institution may lack the digital asset management or infrastructure to support this kind of service, but there are clear benefits for institutions that are able to participate in open access collaborations (Paqua).

Technology Solutions

Fifty two percent of museum respondents in the 2013 digitization survey said they did not have additional digital storage and were using the general server of their institution to store their digital files, while only thirty two percent had their own dedicated server and twelve percent relied on third party digital storage (Primary Research Group 99, 97, 100). Forty eight percent of museums did not employ the use of digital asset management software either (Primary Research Group 86). In general, the museums surveyed tended not to rely on other institutions and third-party services for digitization services. Over a period of three years, only about ten percent of museum digitization was outsourced (Primary Research Group 73, 40).

Undoubtedly, cost plays a role in museums' inability to utilize third party services or cloud storage. However, in 2012, the IMLS funded a project called Preserving Objects with Restricted Resources (POWRR) "to investigate, evaluate, and recommend scalable, sustainable digital preservation solutions" (Han 263). POWRR's white paper recommends the use of cloud storage for institutions with limited resources (Han 263). Additionally, UNESCO recommended the use of cloud storage in the 2016 guidelines for digital heritage, which is gaining global popularity (UNESCO 13). While this has been a trend within the government sector, the cultural heritage sector has been reluctant to embrace the concept, although as of 2014, the UK seems to have gotten on board (Oliver et al.).

The advantages of cloud storage include "availability, scalability, off-site storage, on-demand, and multi-tenancy" (Han 262). With minimal management or service provider interaction, cloud services are able to offer speed and affordability (Mell and Grance 2). Cloud storage was once considered an unaffordable option, but its pricing has dropped seventy percent since 2013, which could make redirecting resources, towards staffing museums with digital

preservation experts, an option (Han 269). In theory, cloud computing is said to offer an increased ability to digitally preserve bit-level content through replication (Oliver et al.). In Bergin's survey, forty eight percent of respondents reported that bit-level preservation was the only strategy they were using to preserve their content. Though it should be noted that bitstream preservation does not guarantee access to future users, without further steps that rely on hardware to decode the bitstream (Anderson et al. 116; Kastellec 64). As hardware becomes threatened by obsolescence, so then does the bitstream (Kastellec 64). This indicates that alone, cloud computing may not be able to ensure long term usability of assets but may serve as part of a multi-step digital preservation plan to provide more economical on demand access, and short-term backup, for some institutions (Bergin 28; Kastellec 64).

When using services like cloud storage, institutions face concerns about cost, but also about control of decision-making, control of the cloud infrastructure, and buy-in from stakeholders (Oliver et al.; Mell and Grance 3). For cultural heritage institutions, there is a need for "technical diligence" and a heightened level of engagement, from a position of institutional mission and purpose (Oliver et al.). As opposed to other sectors, cultural heritage data requires exceptional longevity, greater assurances, and this is said to have significant impact on backup, protection and retention. To utilize this option may require a change to the way institutions operate and may be challenging. At the very least, it requires adaptation on the part of the institution and its professionals using the service (Oliver et al.).

Funding Solutions

Over time, the cost of technology and related services tends to decrease. Cloud services have served as a notable example. Of the adaptation noted as necessary, institutions would need to transition, from a reactive to a proactive position financially, and view their budget from a year

to year perspective. As part of a growing international trend towards governmental cloud computing and shared services worldwide, the National Library of New Zealand's National Digital Heritage Archive transitioned to cloud storage in 2013 (Oliver et al.). The NLNZ has been considered a government department since inception, requiring stricter and law-binding requirements of their content. Their funding comes directly from the government but in migrating their digital data, a change in funding models, from capital to operational expenditures, was required. Theis previous model, set up for in-house storage use, involved periodic equipment purchases, and so was funded as capital expenditures. A new year to year cost model would be necessary, if using cloud services, funded as operating expenditures. It was noted that international governmental support has been given to cloud-based services around the world, including in the US. However, getting these entities to shift the funding models (to an increase in operating expenditures), to pay for this service use has proven difficult, even though by unit price the storage is more economical, and the service is reported to be better (Oliver et al.). Overall it saved the New Zealand government money while enhancing public services (Oliver et al.). Nonetheless, it appears that increased support will have to be advocated and fought for.

Funding in museums is habitually a problem in areas involving digital technology and digital preservation. Although grants and endowments made up forty two percent of their budget, fifty eight percent of their budgets' the institutions need to provide for themselves (Primary Research Group 49, 51, 52). The same 2013 study showed that while the annual digitization budget for all of the surveyed institutions conducting archival digitization was around one hundred and five thousand, nine hundred and seven dollars, the museums had a much lower overall annual budget, at sixteen thousand, two hundred and ninety-one dollars, only a fraction of the available budget of the other institutions (Primary Research Group 35, 48). In general, at

least thirty two percent of museums surveyed about museum digitization, viewed fundraising "[un]favorably" in their institutions (Primary Research Group 53). However, the previously mentioned Simmons Digital Curriculum Laboratory, funded in 2009, serves as an example of how grant funding can successfully be procured to advance the digital preservation field through various initiatives. The program and planning were made possible through grants from the IMLS, NHPRC and Pottruck Curriculum Technology Support Grant. Numerous other agencies named throughout this paper offer funding as well (Bastian et al. 616).

Conclusion

This paper has provided a brief orientation of digital preservation in US cultural heritage including the topics of education, relevant to the museum sector, and in conjunction with international cultural heritage perspectives of organizations, agencies and governments. Previous surveys have highlighted some of the problems and struggles cultural heritage institutions and museums have grappled with. This helps to distinguish the US museum sector's position within a loose framework. Discussion about the history of museum computing and the relevance of digital preservation in museums help provide context to the presented strategies and challenges that digital preservation, stewardship and curation entail. Bastian said that even with meticulous care paid to digital assets, the performance needs of future users are unknown (607). To add to this challenge in digital preservation and policy-writing, connecting on a global scale; providing and preserving cultural heritage data while at the same time providing personal data protection, observing copyright laws and public policy makes digital preservation complex subject matter (Brown 61). Opportunities for digital preservation learning in formal museum studies education are clearly lacking, and an increase of financial support is needed, given the importance of cultural heritage preservation. Additionally, as public resources, and providers of information,

museum professionals need to be supported by their own leaders. Finding examples to follow; opportunities to collaborate; funding for programs, and support from governing institutions; training and education; and mitigating technological threats can be overwhelming for the museum personnel who train, understand and perform these tasks for the greater good (Brown 61). Still, there exists options for the museum community to seek grant funding, changes in funding models and other resources; policy examples can be adapted to the needs of each institution; and institutional collaborations can be forged between museums, libraries, archives, universities and information technology companies. Collaborations like the ones mentioned in this paper, have made possible digital preservation activities and policy writing for museums and other cultural heritage institutions, and can enable more progress in this area (Pad and Rafferty 151; Rinehart et al. 29; Brown 62; Oliver et al.) The potential for convergence, locally and globally, is made possible with cooperation and collaboration between institutions working to digitally preserve cultural heritage. Collaboration increases needed visibility, accessibility and engagement with stakeholders.

While the updated survey, done as part of this research project, offers confirmation that these problems still exist in museums, more extensive research in museum digital preservation and education is needed to understand how better to move forward in museum digital preservation. While the user needs of the future may be in question, the viability of the digital information that digital preservation personnel in museums handle, should not be. As Rinehart has said however "without recognition, there can be no resolution" (38). There must be participation in order to preserve the important history and cultural heritage of our country's museums.

Appendix A - Museum survey project responses

Q-10a - Please enter other struggles your institution has experienced enacting digital preservation and digital preservation policy-writing, or other related concerns:

Please enter other struggles your institution has experienced enacting digi...

The extent of our institution's digital preservation is the scanning and storage of paper documents. The policy was implemented by myself (Registrar/Collection Manager) and the Curator, and I am the individual responsible for carrying out this duty. However, I have found that adding this responsibility onto my already packed workload has proved challenging, as the process does not easily fit into my other routines/duties. As such, I am falling behind in regards to digital preservation of our collection related documents, and would prefer another part/full time staff member to help with these tasks.

We previously did not have a digital asset management system that allowed for digital preservation tasks: we are in the process of migrating to a new system that will allo for digital preservation tasks, like assigning checksums upon ingest, checking file fixity, creating derivative access/preservation files on the fly, etc.

Getting other stakeholders (particularly content owners) engaged in other activities related to digital preservation (such as collection surveying to prepare for collection digitization, cataloging, etc.) has been challenging. In general there needs to be a more coordinated effort at the museum to engage in digital curation.

we have limited staff hour to dedicate to this: our consideration of the project is so new that no formal guidelines and Procedures have been approved by the BOD

lack of concern

Funding to purchase and maintain fully functional equipment, funding to service appropriate technical expertise and support, and funding to hire sufficient staff to complete the work in a timely manner.

We have a staff of 1.25 collections and .5 admin assistant. We recently purchased a NAS with plenty of space, and we are beginning to be more systematic about our digitization efforts. We collect metadata for born digital collections: this includes original file name, creator, creation date, copyright, and file format, size, checksum, bit depth, etc for both the original and the lossless master copy of the file.

The organization has not instituted an ongoing digital preservation plan for organizational content and while a small group of us are working on putting in place preservation strategies for digital artworks in the collection, there is push back that such a small collection is getting the amount of attention it is while other areas of the traditional collections need our small amount of conservation funds. This is an educational opportunity to help folks understand the proactive preservation needs of time-based/digital media art.

At my museum, we do not have a dedicated digital archivist so we request that all staff members submit their own digital files based on a retention schedule. An archivist sends email reminders but the submission rate has not been ideal. The program is a mandate from the top and many express interest during training, but unfortunately this is not a priority for most staff.

Not everyone on staff recognizes that times have changed, that just putting digital files on a server is no longer enough. We need a digital preservation policy and a staff member devoted to both the preservation of and protocols for access to our digital collections but we are at least a few years away from that. We do not have a DAMS but we should. It is just not a priority for those at director-level. It's seen as too expensive and not a priority compared to other initiatives.

No institutional buy-in to make it a priority

Time management

Please enter other struggles your institution has experienced enacting digi...

equipment

After 2-3 years of working to foster institutional support, we are investing in training for existing staff and working with a digital preservation consultant to implement best practices and adopt a formal preservation policy.

Most people do not fully understand what is meant by "digitization"

Not enough time!

We are transitioning to an institutional phase when we can develop relevant policies and practices. Our museum has been without a registrar for 20 years, a situation that will change this summer. All matters relating to the stewardship of our digital collections will fall under this individual's purview.

time and finances are prohibiting current digital preservation efforts.

Small staff size and not enough time to dedicate to the project.

All of the above. Lack of understanding of the issue needed to make it an institutional priority, and figure out what and how to add to workloads

We are a brand new museum, just creating policy and procedures around digital preservation. As we grow, I suspect our efforts will become more formalized and better funded.

We have invested a great deal in a commercial digital preservation system. We do have digital preservation policies, but I answered "No" to the related question because we have not put forth a digital preservation policy to be signed by the committee that have signed off on our collections policy. So in practice, the answer would be "Yes" because the digital preservation system that we are implementing already has about 13 technical preservation plans for different types of materials, and there are also SOPs relating to the system, which are together in effect a policy.

Additional knowledge and staff would improve our ability to conceive, define, and implement DP policy.

We've received a grant to work on how to go about preserving digital media. Once the grant period is over, we'll be much better off. However this does not address archival/records management concerns.

Additional comments?

N/A

Even if you don't currently have a DAMS system that supports preservation tasks, their are things you can do, like assign technical and administrative metadata, that will support preservation tasks in the future. In addition, keeping multiple copies in disparate places (i.e. an external hardrive or two stored securely, on and offsite) will ensure that your digital assets are backed up and allow for fixity checks in the future, or recovery if there's server issues or other technical malfunctions.

I don't know what you wanted me to include about our metadata collection.

One challenge we face is that Conservation staff in museums and digital archivists are the two groups who have driven digital preservation and our institution (1) has no on-staff conservators and (2) does not have digitized archives. There's a lot of work to be done to get folks on board as a result.

Appendix B - Baltimore Museum of Art's digital preservation policy

PURPOSE

The Baltimore Museum of Art's Digital Preservation Policy establishes a framework for long-term preservation and access to the Museum's digitized and born-digital assets. The Policy will also inform the development of detailed plans and procedures for implementing digital preservation activities. As a public museum, the BMA is charged with caring for and providing access to its art collection and the records that support it including a growing number of items in digital formats. These digital assets are an essential component of the overall institutional strategy, and the BMA is dedicated to their preservation. Ensuring the integrity, accessibility, and usability of digital assets over time is recognized as an ongoing core business requirement that is critical to the BMA's future relevance as a cultural institution.

MANDATE

The mandate for digital preservation at the BMA is linked to existing institutional responsibility and legal obligations:

1. The BMA's Strategic Plan (rev. 2015) contains a number of goals and priorities that imply the importance of digital preservation, including Goal I.8: "Build in-house expertise and resources for collecting, conserving, and presenting digital art," and Goal I.13: "Stay abreast of new digital tools for collections care and adopt those that will enhance the BMA's practices."
2. The BMA's Collections Management Policy outlines requirements for care and preservation of artwork.
3. The BMA Records Retention Schedule mandates the permanent retention of certain types of institutional records.
4. The policies and procedures of the Library and Archives Department, such as the Records Access Policy, call for providing access to digital records over their lifetime.

PRINCIPLES

The goal of the BMA digital preservation program is to maintain the authenticity of the Museum's digital assets for long-term access. To the best of the BMA's ability, digital assets identified in this policy for preservation will be maintained in compliance with best practices of the digital preservation community and with national standards, such as the OAIS reference model and the requirements for a trusted digital repository. The program will strive to care for both born-digital and digitized material throughout the lifecycle of the digital asset, maintaining the intellectual property rights of creators and copyright holders.

The program will evolve along with current standards for metadata schema, interoperability, storage, technology, and expertise.

OBJECTIVES

The primary objective of digital preservation activities is the ability to meaningfully access digital content over time. The BMA will provide authenticity, discovery, and access to digital assets for current and future generations. This includes the following activities:

- Maintaining and developing sustainable processes and systems to capture, manage, and preserve digital assets for long-term access.
- Bit-level preservation of all digital assets, which means keeping the original files intact and which includes regular checks on the integrity of stored content.
- Providing authenticity and context for digital assets by creating administrative, technical, structural and descriptive metadata.
- Defining procedures for the preservation and availability of digital assets while maintaining intellectual property ownership and rights.

- Ensuring record authenticity and provenance through preservation and technical solutions that promote and maintain composition (especially for assets with multiple objects or files), lineage, fixity, and validity.
- Adapting preservation strategies in response to changes in technology. Where necessary, migrating assets into formats that are acceptable for long-term preservation and access.
- Complying with and contributing to the development of the standards and best practices of the digital preservation community.
- Supporting research and outreach with increased access to authenticated digital content through the creation and disbursement of digital surrogates.
- Providing tools that facilitate the discovery of online digital assets.
- Periodically reviewing technology and metadata standards to ensure best practices for the long term maintenance of digital assets.

SCOPE

The Digital Preservation Policy applies to all digital artwork in the collection for which the Museum is the primary custodian as well as digital records that have been determined by Museum policy to be valuable and worthy of long-term preservation. Particular emphasis will be given to assets that exist in digital form only. Over time, the scope of assets can be expected to change in response to evolving museum needs and developments in electronic publishing and communication.

The following types of materials are included under the Policy:

- Born-digital materials accessioned into the art collection or Archives.
- Born-digital institutional records identified for permanent retention in the BMA Records Retention Schedule.
- Digital master and service/access files produced by digitizing analog content.

Priorities for preservation action are assigned based on the relative significance of digital assets and the technical complexity of preserving and ensuring access to them.

The following types of materials are considered top priorities for preservation:

- Born-digital accessioned works of art in the BMA's collection.
- Digital assets created to preserve analog works of art in the BMA's collection, such as a digital surrogate of a videocassette.
- Born-digital institutional records critical for Museum operations, such as Board of Trustees minutes, accounting records, building records, and records related to ownership of works of art.

CHALLENGES

The preservation of digital assets represents a significant challenge. The inherent instability and vulnerability of these materials affects the ways in which the BMA secures, manages, and preserves them including:

- **Technology:** Establishing and maintaining a digital program that is responsive to the rapid changes in technology used to capture, store, and make usable digital assets.
- **Costs:** The financial commitment necessary to ensure long-term viability of a preservation program, e.g., staffing, equipment, software, infrastructure, and other miscellaneous costs.
- **Scale and Complexity:** Rapid growth in the volume of digital assets to be preserved; maintaining and describing the complex relationships between the components of digital assets; ensuring that technical characteristics are captured in descriptions and that provenance is maintained; addressing the diversity of types of digital assets.
- **Maintenance:** Creating and sustaining development environments to experiment with new technology and procedures; ongoing monitoring of digital assets, software, hardware, policies and procedures.
- **Access:** Intellectual property and other rights-based constraints on providing access; adequately describing digital assets so that they are accessible; finding an appropriate user interface or building and supporting one to enable users to search and locate, and optimally retrieve digital assets.
- **Artistic Integrity:** Respecting the rights of artists and content creators in an evolving medium; considering both preservation mandates and the intentionally ephemeral nature of some time-based media.
- **Expertise:** Providing staff education and training to keep abreast of standards and technology; hiring and retaining staff with proficiency in both conservation and technology.
- **Collaboration:** Insuring the continued participation of stakeholders across several departments; consistently documenting digital preservation actions for future staff.

The BMA will continually work to mitigate these challenges through policy and technological development.

ROLES AND RESPONSIBILITIES

The action and tasks of preserving digital assets requires collaboration among staff throughout the Museum. Key stakeholders include: Information Technology, Library and Archives, Curatorial Departments, Conservation, Registration, Image Services and Rights, and content creators. Responsibility for digital preservation activities will be shared by staff in the following positions: Librarian/Archivist, Registrar, Curator of Contemporary Art, Curator of Prints, Drawings and Photographs, Conservator, Chief Technology Officer, and Digital Asset Manager.

It is the responsibility of the BMA's administration and Board of Trustees to commit to supporting an environment in which digital preservation is regarded as a critically necessary endeavor. This support includes providing adequate managerial and financial commitment to develop a digital preservation program.

POLICY REVIEW CYCLE

The BMA Digital Preservation Working Group will present a revised Policy for review by the Board of Trustees every three years. The current Policy will be accessible online. On an ongoing basis, the program and procedures will be clearly and consistently documented and updated to reflect evolving technologies and changing needs of the BMA and digital asset users.

ACCESS AND USE

Every effort will be made to provide public access, online or by request, to legally available digital assets. Digital assets under copyright or other rights restriction will be reviewed for special permission and conditions for access. Preservation copies of digital artwork held in cold storage will not be accessible to the public.

Digitized and born-digital institutional records will be made available according to the BMA's Records Access Policy.

Works Cited

"About." *National Digital Stewardship Residency Art*, 12 Feb. 2018, ndsr-pma.arlisna.org/about/.

Allbritton, Benjamin. "Fellow Travelers: The Canterbury Tales and IIIF." *Digital Manuscripts at Stanford*, 14 July 2015, web.stanford.edu/group/dmstech/cgi-bin/wordpress/tag/mirador/.

Allen, Stephanie et al. "Collective Wisdom: An Exploration of Library, Archives and Museum Cultures." *Coalition to Advance Learning in Archives, Libraries and Museums* 2017. oclc.org/research/publications/2017/oclcresearch-collective-wisdom-lam-culture.html.

Anderson, David, et al. "Toward A Workable Emulation-Based Preservation Strategy: Rationale and Technical Metadata." New Review of Information Networking, vol. 15, no. 2, 2010, pp. 110–131.

"At a Glance." *NSF*, National Science Foundation, Apr. 2019, nsf.gov/about/glance.jsp.

Athow, Desire. "The Data Capacity Gap: Why the World Is Running out of Data Storage." *TechRadar*, TechRadar pro IT Insights for Business, 10 Feb. 2015, techradar.com/news/computing-components/storage/the-data-capacity-gap-why-the-world-is-running-out-of-data-storage-1284024/2.

"Are We Running out of Data Storage Space?" *Economist*, GE Look Ahead, 26 Aug. 2015, gelookahead.economist.com/storage/. Accessed 10 Apr. 2018.

Bailey, Jefferson, et al. "Digital Preservation Capabilities at Cultural Heritage Institutions: An Interview with Meghan Banach Bergin." *The Signal - Library of Congress*, 10 Nov. 2014, blogs.loc.gov/thesignal/2014/11/digital-preservation-capabilities-at-cultural-heritage-institutions-an-interview-with-meghan-banach-bergin/.

Bastian, Jeannette A., et al. “From Teacher to Learner to User: Developing a Digital Stewardship Pedagogy.” *Library Trends*, vol. 59, no. 4, 2011, pp. 607–622.

Bastian, Jeannette A., and Ross Harvey. "The convergence of cultural heritage: practical experiments and lessons learned." The Memory of the World in the Digital Age: Digitization and Preservation-An International Conference on Permanent Access to Digital Documentary Heritage. 2012., unesco.org/new/fileadmin/MULTIMEDIA/HQ/CI/CI/pdf/mow/VC_Bastian_Harvey_27_D_1430.pdf

Bawden, David, and Lena Roland. “The Future of History: Investigating the Preservation of Information in the Digital Age.” *Library & Information History*, vol. 28, no. 3, Sept. 2012, pp. 220–236. *Routlege, Taylor & Francis Group*, doi:10.1179/1758348912z.00000000017.

Bergin, Meghan Banach. “Sabbatical Report: Summary of Survey Results on Digital Preservation Practices at 148 Institutions.” University of Massachusetts Amherst ScholarWorks@UMass Amherst Gallery Expert Gallery, Berkeley Electronic Press, 2013, works.bepress.com/meghan_banach/7/.

Berman, Francine. “Got Data? A Guide to Data Preservation in the Information Age.” *Communications of the ACM*, Dec. 2008, pp. 50–56, DOI:10.1145/1409360.1409376.

Bhat, Wasim Ahmad. “Bridging Data-Capacity Gap in Big Data Storage.” *Future Generation Computer Systems*, Jan. 2018, doi:10.1016/j.future.2017.12.066. Research Gate.

Botticelli, Peter, et al. “Educating Digital Curators: Challenges and Opportunities.” *International Journal of Digital Curation*, vol. 6, no. 2, 2011, pp. 146–164., doi:10.2218/ijdc.v6i2.193.

Brown, Heather. “Convergence and Preservation in the Digital Age *.” *World Digital Libraries*, vol. 9, no. 1, 2016, pp. 61–72.

Brungs, Julia, and Stephen Wyber. “Preserving Our Digital Culture for the Future: Overcoming Obstacles through Collaboration.” *Global Information Society Watch 2016: Economic, Cultural and Social Rights and the Internet*, 2016, pp. 36–40., ifla.org/files/assets/clm/publications/161208_brungs-wyber_preserving_our_digital_culture_for_the_future.pdf

Carden, Michael. "Digital Archiving at the National Archives of Australia: Putting Principles into Practice." International Council on Archives Congress, Brisbane, Australia, August. 2012.

“Checking Your Digital Content: How, What and When to Check Fixity?” [PDF]. NDSA Infrastructure & Standards Working Group, February 2012.

Chanod, J., et al. "Issues in digital preservation: towards a new research agenda." Automation in Digital Preservation. 2010.

Clareson, Tom. “NEDCC Survey and Colloquium Explore Digitization and Digital Preservation Policies and Practices.” *RLG DigiNews*, vol. 10, no. 1, 2006, p. np.

Cocciolo, Anthony. “When Archivists and Digital Asset Managers Collide: Tensions and Ways Forward.” The American Archivist, vol. 79, no. 1, 2016, pp. 121–136.

Cochrane, Euan. “Emulation as a Service (EaaS) at Yale University Library ...” *The Signal*, Library of Congress, 20 Aug. 2014, blogs.loc.gov/thesignal/2014/08/emulation-as-a-service-eaas-at-yale-university-library/.

Conway, Paul. “Preservation in the Age of Google: Digitization, Digital Preservation, and Dilemmas.” *The Library Quarterly*, vol. 80, no. 1, 2010, pp. 61–79., doi:10.1086/648463. Accessed 14 Mar. 2018.

Conway, Paul. “The relevance of preservation in a digital world.” Preservation leaflet. N*ortheast Document Conservation Center,*2007. nedcc.org/resources/leaflet/6Reformatting/04RelevanceOfPreservation.php.

Dappert, Angela, and Markus Enders. “Digital Preservation Metadata Standards.” Information Standards Quarterly, vol. 22, no. 2, 2010, pp. 4–13., groups.niso.org/apps/group_public/download.php/4236/FE_Dappert_Enders_MetadataStds_isqv22no2.pdf

DeRidder, Jody L.

“Benign Neglect: Developing Life Rafts for Digital Content.” *Information Technologies and Libraries*, vol. 30, no. 2, June 2011, pp. 71–74., ejournals.bc.edu/ojs/index.php/ital/article/download/3006/2620. Accessed 10 Apr. 2017.

“Digital Preservation Strategies.” *Digital Preservation Management*, Implementing Short Term Strategies for Long Term Problems, dpworkshop.org/dpm-eng/terminology/strategies.html.

Economou, Maria. “Use and Impact of Digital in Cultural Heritage: Insights from the Scottish Network of Digital Cultural Resources Evaluation.” *Museums and the Web 2017*, 2016, mw17.mwconf.org/paper/evaluating-impact-and-use-of-digital-cultural-resources-lessons-from-the-scotdigich-network/.

Elford, Douglas, et al. “Getting the Whole Picture: Finding a Common Language Between Digital Preservation and Conservation.” *National Library of Australia*, 1 Aug. 2012,

nla.gov.au/content/getting-the-whole-picture-finding-a-common-language-between-digital-preservation-and.

Enge, Juergen, et al. “Emulation in the Context of Digital Art and Cultural Heritage Preservation.” PIK - Praxis Der Informationsverarbeitung Und Kommunikation, vol. 35, no. 4, 2012, pp. 245–254.

Evens, Tom, and Hauttekeete, Laurence. “Challenges of Digital Preservation for Cultural Heritage Institutions.” Journal of Librarianship and Information Science, vol. 43, no. 3, 2011, pp. 157–165.

“Fran Berman Digital Preservation Pioneer.” *Library of Congress: Digital Preservation*, digitalpreservation.gov/series/pioneers/berman.html.

“Fostering a Community of Practice: Software Preservation in Libraries, Archives, and Museums (FCoP) About FCoP .” *Saving Software Together*, softwarepreservationnetwork.org/fcop/.

Fresa, Antonella. “Digital Cultural Heritage Roadmap for Preservation.” International Journal of Humanities and Arts Computing, vol. 8, no. supplement, 2014, pp. 107–123., doi:10.3366/ijhac.2014.0102.

Frey, Franziska. “IIIF DC - IIIF and Mirador at Harvard.”YouTube, 24 July 2015, youtube.com/watch?v=mDCyUszGU5w&t=40s.

Ghosh, Pallab. “Google's Vint Cerf Warns of 'Digital Dark Age'.” *BBC News*, BBC, 13 Feb. 2015, bbc.com/news/science-environment-31450389. Accessed 12 Apr. 2017.

Grainger, Stewart. “Emulation as a Digital Preservation Strategy.” *D-Lib Magazine*, Oct. 2000, dlib.org/dlib/october00/granger/10granger.html.

Han, Yan. “Cloud Storage for Digital Preservation: Optimal Uses of Amazon S3 and Glacier.” *Library Hi Tech*, vol. 33, no. 2, 2015, pp. 261–271.

Harvey, Ross, and Martha Mahard. “Mapping the Preservation Landscape for the Twenty-First Century.” *Preservation, Digital Technology & Culture*, vol. 42, no. 1, 22 Mar. 2013, pp. 5–16. *De Gryter Online*, doi:10.1515/pdtc-2013-0002.

Harvey, Ross and Martha R. Mahard. “Preserving Digital Materials.” *The Preservation Management Handbook: a 21st-Century Guide for Libraries, Archives, and Museums*, 2nd ed., 2011, *De Gruyter Saur.*

Henry, W, 2000 ‘Digital Preservation: A Conservator’s Perspective’, Stanford Universities Libraries

Hirtle, Peter B. “The History and Current State of Digital Preservation in the United States.” Cornell University Library, Cornell University, Apr. 2008, ecommons.cornell.edu/handle/1813/45862.

“History.” *MCN*, mcn.edu/about/history/.

Hofman, Hans. "Rethinking the archival function in the digital era." Comma 2012.2: 25-34. (2012), ica2012.ica.org/files/pdf/Full%20papers%20upload/ica12final00187.pdf.

“Home.” *Mirador*, projectmirador.org/.

Hui, Stephen. “Geek Speak: Kip Warner, Project Lead for Avaneya.” *Georgia Straight Vancouver's News & Entertainment Weekly*, 6 Dec. 2013, 9:03 a.m., straight.com/life/544186/geek-speak-kip-warner-project-lead-avaneya.

Innocenti, Perla. "Bridging the gap in digital art preservation: interdisciplinary reflections on authenticity, longevity and potential collaborations." (2012): 71-84.

Johnston, Leslie. “Considering Emulation for Digital Preservation | The Signal.” *The Signal*, Library of Congress, 11 Feb. 2014, blogs.loc.gov/thesignal/2014/02/considering-emulation-for-digital-preservation/.

Kay, Russell. “Virtualization or Emulation?” *Computerworld*, Computerworld, 22 June 2009, computerworld.com/article/2551154/virtualization/emulation-or-virtualization-.html.

Kastellec, Mike. “Practical Limits to the Scope of Digital Preservation.” Information Technology and Libraries, vol. 31, no. 2, 2012, pp. 63–71.

Keene, S, 2001, ‘Preserving digital materials: Confronting tomorrow’s problems today suzannekeene.info/articles/digipres.htm’, The Conservator, vol. 26, pp. 93–99,

Kim, Jeonghyun. “Building Rapport Between LIS and Museum Studies.” Journal of Education for Library and Information Science, vol. 53, no. 2, 2012, pp. 149–161.

Kondayen, Kate. “Saving the Digital Record.” *Harvard Gazette*, Harvard Public Affairs & Communications, 8 May 2015, news.harvard.edu/gazette/story/2015/05/saving-the-digital-record/. Accessed 11 Apr. 2017.

Lavoie, Brian. “The OAIS Reference Model.” *OCLC Research*, oclc.org/research/publications/library/2000/lavoie-oais.html.

Lynch, Clifford. “Born-Digital News Preservation in Perspective.” Preservation, Digital Technology & Culture, vol. 46, no. 3, 2017, pp. 94–98.

Manjarrez, C. *Exhibiting public value: government funding for museums in the United States*. Institute of museum and library services, 2008.

Marty, Paul F., and Katherine Burton Jones. "The Transformation Of The Digital Museum. "Museum Informatics: People, Information, and Technology in Museums, Routledge, New York, 2009, pp. 9–25

"Matthew S Weber." *University of Minnesota: College of Liberal Arts*, Regents of the University of Minnesota, 3 June 2010, apps.cla.umn.edu/directory/profiles/msw?search_results_referer_url=%2Fdirectory%2Fresults%3Fpage%3D28%26q%3DPopular%2BCulture.

Mell, P. and Grance, T. "The NIST Definition of Cloud Computing". Special Publication 800-145, National Institutes of Standards and Technology. 2011, faculty.winthrop.edu/domanm/csci411/Handouts/NIST.pdf

Meyerson, Jessica, et al. "RE-95-17-0058-17: Fostering a Community of Practice: Software Preservationists and Emulation Experts in Libraries and Archives." *Institute of Museum and Library Services*, Institute of Museum and Library Services, Aug. 2016, imls.gov/sites/default/files/grants/re-95-17-0058-17/proposals/re-95-17-0058-17-full-proposal-documents.pdf.

"Mind the Gap." Digital Preservation Coalition, Digital Preservation Coalition, 1 June 2008, dpconline.org/news/mind-the-gap.

Misunas, Marla, and Richard Urban. "9: Organizations; 'A Brief History of the Museum Computer Network.'" *Encyclopedia of Library and Information Sciences*, by Marcia J. Bates, third ed., Ketchikan Press, 2009.

National Science Foundation. "Building the Future Investing in Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2018-2022." *NSF*, National Science Foundation, Feb. 2018, nsf.gov/publications/pub_summ.jsp?ods_key=nsf18045.

"New 'Emulation as a Service' Technology Opens up New Opportunities for Engagement with Historic Digital Content." *Yale University Library*, Yale University, Apr. 2014, web.library.yale.edu/news/2014/02/new-emulation-service-technology-opens-new-opportunities.

Niu, Jinfang. "Appraisal and Selection for Digital Curation." International Journal of Digital Curation, vol. 9, no. 2, 2014, pp. 65–82.

Oliver, Gillian, and Steve Knight. "Storage Is a Strategic Issue: Digital Preservation in the Cloud." D-Lib Magazine, vol. 21, no. 3/4, 2015, doi:10.1045/march2015-oliver.

Pad, Becca, and Elizabeth Rafferty. "Better Together: A Holistic Approach to Creating a Digital Preservation Policy in an Art Museum." Art Documentation: Journal of the Art Libraries Society of North America, vol. 36, no. 1, 2017, pp. 149–162.

Paqua, Megan. "Beyond Digitization: Planning for Open Access Collections." *Museums and Digital Culture - Pratt Institute*, 6 Nov. 2018, museumsdigitalculture.prattsi.org/beyond-digitization-planning-for-open-access-collections-fb7325163f5d.

Primary Research Group. *Survey of Library & Museum Digitization Projects, 2013 Edition*. 2013th ed., Primary Research Group, 2013.

Ray, Joyce "Digital Curation in Museums." Library Hi Tech, vol. 35, no. 1, 2017, pp. 32–39.

"RE-95-17-0058-17." *Institute of Museum and Library Services*, 16 May 2017, imls.gov/grants/awarded/re-95-17-0058-17.

Rechert, Klaus, et al. "The RESTful EMiL: Integrating Emulation into Library Reading Rooms." Alexandria: The Journal of National and International Library and Information Issues, vol. 27, no. 2, 2017, pp. 120–136., doi:10.1177/0955749017725427.

Richards, Julian D., Kieron Niven, and Stuart Jeffrey. "Preserving our digital heritage: Information systems for data management and preservation." Visual heritage in the digital age. Springer, London, 2013. 311-326.

Rinehart, Amanda Kay, et al. “Overwhelmed to Action: Digital Preservation Challenges at the under-Resourced Institution.” OCLC Systems & Services: International Digital Library Perspectives, vol. 30, no. 1, Apr. 2014, pp. 28–42., doi:10.1108/oclc-06-2013-0019

Rosenthal, David S. H. “Emulation & Virtualization as Preservation Strategies.” *University of North Texas Libraries*, 2015, digital.library.unt.edu/ark:/67531/metadc799755/.

Rosenthal, David S.H. “Format Obsolescence: Assessing the Threat and the Defenses.” Library Hi Tech, vol. 28, no. 2, 2010, p. 195.

Rosenthal, David S. H., et al. “Requirements for Digital Preservation Systems: A Bottom-Up Approach.” 2005.

Rothenberg, Jeff. “Ensuring the Longevity of Digital Documents.” Scientific American, vol. 272, no. 1, 1995, pp. 24–29.

Rothenberg, Jeff. “Preserving Authentic Digital Information ” *CLIR*, 2000, clir.org/pubs/reports/pub92/rothenberg/.

Rusbridge, Chris. “Excuse Me... Some Digital Preservation Fallacies?” *Ariadne; Website Magazine for Information Professionals*, Ariadne, 8 Feb. 2006, ariadne.ac.uk/issue/46/rusbridge/.

Sanett, Shelby. “Archival Digital Preservation Programs: Staffing, Costs, and Policy.” Preservation, Digital Technology &Amp; Culture, vol. 42, no. 3, 2013, pp. 137–149.

Seifert, Christin, et al. “Ubiquitous Access to Digital Cultural Heritage.” Journal on Computing and Cultural Heritage (JOCCH), vol. 10, no. 1, 2017, pp. 1–27.

Semmel, Marsha L., and Mamie Bittner. “Demonstrating Museum Value : the Role of the Institute of Museum and Library Services.” Museum Management and Curatorship (Online), vol. 24, no. 3, 2009, pp. 271–288.

“Session 7: Reformatting and Digitization.” *Northeast Document Conservation Center*, nedcc.org/preservation101/session-7/7digitization.

Shaw, Jonathon. “Digital Preservation: An Unsolved Problem.” *Harvard Magazine*, 2010, Accessed 13 Mar. 2017.

Shaw, Norman. “It Shouldn't Matter How Many USBs Are Lost.” *Infosecurity Magazine*, ExactTrac, 27 Jan. 2016, infosecurity-magazine.com/blogs/it-shouldnt-matter-how-many-usbs/.

Sheldon, Madeline. “Analysis of Current Digital Preservation Policies Archives, Libraries, and Museums.” *Digital Preservation*, Library of Congress, 22 July 2013, digitalpreservation.gov/documents/Analysis%20of%20Current%20Digital%20Preservation%20Policies.pdf.

Sheldon, Madeline. “Towards a Digital Preservation Policy For Museums.” The Signal - Library of Congress, Library of Congress, 13 June 2013, blogs.loc.gov/thesignal/2013/06/towards-a-digital-preservation-policy-for-museums/.

Smith, Abby. “Preservation.” A Companion to Digital Humanities, Blackwell, Malden, MA, pp. 576–91. Blackwell Companions to Literature and Culture.

Smith, Kai Alexis. “Digitizing Ephemera Reloaded: A Digitization Plan for an Art Museum Library.” Art Documentation: Journal of the Art Libraries Society of North America, vol. 35, no. 2, 2016, pp. 329–338.

"Status of Technology and Digitization in the Nation's Museums and Libraries, 2006." *Institute of Museum and Library Services*, 5 July 2017, imls.gov/publications/status-technology-and-digitization-nations-museums-and-libraries-2006.

"Term: Born Digital." *Federal Agencies Digitization Guidelines Initiative*, digitizationguidelines.gov/term.php?term=borndigital.

Tibbo, Helen R, and Wendy Duff. "2008 Annual Conference of CIDOC Athens, September 15 – 18, 2008." 18 June 2008, digitalcurationexchange.org/sites/default/files/drfile2008-06-18.4718982366.pdf.

"Timeline: Digital Technology and Preservation." *Digital Preservation Management Workshops and Tutorial*, MIT Libraries, dpworkshop.org/dpm-eng/timeline/viewall.html.

UNESCO PERSIST Content Task Force. "International Federation of Library Associations and Institutions." International Federation of Library Associations and Institutions, UNESCO, Mar. 2016. ifla.org/files/assets/hq/topics/cultural-heritage/documents/persist-content-guidelines_en.pdf.

Valetutti, Lynn. "Cultural Heritage Preservation in Digital Repositories: A Bibliometric Analysis." SLIS Connecting, vol. 4, no. 2, 2015, pp. SLIS Connecting, 12/18/2015, Vol.4(2). doi.org/10.18785/slis.0402.09

Van Gorsel, Margriet, et al. "2nd Annual Conference of the ICA, Girona, UNESCO-PERSIST." UNESCO, Evaluation and Strategies of Digital Preservation & UNESCO's Role in Facing the Technical Challenges, Oct. 2014, unesco.nl/sites/default/files/uploads/Comm_Info/20141011_evaluation_and_strategies_of_digital_preservation_unescos_role_in_facing_the_technical_challenges.pdf.

Walters, Tyler, and Katherine Skinner. “New Roles for New Times: Digital Curation for Preservation.” 2011.

Weber, Matthew Scott. “Why the United States Needs Digital Preservation Policies.” *Scholars Strategy Network*, 18 Jan. 2019, scholars.org/contribution/why-united-states-needs-digital-preservation-policies.

“What Is LOCKSS?” *LOCKSS*, Stanford University, lockss.org/about/what-lockss.

Whitt, Richard S. “Through a Glass, Darkly”: Technical, Policy, and Financial Actions to Avert the Coming Digital Dark Ages.” Santa Clara High Technology Law Journal, vol. 33, no. 2, 2016, pp. 117–229.

Zorich, Diane. “Information Policy in Museums.” *Museum Informatics: People, Information, and Technology in Museums*, Routledge, 2009, pp. 53–63.

Zorich, Diane. “Report of the summit on digital curation and art museums.” Summit on Digital Curation and Art Museums. 2015., advanced.jhu.edu/wp-content/uploads/2016/04/digitalCuration_summitReport10_2015.pdf