The Emergence of Digital Reformatting in the History of Preservation Knowledge: 1823 to 2015

Abstract

Purpose

The purpose of this paper is to understand the emergence of digital reformatting as a technique for preserving information within the cultural heritage preservation community by reviewing historical trends in modern preservation research.

Design/methodology/approach

This paper analyzes secondary sources, reviews, and historical texts to identify trends in the intellectual and technological histories of preservation research, beginning with the first applications of the scientific method to combating book decay in the early nineteenth to the emergence of digitization techniques in the late twentieth and early twenty-first centuries.

Findings

This paper identifies five major historical periods in the development of preservation knowledge: the early experimental era; era of microfilm experimentation; era of professionalization; era of digital library research; and the era of digital reformatting and mass digitization; and identifies three major trends in its development: empirical inquiry; standardization; and centralization.

Research limitations/implications

Findings reflect broad trends in the field of preservation in primarily a United States context and are limited to the modern era of preservation research.
Practical implications

This paper’s broad historical overview provides a reference for preservation professionals and students in library science or archives programs. Identifying historical trends enables practitioners to critically examine their own preservation techniques and make better decisions when adopting and using new preservation technologies.

Originality/value

This paper provides a unique perspective on the history of preservation knowledge that synthesizes existing historical research in order to identify periods and trends that enable a clearer understanding of digital reformatting in its historical emergence.

Keywords: digitization, preservation, access, information history, standards, archives, libraries, museums, professional knowledge
As physical configurations of matter in the world, every medium is in a state of continuous decay. To preserve access to information resources, institutions configure technologies and practices to either conserve physical materials and slow their inevitable decay or copy the information they contain to new carriers. Digital reformatting, the digitization of cultural heritage collections for preservation purposes has radically altered how institutions preserve, organize, and make accessible their information resources. It expands access to collections consisting of a wide range of analog formats—including manuscripts, printed texts, maps, photographs, multimedia recordings, and motion picture films—enabling new ways of interacting with these materials through expanded search capabilities, annotation, computational methods of analysis, and other techniques for working with digital materials. At the same time, digital reformatting is increasingly understood by information studies researchers as a cultural practice of translation between representational systems, rather than a seamless and unproblematic transmission of encoded signals from one carrier to another. Digital reformatting, as a socially constructed preservation practice, has a history embedded within broader intellectual trends in the field of preservation.

Digitization is a form of copying that translates information stored in analog form into digital formats. In order for digitization to be accepted into existing practices of cultural heritage institutions, it first had to be constructed in ways that would enable it to fit with existing preservation knowledge, concepts and terminology. To that end, in June 2004, the Association of Research Libraries (ARL) issued a report titled, Recognizing Digitization as a Preservation Reformatting Method, which officially endorsed digitization as a preservation strategy for library materials. Framing digitization as a “preservation reformatting method” aligned digitization techniques with earlier paradigms of copying in libraries, such as microfilm reformatting. The
use of terminology that was already familiar to information professionals constructed the idea of digitization as a reasonable and responsible approach for preserving library materials in a way that appeared as an extension of existing strategies.

Debate about digitization as a preservation strategy for analog originals has continued as its risks and limitations have become apparent. For example, Paul Conway (2013) has shown in his analysis of digitized books in the Google Books collection that digitization can embed significant quantities of errors in their digitally encoded pages. Concerns over the quality of copies produced through digital reformatting programs in libraries and archives have encouraged institutions to develop standards and best practices documents to help guide and legitimize their digitization activities. Efforts to standardize practices and products of digitization is part of a broader trend in the modernist project to enact control and produce sameness over space and time (Timmermans and Epstein, 2010; Lampland and Star, 2009).

At the same time, information studies researchers are considering the ways in which the practices of preservationists and the technologies they choose to use shape the resulting digital copies and how they can be interpreted into the future. For instance, Bonnie Mak (2014) has traced changes in the meaning of digitized texts as they are reformatted from paper to microfilm to digital files stored in a database, finding that each act of copying embeds traces of its cultural and historical context. Conway (2015) has pointed to the possibility of looking at digitized collections as documents in themselves that provide evidence of the digitization projects and the cultural and historical contexts that produced them. Digitization is never merely a direct transmission of signals between formats but is perhaps better understood as a process of translation between two media formats constituted by fundamentally different representational
The production of digital copies can be disastrous if one ignores the process of translation and assumes that this is purely a form of information transfer between media, unproblematic, simple, and technically perfect. Considering digital reformatting as a risky process of translation instead of as a neutral transmission draws attention to the particular historical context and the epistemological and cultural biases that become embedded in the discourses and practices of the technology. From this perspective, the act of digitization is shaped by the materiality of the media formats involved, their corresponding affordances and means of encoding, as well as by the historical and cultural discourses that shape their development and use.

This paper examines the historical emergence of digital reformatting, situating it within the history of preservation knowledge primarily in a U.S. context in order to better understand the intellectual, institutional, and professional trends that have shaped it. It integrates and synthesizes existing research in preservation history, beginning with studies that look at early research on the decay of physical materials in the early nineteenth century, and concluding with the emergence of digital reformatting at the turn of the twenty-first century. This paper provides insight into how trends in the development of preservation knowledge have shaped the work of cultural heritage institutions, and by extension, transformed analog collections through practices of copying. It argues that considering these trends opens up new avenues of research, in

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1 For instance, the digitization of a black and white, gelatine-based, silver halide photographic print involves translating the shades of varying tone across the stochastic distribution of silver crystals randomly upon the surface of the photographic paper into a set of data points that encode the visual information in discrete numerical form and sampled across a predefined grid. Visual information encoded in a field of the randomly distributed silver particles must be translated into a regular grid of sampled pixel values (see: Hoy, 2017). The idea of producing an image using grids or dots is not unique to the digital world and has its roots in half-tone printing. Earlier ideas of sampling points of an image electronically can be located in early techniques for scanning images in mechanical television systems in the early 20th century, based on the development of the image scanning, Nipkow disk in 1884 (Shiers and Shiers, 1997). Attempts to scan visual information for electronic transmission can be traced even further back to experiments with facsimile systems in the early 18th century (Huurdeeman, 2003).
particular, it draws attention to preservation standards as important carriers of knowledge (Scott, 2003) that control and coordinate institutional activities and shape how knowledge circulates in the field of preservation. Preservation standards can have power effects, as they may determine which organizations have access to funding for digitization projects (access to grants may depend on following accepted standards and best practices), and Bettivia (2016) has described the ways in which preservation standards, particularly the Open Archival Information System (OAIS) Reference Model (ISO 14721)\(^2\) for digital archives may exclude particular users of those archives as early as the design stage. Furthermore, this paper supports preservationists in understanding the history of the digital tools and techniques that they use in their work. It supports critical reflection on their professional practice and helps them make more informed decisions about the technologies they use, which can enable more transparent and honest reflections on preservation practice. This may benefit preservation professionals’ self-understanding and can provide the context necessary for the users of preserved collections to critically engage with collections and understand the role of institutional technologies and practices in shaping the form of preserved digital collections.

**Defining Preservation Knowledge**

Digital reformatting is defined here as the application of digitization techniques for preservation purposes in the context of information institutions. The term “preservation” is the conceptual foundation of a set of technologies, activities, and discourses, and has been widely discussed in the archival studies literature and continues to evolve (Cloonan, 2018). Preservation is commonly defined in terms of keeping things, saving things, or “the action of preserving from damage, decay, or destruction” (OED Online, 2020). In the modern context of libraries, archives,

\(^2\) [https://www.iso.org/standard/57284.html](https://www.iso.org/standard/57284.html)
and museums, preservation is defined in terms of specific professional and institutional practices, and the systematic development and application of materials and tools to keep collections safe and accessible for a variety of future uses. Even within the professional definition of preservation, there is little consensus, especially with regards to distinguishing and delimiting it from cognate terms, such as conservation, restoration, stewardship, and related terms.³

Rather than focusing on definitions of the preservation field or the diversity in terminology, this historical analysis focuses on institutionalized preservation knowledge as a primary phenomenon of study. This approach allows for the inclusion of a range of institutional contexts that have been involved in the systematic development of preservation knowledge. Throughout this paper, “preservation knowledge” will be used to refer to the body of practical and theoretical knowledge built up around preservation techniques, including the development of particular materials, tools, and practices that enable preservation work at various historical moments.

This historical overview is limited to the emergence of preservation as a distinct field of knowledge and practice in modern libraries, archives, and museums. From this perspective, the earliest modern preservation research can be traced to the early eighteenth century, with a formal field only emerging in the twentieth century. Michele Cloonan (2015) explains

The need for the preservation of documents has been recognized for nearly 3,000 years, although conservation and preservation have emerged as formal fields only in the twentieth century. This recognition is manifest in many texts that talk of preserving

³ Conservation is most closely related to preservation, with common definitions referring to conservation as the physical methods of maintaining or repairing materials, whereas preservation refers to broader administrative processes and policies for ensuring collections are cared for into the future, although terms vary (Gilliland, 2014).
history, documents, ideas, and the oral and written record, though only rarely do these early writers propose strategies for achieving the longevity of cultural heritage. (p. 1)

Preservation is an ongoing human concern that is essential for complex systems of social organization, but its systematic study and development as a field of professional practice is a recent development. This systematic approach has produced a body of knowledge for dealing with the critical preservation challenges identified in the field. Similar to other cultural products of human activity, preservation knowledge emerges within particular cultural and historical contexts. Existing research in information studies has touched upon the cultural and historical dimensions of preservation knowledge, including qualitative studies of the social construction of the values of document formats (Yakel, 2001), ethnographic studies of preservation practices (Gracy, 2001, 2003, 2004, 2007a, 2007b), surveys of the adoption of archival standards across and within institutions (Donaldson and Conway, 2010; Donaldson and Yakel, 2013), studies of the quality of digital copies (Conway, 2013, 2015), and studies on the social aspects of the adoption of digital file formats for the preservation of archival video formats (Jones, 2019; Lischer-Katz, 2014). Taken together, these studies help to articulate a more reflexive approach to preservation technologies and practices that problematizes how preservation knowledge becomes institutionalized and accepted as established fact, emphasizing its particular cultural and historical contingencies. Libraries, archives, and museums have historically approached the problem of preservation with different sets of values and priorities. Libraries have focused primarily on the informational qualities of information resources and providing access for a broad range of patrons to those resources in the most useful form, while museums have focused on the unique artifacts and their conservation and curation in exhibitions. Traditional corporate or governmental archives have been concerned with preserving the original order of records,
making the informational content and the structure of that content and the relationships between records fundamental concerns of preservation management. Specialized archives, such as film and media archives, blend museum and library approaches, as they may be concerned with both the informational content of the unique artifacts in their collections and making them available to users in their most useful format, at the same time maintaining accessible information objects in their original material forms for as long as possible. However, with the trend towards digital collections, these perspectives have been converging. For instance, museums have started to follow the lead of digital libraries by scanning their cultural and artistic objects to support new forms of engagement and study. The Smithsonian Institute’s 3D scanning project provides a compelling example of how the digitization of physical artifacts may develop in the coming decades.\(^4\)

Approaches from science and technology studies (STS) are helpful for understanding these dimensions of preservation knowledge. According to scholars in the field of STS, technologies are entwined and inseparable from their cultural and historical contexts. They reject technological determinism (the idea that the introduction of new technologies will shape society in predictable ways), instead embracing an approach that looks at the ways in which society and technology are co-constructed (MacKenzie and Wajcman, 1999). Understanding preservation as both social and technical opens up a field of approaches beyond a focus on tools or policies. STS scholars point to the essential relationship between the development of technology and scientific knowledge (e.g., Pinch and Bijker, 1984), the role of technology and social action in the production of knowledge in laboratory practice (e.g., Latour and Woolgar, 1986), and how social biases shape technological development (e.g., Winner, 1980), among other research areas. Thus,

\(^4\) https://3d.si.edu/
from an STS perspective, preservation work can be studied as emerging within historically-specific sociotechnical configurations of information recording media (including paper, punch cards, magnetic tape, hard drives, etc.), traditions of materials science (studying the natural decay of media and how to slow this process), and socio-cultural factors (social needs for recording information, beliefs in the trustworthiness of documents and methods of verification, institutional imperatives of collecting organizations, etc.). Applying this perspective to the context of digital reformatting establishes a framework in which the practices of preservation can be seen to be co-constructed with the preservation technologies and in which similar technologies can have different histories of development and application in different contexts. For instance, the same basic digital tools used by Google for scanning millions of books could be used in a preservation lab following different protocols in order to scan library books or archival materials for preservation purposes. The institutional context in which the work is conducted, including its values, mission, and the professional commitments of the human agents involved each contribute to defining how the technical work will be carried out and how that work will be characterized as a particular type of “labor.” Together, these practices and technologies can be studied as a collective stock of preservation knowledge that emerges from a particular cultural and historical context, which embeds its own biases into what gets saved and how it is represented. This approach can be used to extend archival theorist, Terry Cook’s (2011) emphasis on critically examining the history of archives to understand how they shape the records available to the researchers of today and into the future: “archivists need to examine much more consciously, and historically, their many choices (and the assumptions behind them) in the archives-creating and memory-formation process, and they need to leave transparent evidence of their own activity so they may be held accountable for their choices to posterity” (p. 631). Similarly, preservation
activities across archives, libraries, and museums need critical historical assessment to understand how they are shaping the availability of their information resources into the future.

**Methodology**

In order to better understand the context of digital reformatting and its emergence in the U.S. context, this paper analyzes published articles on preservation history in information institutions to chart the development of preservation knowledge by looking at key events in the field, important inventions, and the development of preservation specifications and other forms of codified knowledge. A timeline was built to organize the historical data.\(^5\)

This historical analysis is limited to the first emergence of library preservation as a distinct field of knowledge beginning in the early nineteenth century as scientific investigations began in laboratories and focuses primarily on processes of institutionalization and professionalization in the preservation field. This history of preservation knowledge begins in 1823, which marks the beginning of efforts to systematically develop knowledge related to the preservation of recorded information, with the earliest documented empirical investigations into preservation-related issues in the work of John Murray’s research on paper decay in the U.K. The year 2015 was selected as the endpoint of this analysis because by this time, digital reformatting technologies have become well-established for preserving a variety of formats in most large academic libraries. Digitization programs in academic libraries and other institutions became common across the U.S. by this time, and using STS terminology, we can see 2015 as a period of “closure and stabilization” of the technology. Pinch and Bijker (1984) explain: “closure in technology involves the stabilization of an artifact and the ‘disappearance’ of problems” (p.

\(^5\) The full timeline used for this analysis is available in graphical form online here: [http://www.tiki-toki.com/timeline/entry/484475/History-of-Preservation/](http://www.tiki-toki.com/timeline/entry/484475/History-of-Preservation/) (it was constructed using online timeline software, Tiki-Toki, [www.tiki-toki.com](http://www.tiki-toki.com)).
37). By 2015, digital reformatting of text, image, and video formats had been commonly adopted in academic libraries for preservation purposes, and alternatives to digital reformatting, such as analog reformatting were no longer seen as credible alternative approaches.

Selection of Sources

This analysis was conducted based on historical information drawn from existing literature on preservation history. Texts were selected that offered broad historical perspectives, to enable a general view of existing historical research to identify overarching trends over the period of study. Sources include Lee E. Grove’s (1966) history of scientist John Murray; Barbara Higginbotham’s (1990) history of American library preservation, 1876-1910; Michael Buckland’s (1992) discussion of the invention of microfilm rapid selectors, 1920-1940; Michèle V. Cloonan’s (2015) edited collection of historical and contemporary perspectives on preservation covering 740 BCE to 2012 CE; Sherelyn Ogden’s (1979) study of the impact of the 1966 Florence Floods on the preservation literature, 1956-1976; Pamela W. Darling and Sherelyn Ogden’s (1981) history of the preservation movement in the United States, 1956-1980; Caroline Frick’s (2010) history of the film preservation movement in the United States, 1920-2009; and Anna H. Perrault’s (2005) review of the history of microfilm in libraries, 1839-2001. Two proceedings from symposia on the topic of microphotography in libraries (edited by M. Llewellyn Raney, Director of Libraries at University of Chicago at the time), held at the American Library Association annual meeting (Raney, 1936; 1937), helped support analysis of the emergence of microphotography in libraries. Information about more recent historical events around digital libraries and digitization were gathered by reviewing research on the history of digital libraries, including Marija Dalbello’s (2005a; 2005b) study of the experiences of key personnel involved in the construction of the Library of Congress’s National Digital Library.

The focus of this paper is on identifying the basic historical facts of the history of preservation knowledge and identifying key trends across those facts, and a major assumption is that the sources consulted are factually accurate; however, it is limited by the perspectives offered by the authors of the texts that were analyzed. This paper seeks to find common trends across the reviewed texts, seeking to identify and describe major trends covering a variety of historical events. Further analysis of the discourses and practices of the current era of preservation research would complement this historical overview.

**Findings**

The analysis shows that the history of preservation knowledge during this period is characterized by increasing systematization and professionalization, culminating in the emergence of a distinctive institutionalized field of knowledge and practice between the late 1960s and early 1970s.

*Periods in the History of Preservation Knowledge*

The analysis identified five major periods of development in the history of preservation, summarized as a timeline in Figure 1.


Figure 1 – Periods in Modern History of Preservation Knowledge

Early Experimental Era (1823-1910)

The first period, “Early Experimental Era of Preservation Research, (1823-1910)” began with early experimental work on the physical problems of book decay, continues through the professionalization of the library field (e.g., the American Library Association is founded in 1876) and leads up to the next wave of preservation research in the early twentieth century. While the problem of preserving individual books, documents and relics had long been the concern of book collectors, antiquarians, museum administrators, and others, it was not until the nineteenth century that the problem of material decay was studied through scientific experimentation in order to create systematic solutions that could be applied to individual items and whole collections. As will be discussed further in the later section “Trends in Preservation Knowledge,” this distinction between ad hoc, idiosyncratic practices and standardized global systems will emerge as an important element of the underlying tensions in the preservation field today.

Work in this period began with the first application of scientific techniques of measurement to the problems of book decay. Printers, bookbinders, librarians, and others were already concerned with the durability of paper, but it was John Murray working in the U.K who first applied the scientific method to understanding the chemical breakdown of paper. Following publication of a letter on the perils of paper decay in *The Gentleman’s Magazine* in 1823 (“On the Bad Composition of Modern Paper”), Murray published a pamphlet in 1829 titled *Practical*
Remarks on Modern Paper, detailing his experiments exploring the chemical makeup of paper, seeking to find the roots of the decay of particular paper stocks (Cloonan, 2015). Through scientific tests, Murray correctly identified the presence of high-acid and the use of excessive bleaching agents as chief culprits in the decay of paper.

The concern for a systematic approach to the preservation of information carriers such as books saw parallels in broad interest in Europe with emerging approaches to preserving historic buildings and monuments. Most notably, in France, Prosper Mérimée (1803-1870) and Eugène-Emmanuel Viollet-le-Duc (1814-1879) debated how to preserve monuments, whether the focus should be on maintaining authenticity or restoring the “truth” of a building (Kalčić, 2014). Mérimée stressed rationalized and systematic descriptions of monuments, reflecting “the new scientific perspective developing in the 1830s and 1840s […] and Mérimée’s texts offered methodological guidance by setting the example” (Bonafos, 2018, p. 94). Viollet-le-Duc, in the article “Restauration” in his Dictionnaire Raisonné de l'Architecture Française du XIe au XVIe siècle (10 volumes, 1854-1868), published in English as On Restoration in 1875, emphasized the importance of establishing the original intent of the architect in guiding the restoration process and also advocated for the use of photography to document historic architecture.

Research on paper decay would continue through the nineteenth century as more and more paper was being derived through new methods using wood pulp instead of cotton rags.6 The British scientist Michael Faraday (perhaps inspired by his earlier work as a book binder) gave an April 7, 1843, lecture at the Royal Institute in London in which he lamented the decay of

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6 The acidic paper derived from wood pulp that is associated today with “brittle book” decay was not commonly used in the U.K. or U.S. until the late nineteenth century. Murray’s concern in the early nineteenth century was with the use of additives to rag-based paper and their effects on decay, including chlorine-based bleaching agents and alum-resin sizing (Cloonan, 2015). Wheelock (1928) notes that most U.S. daily newspapers were still using rag-based paper production methods through the 1860s.
leather book bindings due to the exhaust of gas lamps used in libraries. In referring to the degradation of book copies in the libraries of London’s Athenaeum Club, Faraday (1843) lamented, “our loss in the destruction of books has been very great. Here are books, the binding of which is completely gone. It was supposed it was all the effect of the gas” (p. 15). Faraday’s preservation concerns emerged from three elements: the production of the objects themselves, their storage environments, and their interactions with chemical agents.

In addition to the work of these singular scientists studying the issues of material decay during this time, the American library community, which was undergoing a process of professionalization (from 1853-1876), also took an increased interest in problems of preservation. Aided by institutions such as the National Bureau of Standards (with similar work being conducted in the Royal Academy of Arts in London), librarians were looking for better quality books, with a particular focus on more durable book bindings.

By the late nineteenth century, a central concern for the newly professionalized field of librarianship was the problem of poorly manufactured books and how to convince publishers to make changes to address this problem. The ALA’s Committee on Bookbinding and the advocacy of individual librarians, such as librarian, Ellen Biscoe of Eau Claire, Wisconsin (Higginbotham, 1990), attempted to put pressure on publishers to improve the quality of book production. Some publishers responded by offering special library bindings (“preservation bindings”), while in other cases, libraries would have book sheets bound by special binderies (Higginbotham, 1990).

Librarians were also concerned during this time with using new techniques to make copies of unique or rare materials from the world’s libraries for distribution to other nations for safekeeping. These technological approaches complemented ongoing efforts to systematize the

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7 The period of library professionalization stretches from around 1853 with the first librarian convention in New York City to 1876 with the formation of the American Library Association.
process of transcribing and collating texts to produce scholarly editions, such as in the methodology of Karl Lachmann (Timpanaro, 2005/1981), as well as the techniques of documentary editing, which created editions of archival materials for preservation through publication (Riter, 2020). By assembling authoritative texts in carefully transcribed and edited editions, the replication and dissemination of texts through publication and incorporation into worldwide libraries, was envisioned to support preservation through carefully rationalized acts of copying, multiplication, and distribution.

After a series of highly-publicized library fires at the turn of the twentieth century, such as at the University National Library of Turin in 1904, American and European librarians began discussing methods of protecting manuscripts and rare books through the use of photography. The first research on the use of photography to preserve manuscripts was conducted in the U.S. and in Europe, including the founding of the photo reproduction department at the New York Public Library in 1896, the work of Guido Biagi in Italy in 1904, and Charles Mills Gayley at the University of California, Berkeley in 1905 (Higginbotham, 1990). After 1909, this research trajectory appears to have lost momentum. According to Higginbotham (1990), by 1910 “growth, prosperity, and the international exchange of ideas and research began to slow,” and the year 1910 also “represents the close of the period of initial research into the causes of deterioration in library materials by the U.S. Bureau of Standards and the Royal Society of Arts (London)” (p. 4). Photo reproduction would not see massive or systematic deployment in U.S. libraries during this period, with the exception of a few large public libraries, including the Boston Public Library, which offered photographic reproduction services for their patrons during this period (Higginbotham, 1990). In the coming years, more libraries would provide

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photographic services with the development of projector photocopying (“Photostats”) and a variety of contact printing techniques for duplicating documents directly onto photo-sensitive paper. These relatively quick photocopying processes were adopted in a number of U.S. libraries by 1912, including the Library of Congress, Chicago’s John Crerar Library, and the New York Public Library (Ballou, 1956). Writing in 1956, Hubbard W. Ballou, Head of Photographic Services at Columbia University Libraries claimed, “by 1912, American libraries awoke to the possibilities of the Photostat camera” (p. 270). By 1929, at least forty-two U.S. libraries had Photostat cameras (Ballou, 1956).

**Era of Microfilm Experimentation (1920-1956)**

The second period began in the early 1920s and is referred to as the “Era of Microfilm Experimentation” (1920-1956). Techniques of microphotography emerged as a new tool that libraries enthusiastically explored in the 1920s and 1930s. Michael Buckland (1992) writes “the literature on documentation in the 1930's was as preoccupied with microfilm technology as it is now with computer technology, and for the same reason, each being the most promising information retrieval technology of the time” (p. 290). Proponents of microfilm saw it as a promising medium for copying textual information and making it more widely available, without adding significant storage requirements or shipping costs. Following earlier experiments on the use of photography for copying rare books and manuscripts, microphotography was perceived to have similar capabilities for preserving information, with the added benefit of saving space through the greater information storage density and lighter materiality of microfilm formats.

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9 There is a gap in the timeline (see Figure 1) between the first and second periods. The time between 1910 and 1925 is characterized in the literature on the history of preservation as a lull in preservation research and development. Higginbotham (1990) suggests that World War I (1914-1918) played a role in disrupting library research in Europe on preservation issues during this period.
Microfilm copying emerged from earlier work in Europe on the photographic reproduction of texts, first proposed in England by Fox Talbot in 1844 in his book, *The Pencil of Nature* (Ballou, 1956). By the end of the 19th century several large European libraries had introduced photographic duplication services: By 1877, France’s Bibliothèque National provided two darkrooms for patrons who conducted their own photoduplication of library materials; by 1887 the British Museum set up a photographic reproduction service; and by 1890, Oxford’s Bodleian Library was providing a pricelist for photographic reproduction services (Ballou, 1956).

While the first techniques of microphotography can be traced back to John Benjamin Dancer’s work beginning around 1839, the usefulness of the process for efficiently storing documents and other information resources took nearly a century to become broadly recognized for use in the library field. In the interim, many European theorists championed the possibilities of microphotography for copying and preserving texts, including Sir John Herschel, who suggested microscopic editions of reference works as early as 1853. In 1906, Robert Goldschmidt and Paul Otlet suggested using microphotography to copy books onto photocards that would also include bibliographic descriptions (Ballou, 1956). In the U.S., the Library of Congress used microphotography to copy manuscripts held by European libraries from 1927-1935 (Saffady, 2000), and the Recordak Corporation (a subsidiary of Eastman Kodak) began producing microfilm copies of newspapers for purchase beginning in 1933 (Ballou, 1956). University Microfilms (which would became ProQuest, now a subsidiary of Clarivate), was founded in 1938 and began by providing microfilm copies of dissertations. By 1939, Columbia’s School of Library Service began offering a course in microphotography for libraries (Ballou, 1956).
The experiments with microfilm in the 1920s and 1930s helped to convince the library community that photographic techniques for reformatting library materials could be used as an affordable and practical preservation strategy at a large scale. With the refinement of microphotography in the early twentieth century, librarians could combine both goals of preserving information and making it more widely available. Copying of the world’s texts and distributing them throughout the globe was seen by many as a promising approach for preserving the body of human knowledge, perceived to be particularly at-risk in an era of world wars and library fires.\(^\text{10}\)

Even as microfilm maintained its experimental status in most libraries during this time, corporations, banks, and research contexts had already started to adopt the use of microphotography for record-keeping and scholarly purposes. Growing concerns expressed throughout society about the explosion of information in the first decades of the twentieth century encouraged new developments in microfilm rapid retrieval systems designed by such innovators as Emmanuel Goldberg in Germany, which would inspire the work of Vannevar Bush and his Memex machine later in the 1940s (Buckland, 1992, 2006).

The promises of microfilm and growing interest in mathematical, signal-based models of information (Shannon and Weaver, 1999) may have contributed to a widening conceptual split between the informational content of a book or document and its material instantiation. Conceptualizing information as something apart from its physical medium would become necessary for future developments in thinking about reformatting and digitization techniques that

\(^{10}\) The idea that copying and wide dispersion of texts could serve as an effective preservation strategy can be seen much earlier in the eighteenth-century writings of Thomas Jefferson, who commented on the loss of historical American documents from earlier eras: “let us save what remains: not by vaults and locks which fence them from the public eye and use … but by such a multiplication of copies, as shall place them beyond the reach of accident” (cited in Cloonan, 2015, xxiv).
conceptualized information as primarily immaterial. James O’Toole (1989) points out that early American preservationists (working in archives and historical repositories in the eighteenth and nineteenth centuries) had already started to make a distinction between the preservation of documents as material artifacts and the preservation of the information stored in the documents.

Also, during this period, preservation knowledge related to a range of photographic and microphotographic techniques began to be institutionalized through the formation of library departments devoted to photographic reproduction, such as Herman Fussler’s founding of a lab for microphotography at the University of Chicago libraries in 1936 (Jones, 2003). Fussler was not the first to employ microphotography in libraries, but he did much to promote it, especially among academic libraries at research universities. Early work by Ludowik Bendikson at the Huntington Library in the early 1920s, work by M. Llewellyn Raney at the University of Chicago, and Vernon Dale Tate’s work at the Library of Congress helped pave the way for Fussler’s initiatives (Raney, 1936). Fussler was part of a cohort of library administrators and technologists who participated in symposia on microphotography held during the American Library Association’s annual meetings in 1936 and 1937 (with a follow-up meeting in 1939, with proceedings published in the Journal of Documentary Reproduction). Ballou (1956) suggests that the 1936 symposium “may well be regarded as the official birth of library microfilm” (p. 278). Proceedings for the two symposia were published as Microphotography for Libraries in two volumes. The proceedings for the 1936 symposia included an extended discussion (led by Robert C. Binkely) on the importance of standardizing microphotography techniques (including the practices of copying, as well as the physical properties of the film, width, perforations, etc.). Along with these two publications, Robert C. Binkley’s book, Manual on Methods for
Reproducing Research Materials in 1936, helped to promote new techniques for expanding the availability of library resources through copying to the wider library community.

By the 1940s, microphotography techniques were becoming further codified in guides and articles, such as Fussler’s (1942) publication, Photographic Reproduction for Libraries: A Study of Administrative Problems (based on his Masters thesis).\(^{11}\) In 1950, “A Proposed Standard for the Microphotographic Reproduction of Newspapers” was published in American Documentation, reporting on the work of the Committee on the Photographic Reproduction of Research Materials (appointed by the Association of Research Libraries), which included Herman Fussler as a member, with Vernon D. Tate as chairman. Journal articles began appearing, such as “Photographic Reproduction of Research Materials” published in Library Trends in 1954.

The problem of paper decay had not been forgotten, even as microphotography became a major focus of the library field. During this time, earlier experimental research on material decay and book binding standards continued through the work of Harry Lydenberg at the New York Public Library and at William Barrow’s deacidification research lab (Higginbotham, 1990). Barrow’s lab systematically studied techniques of deacidification for paper, starting in 1940 and finally closing its doors in 1977. Interest in microfilm in libraries lasted well into the digital age (see: Gwinn, 1987), even as corporations and government agencies switched to digital storage of records as mainframe computers became available.

\(^{11}\)The Fussler Collection can be accessed through this finding aid at the University of Chicago Library: https://www.lib.uchicago.edu/e/src/cfindingaids/view.php?eadid=ICU.SPCL.FUSSLERHH
Era of Professionalization (1956-1980)

The third period, “Era of Professionalization (1956-1980)” covers the time period in which preservation knowledge moved from a loose collection of techniques, tools, and ideas developed by individual researchers and specialized institutions, to coalesce as a cohesive body of knowledge that formed the foundation for the professional field of preservation. This period began in 1956, the year in which the Council on Library Resources (CLR)\(^{12}\) was founded and the journal *Library Trends* published a special issue devoted to preservation research. This period of development continues until the early 1980s, at which point the preservation field is fully professionalized and a new era of intensive standards development and experiments in the creation of digital libraries begins.

The era of professionalization is characterized by widespread activity in preservation research and the establishment of preservation units in organizations. Preservation activity in the U.S. was motivated in part by trends in the rise of Cold War geopolitics, with the defense department and corporate funding flowing into preservation institutions, such as CLR (Cunningham-Kruppa, 2015).

In earlier eras, threats of fires and wars had helped to motivate preservation research. In this period, interest in preservation of a variety of informational and cultural resources increased with the threat of nuclear war during intensification of the Cold War between the U.S. and U.S.S.R and the occurrence of natural disasters in the world, such as the Florence Floods of 1966, which damaged significant artworks stored in museums and other institutions around Florence, Italy.\(^{13}\) Sherlyn Ogden (1979), in her review of the preservation literature, pre and post

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\(^{12}\) CLR would become the Council on Library and Information Services (CLIR) with its merger with the Commission on Preservation and Access (CPA) in 1997.

\(^{13}\) Coincidentally, the U.S. had just signed into law the National Historic Preservation Act in October 1966, less than three weeks before the infamous Florence Floods.
1966 suggests that the Florence Floods accelerated development in some areas of preservation, and that “the salvage operation raised the level of awareness of and support for scientific investigation in library conservation” (p. 22). Higginbotham (1990) offers another possible explanation for increasing interest in preservation concerns in this era, drawing parallels between the increased activity in library preservation and the increasing interest in other forms of cultural preservation developing in the 1960s, suggesting “the library community’s concern with the conservation of library materials may be related to the nation’s growth of interest in preserving other parts of its cultural heritage, such as architectural conservation. Like library preservation, architectural conservation began as a grassroots movement in America” (p. 190).

During this period, a variety of critical developments that were focused on the production and sharing of preservation knowledge demonstrated how the field was rapidly becoming a profession. Preservation researchers adopted two competing strategies for establishing preservation knowledge: a strategy of centralization through national or regional sites, and a strategy of codification in guidebooks, guidelines, and specifications disseminated for other organizations to implement within their own collections. For instance, the Library of Congress began to take an active role in establishing a national preservation program, which worked to simultaneously centralize and codify preservation knowledge. During this time a number of research libraries also formed special preservation departments and/or initiatives, such as at the Newberry Library (in 1964), and at Ivy League university libraries such as Yale (in 1971), Harvard (in 1973), and Columbia (in 1974). Also, during this period, institutions that have become leaders in codifying and disseminating preservation knowledge, such as the Northeast Document Conservation Center (NEDCC) and the Research Libraries Group (RLG), were founded. By 1975, studies, surveys, and needs assessments became common preservation
management tools (Darling and Ogden, 1981), which offered systematized approaches for integrating preservation knowledge, techniques, and tools within models of organizational management. During this time, the library preservation community formed closer working relationships with other parts of the preservation community such as the American Institute for Conservation (AIC). Key moments during this period included the founding of the National Conservation Advisory Council in 1973 and the Society of American Archivists (SAA) receiving a National Endowment for the Humanities (NEH) grant in 1980 for the “development of manuals and an extensive series of workshops” (Darling and Ogden, 1981, p. 23). The field became increasingly professionalized and preservation emerged as a cohesive field of knowledge and practice. According to Darling and Ogden (1981), by 1980, “the territory had been mapped and a common intellectual approach was rapidly emerging” (p. 20). By the end of this era, strategies to codify preservation knowledge evolved into efforts to set national and international standards for preservation.

The development of preservation standards was an important trend that began towards the end of the era of professionalization and continued beyond it. For instance, in 1984, NISO (National Information Standards Organization) and ISO (International Organization for Standardization) published national and international standards, respectively, defining permanent paper quality, nearly 150 years after John Murray and others began scientifically investigating the problem of book decay. The idea of standardized techniques and technological configurations reemerged as libraries would begin to develop digitization programs in the decades to come. On one hand, standardization helped to support concerns over interoperability and quality control, but on the other hand, standards developed by larger organizations could be difficult for smaller
organizations to adopt, which could leave them to develop their own ad hoc approaches or lead to frustration and inaction on their part.

Additionally, the Image Permanence Institute was founded in 1985 at the Rochester Institute of Technology, which today continues the tradition of empirical analysis of the decay of information carriers. While digitization and digital preservation would soon emerge in the 1980s and 1990s, interest in earlier preservation techniques continued in this period. For instance, in 1987, Nancy Gwinn published an extensive manual for librarians to produce preservation-quality microfilm for their collections. The next era of preservation research would make microfilm techniques increasingly at risk of being outmoded by digital techniques for supporting preservation and access capabilities in many libraries.


The fourth period identified is the “Era of Digital Library Research (1980-2004),” which begins with the experiments conducted at the Library of Congress to provide access to digitized images and texts via optical disk technology. Other innovations during this time that facilitated these developments included improvements in digital imaging technology and computer processing capabilities and the rise of computer networks for digital data exchange, including the further development of the Internet and the birth of the World Wide Web (Berners-Lee, 1996). This period began in the early 1980s and continued until 2004 when the first wave of digital library projects were being completed and digital reformatting was formally recognized by the Association of Research Libraries (ARL) as a preservation strategy (Arthur, et al., 2004).

Digitization technology emerged as a critical component of first-wave digital library projects in the United States, between 1994-2002 (see: Dalbello, 2005a, 2005b). Staff members at the Library of Congress who were involved in these projects distinguished between the use of
digitization as a means of “preservation” and a means of “access” (Dalbello, 2005a, 2005b), which suggests tensions between the long-term persistence of digitized documents and their immediate use and usability. It also showed how preconceived notions about the uses of digitization for preservation evolved over time and did not emerge as a fully formed technology that was commonly understood by all preservationists or preservation institutions. The experimental work of the Library of Congress and its National Digital Library Project (1995-2000), including the American Memory prototypes, grappled with this relationship between preservation and access in digital library projects and how the primary uses of digital copies should be conceptualized. At the same time, increasing emphasis was placed on the preservation of electronic records, and the National Digital Information Infrastructure and Preservation Program (NDIIPP), established through an act of the U.S. Congress in 2000 and facilitated by the Library of Congress, set in place the groundwork for the development of centralized digital repositories. This work of creating centralized repositories, in effect, helped to further earlier efforts by the Library of Congress in the 1960s and 1970s to centralize preservation knowledge in the U.S. This helped to ensure that any digital preservation solutions would become part of a national program of preservation knowledge through this program.


The fifth and final period identified is the “Era of Digital Reformatting and Mass Digitization (2004-2015).” This period is characterized by the development of digitization guidelines by influential and typically large organizations, focused primarily on digitizing texts and images. Guidelines were circulated and widely debated (see: Conway, 2008) in library and archives fields. At the same time, guidelines for complex visual formats, such as film and analog video tapes were also critical topics of discussion in the recently-professionalized, “moving image
preservation community” by the end of this period. Two important strands of research include the creation and publication of digitization guidelines and standards, and research on non-book and other complex media (which had started in the previous period but continued through this period). The important actors during this period include the Association for Research Libraries (ARL), Google, the Library of Congress, and academic libraries at research universities.

This period begins in 2004 with ARL’s endorsement of digital reformatting as a preservation strategy (Arthur, et al., 2004) and Google’s announcement of its Google Books mass digitization project (“Google Checks Out Library Books”, 2004), and continues to 2015, at which point digital reformatting technology had become widely accepted across preservation institutions and the knowledge related to digital reformatting had gained a significant degree of systematization and codification. This cohesive body of knowledge concerning digitization took time to develop and circulate across the field of preservation. Writing in 2007, Puglia and Rhodes (2007) examined the current state of digitization practice in preservation institutions and found a lack of development in terms of preservation practice and the systematic use of digitization technologies:

It is a little humbling to look back and admit that we are still asking many of the difficult questions that we were asking over a decade ago – particularly about the relationship of digitization to preservation and agreement on approaches that are appropriate for preservation reformatting using digitization. (p. 10)

During this period, the Library of Congress (LC), alongside a variety of other academic libraries and other collecting institutions released numerous reports and digitization specifications. Some significant digitization guidelines from this era include:


Conway (2008) has pointed to the difficulty in measuring the diffusion of preservation standards and speculates that smaller preservation projects may find it difficult to follow standards developed by larger organizations. Implementing any standard has costs associated with it, and smaller institutions may not always have the necessary resources to adopt the technologies and procedures that are feasible for larger institutions.

*Preservation of Non-book Materials*

Preservation knowledge concerning the complex visual document formats beyond texts and images took longer to develop in this period, due to technical, institutional, and professional barriers. Writing in 2010, Paul Conway pointed out that for visual documents “the preservation
community has not made the sort of transformative progress with standards, best practices, appraisal and selection strategies, and other procedural requirements that undergird past successes with book and paper preservation” (p. 72). Part of this “nonbook dilemma” identified by Conway (2010) can be attributed to professional, institutional, and scholarly bias for preserving books and documents to the detriment of other information formats (Andreano, 2007) and the bias of intellectual inquiry towards numeric and linguistic forms of knowledge (Drucker, 2014). In addition, the subfields tasked with preserving complex media formats have only recently coalesced. For instance, the moving image preservation field, concerned with preserving audiovisual materials constituting a range of film, video, and digital formats, became professionalized decades later than the broader preservation field that was focused on book and art preservation.14 During this period, a number of important reports by the Library of Congress were published, including a four-volume report on film preservation, Film Preservation 1993: A Study of the Current State of American Film Preservation (Melville and Simmon, 1993), and a five-volume report on video preservation, Television and Video Preservation, 1997: A Report on the Current State of American Television and Video Preservation (Murphy, 1997). These two authoritative reports identified the central problems facing the preservation of film and video formats at a national level, helping to establish a set of common concerns for the nascent professionalization of the moving image preservation field, motivated by the perception of increasingly dire threats that material decay and technological obsolescence posed to the audiovisual heritage of the United States.

14 Gregory Lukow (2000) traces the emergence of moving image preservation as a distinct profession to the early 1990s. The Association of Moving Image Archivists (AMIA) was founded in 1992 and it was at this time that concerns about a cohesive professional identity were becoming common in the practitioner literature (Edmondson, 1995) in the U.S. context.
Other important initiatives during this era sought to develop and evaluate technologies for digitally reformatting a range of visual formats. For instance, Howard Besser (1999) discussed guidelines for designing systems to digitally reformat collections of photographs of fine art, and Jane Hunter and Charmin Choudhury (2003) developed guidelines for preserving complex multimedia objects in museum contexts by evaluating tools through a series of case studies. In the moving image preservation field, Jerome McDonough and Mona Jimenez (2007) argued that the same digital conversion approaches developed by digital libraries communities and other fields for making text and image materials more widely available should be applied to preservation of analog video recordings. They pointed out that preservationists need to look to trends in the broader field of digital content and distribution, noting “efforts to preserve digital information thus tend to fuel the movement towards using digital technologies to preserve non-digital information” (McDonough and Jimenez, 2007, p. 172). Karen Gracy (2007b) studied the practices of film preservationists and how they construct meaning around contested concepts such as “preservation,” “access,” “film as artifact,” and “film as asset,” showing a growing interest in empirically analyzing the work of preservationists with complex, non-book media formats.

Three graduate-level audiovisual preservation programs were founded in the U.S., between 2002 and 2005. The University of California, Los Angeles – Moving Image Archive Studies (founded in 2002),\(^\text{15}\) New York University – Moving Image Archiving and Preservation (founded in 2004),\(^\text{16}\) and the Selznick Graduate Program in Film and Media Preservation, at the University of Rochester and the George Eastman House (their Graduate program was founded in

\(^{15}\) https://web.archive.org/web/20131020024005/http://mias.gseis.ucla.edu/
\(^{16}\) http://tisch.nyu.edu/cinema-studies/courses/ma-in-moving-image-archiving-and-preservation
2005; a one-year certificate program has been offered at the Selznick School since 1996)\textsuperscript{17} are graduate programs dedicated to educating students in preserving visual materials. While explicitly focusing on the preservation of “moving images,” the programs were developed to also educate students in preserving sound recordings and various types of digital media formats.

As educational programs continued to be important means of disseminating preservation knowledge, knowledge continued to be centralized through the efforts of the Library of Congress to found a national center for preserving moving image media and sound recordings. In 2007, following closely behind the founding of the three moving image preservation educational programs, the Library of Congress opened its new Packard Campus of the National Audiovisual Conservation Center (PCAVC).\textsuperscript{18} The PCAVC is responsible for preserving the audiovisual heritage of the United States and it continues the work of the Library of Congress to centralize preservation knowledge related to digital reformatting and preserving audiovisual content, in conjunction with such initiatives as the Federal Audiovisual Digitization Guidelines Initiative (FADGI) (Fleischauer, 2010). The PCAVC is equipped to store and digitally reformat a range of media types, including film, video, and audio formats (Mashon, 2007). This large-scale, government-supported organization has become the largest collection of moving image and sound documents in the world, and continues to play an important role, through its practical work of digital reformatting for preservation and access purposes and developing standards with FADGI to further codify and institutionalize preservation knowledge.

Based on these examples and the assembled timeline,\textsuperscript{19} it is clear that an important component of the work of larger information institutions during this period involved the

\textsuperscript{17} https://web.archive.org/web/20180423005226/http://selznickschool.eastmanhouse.org/masters_about.html
\textsuperscript{18} http://www.loc.gov/avconservation/packard/
\textsuperscript{19} http://www.tiki-toki.com/timeline/entry/484475/History-of-Preservation/
production of internal standards, best practices, and other documents to guide their employees’ work and to maintain the credibility and transparency of information institutions. However, while there has been significant work by the Library of Congress and other large institutions to develop preservation standards and guidelines, it is unclear if smaller institutions have been able to follow these standards, and there are likely power effects that may negatively impact them. By the end of this period, standards and guidelines for digitizing texts widely proliferated, and for most institutions, digitizing books and documents became routine and less discussed, while guidelines and standards for other formats continued to be debated.

**Discussion: Trends in the History of Preservation Knowledge**

The periods of activity in the history of modern preservation knowledge, based on this broad summary and associated timeline of key events, can be characterized by increasing specialization of work functions in information institutions and by three guiding trends of development, *empirical inquiry*, *standardization of practice*, and *centralization of knowledge*.

*Empirical Inquiry*

Empirical inquiry refers to the application of the scientific method to preservation problems. This trend emerged with scientific experiments in the early years of the first period of preservation history (1823-1910) and continues to the present day in research labs, most notably the Image Permanence Institute.²⁰ The scientific method was applied to the development of knowledge for preservation work, both in terms of managing documents and organizational activity, including managing staff, resources, and developing policies. Techniques were developed to shape micro and macro storage environments through architecture, heating and cooling, air filtration and

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²⁰ [https://www.imagepermanenceinstitute.org/](https://www.imagepermanenceinstitute.org/)
lighting controls, fire suppression systems and special containers; and chemical and physical treatments including deacidification, lamination, and rebinding. Preservationists developed copying techniques including the use of Photostats, Xerox copying, photography and microphotography, and eventually, digitization and digital preservation. They also developed administrative techniques, including establishing guidelines and procedures that could be adopted within a preservation organization in a top down fashion in order to legitimize local preservation work, aligning it with normative pressures imposed by experts and larger organizations within the preservation community.

*Standardization*

Initial efforts at standardization began towards the end of the first period (1823-1910), when the American Library Association began pressuring publishers to adopt standards for the binding of library editions around 1909 and would emerge fully in the second period of preservation history (1920-1956) with the publication of the first formally adopted library binding standard (ALA’s “Minimum Specifications for Class ‘A’ Library Binding” in 1935). Standardization intensified in the fourth (1980-2004) and fifth periods (2004-2015) with an explosion in the development of standards and specifications related to preservation. The centralization of institutionalized preservation knowledge began in the third period (1956-1980), with the development of important organizations (such as the founding of the Council on Library Resources [CLR] in 1956) and initiatives (such as the founding of the Preservation Program at the Library of Congress in 1967), continued through the fourth period (1980-2004) with work at the Library of Congress on digitization techniques and the National Digital Library Project (1995-2000), and culminated in the fifth period (2004-2015) with the further development of preservation research.
programs at the Library of Congress and CLR’s later incarnation, CLIR (Council on Library and Information Resources).

Standardization is understood here as the process of producing standards, codified forms of knowledge encoded within organizational processes, documents, and tools, which are then used in the preservation field to circulate knowledge about new preservation techniques across space and time. Understood as “models for reality” (Busch, 2011), standards are commonly used throughout other parts of modern society to ensure consistency across space, time, and scale, and help to centralize control. Research in the “sociology of standards” draws on theories of social epistemology, institutional theory (e.g., Scott, 2003), organizational change (e.g., DiMaggio and Powell, 1983), and science and technology studies. Timmermans and Epstein (2010) suggest that standards and standardization are “ubiquitous but underestimated phenomena that help regulate and calibrate social life by rendering the modern world equivalent across cultures, time, and geography” (p. 70). Standards embed classifications (Bowker and Star, 1999). The development of standards is closely related to trends in “quantification, formal modeling, and data mining, reuse, and classification” (Lampland and Star, 2009, p. 9).

Even before preservation coalesced as a professional field, efforts to establish commonly-accepted methods of carrying out preservation activities were focused on developing ways of systematically considering risks to items and collections and for evaluating appropriate and legitimate techniques and tools. Work being conducted by large organizations, including the Library of Congress (LC) and National Archives and Records Administration (NARA), to standardize digitization practices continues to play a significant role in the institutionalization of preservation knowledge for the wider preservation field. Standardization includes the development of formalized specifications approved through official standards-setting
organizations, such as International Organization for Standardization (ISO), as well as via *ad hoc* standards in the form of specifications and guidelines adopted by preservation institutions as “accepted” methods and tools.

In the history of preservation knowledge, standardization activities are both a particular mode of constructing knowledge in the field of preservation and are useful “institutional carriers” (Scott, 2003) for circulating knowledge within and between organizations. While it took decades for the systematic approach to preservation to develop as a distinctive field in the early 1970s, standardization efforts by libraries had already been shown to be effective as early as the 1930s with the ALA-sponsored development of standards for preservation book bindings. In addition, the work conducted by large organizations such as LC and NARA to develop standardized guidelines for digitization practices beginning in 2004, played a crucial role in the institutionalization of knowledge about new preservation techniques through standardization initiatives, such as the Federal Agencies Digitization Guidelines Initiative (FADGI), which was founded in 2007.21

Given their power effects, standards should not be treated as panaceas, but instead need to be considered critically in terms of their impact on smaller, diverse institutions and the communities they serve. The trend of standardization can have negative impacts on smaller institutions that are often excluded from the standardization process. The adoption of preservation standards can disrupt existing organizational practices (Donaldson and Conway, 2010; Donaldson and Yakel, 2013) and standards are used to reduce diversity of practices (Lampland and Star, 2009) and produce sameness and control over space and time (Timmermans and Epstein, 2010). Standardization of preservation knowledge and practices, without proper

consideration, can thus negatively impact a diversity of organizations, potentially limiting their access to funding and prestige, and potentially enacting symbolic violence upon the users of collections (Bettivia, 2016).

Centralization

The development of preservation as a field has been shaped by initiatives designed to centrally concentrate expertise. The rise of standardization can be seen to support efforts in the preservation field to centralize preservation knowledge. Through nationwide initiatives funded in the 1970s by LC and the National Endowment for the Humanities (NEH), the development of preservation knowledge tended to move from labs of experts and large national organizations to the library community more broadly. While preservation standards may be developed by a particular institution, the goal of standards development for widespread adoption across the field is to promote uniformity across space, time, and scale. There has been some push back against the trends of standardization and centralization, as groups of preservationists working with complex visual formats develop guidelines for their own local practices and sometimes adopt a “do-it-yourself” (DIY) or “maker” ethos (See: Rinehart and Ippolito, 2014 for a discussion of DIY preservation in the age of digital media). For instance, some preservationists are using 3D printers to create preservation tools and equipment (See: Neumüller, et al., 2014) and other preservationists have been building their own digitization systems using open source technologies such as the FFv1 video format (see: Marsh, 2015; Jones, 2019). They work in opposition to centralized and standardized sources of preservation knowledge.

Implications for Preservation Research

The work to develop digitization as a preservation strategy has tended to privilege an informational over an artifactual model of preservation (Owens, 2018), one in which it is
assumed that the informational content of an information carrier can be transferred without significant loss to a new form. Critics of digitization point to the ways in which the materiality of information carriers is overlooked in this model. The form, format, and materiality of information artifacts shapes how they are interpreted, and mainstream digitization approaches tend to privilege a narrow definition of informational “content.” Book historians are well acquainted with the ways in which the material form of the book can support analysis of variants, the socialization of texts, reading practices and marginalia, and evidence of a text’s transmission. When analog information carriers are digitized, the structure can be lost or elements that the digitizers perceive is non-informational may be discarded. This has been shown to be quite common in the Google Books project corpus, wherein Paul Conway (2013) has found a significant incidence of errors through a sampling of 1,000 pre-1923 volumes, including the omission of pages, illustrations, paratextual information, etc. Anecdotal stories abound of surprising discoveries based on non-textual dimensions of information carriers, such as taste, touch, and chemical properties, which can serve as essential forms of research data. Brown and Duguid (2017) relate the story of a postal historian inspecting envelopes for the smell of vinegar to indicate envelopes disinfected during past cholera outbreaks. Trevor Owens (2018) points to the ways in which multi-spectral imaging can surface texts hidden on palimpsests as an example of how the materiality of an information carrier can hide additional depths of information:

While the focus on the informational content of records has been and continues to be primary, there is of course always a nearly limitless amount of information in any given material object that could potentially be probed and explored to provide additional information. Recent work in multi-spectral imaging has been particularly relevant in this area. Through creating composite images of records like drafts of the constitution or of
the Archimedes Palimpsest these techniques have been demonstrated as viable ways to
surface seemingly hidden information from inside the artefactual and material features of
an archival record. (p. 23)

Hodges, et al. (2021) have shown how even digital images circulating on social media carry traces of each moment of copying, as they are uploaded, screen grabbed, and re-uploaded to social media platforms that often re-compress file formats and re-edit their embedded metadata. Furthermore, as digital formats are migrated to new formats they inevitably change as functionality deemed unimportant to include in the new format is lost in the transformation process. Or, in the case of emulation, the behavior of interactive software, especially video games, can vary in unexpected ways, such as through speed and sound quality. In each case, decisions about what constitutes the significant properties (Hedstrom, et al., 2006) of the digital object must be defined, and these definitions will determine which properties get saved and which get lost.

In addition to forcing preservationists to choose which aspects of analog originals to translate over into the digital world, and which to leave behind, digitization also shifts long-term preservation management from the world of physical objects to the world of digital bits. Thus, digital reformatting directly interfaces with a growing body of knowledge and practice in the field of digital preservation, which suggests that digitization is only the beginning of a longer and more complex preservation lifecycle, not a final resting place for information. The basic preservation of bits over the short to medium term has been well understood by credit card companies, banks, and other corporations and organizations for decades, and solutions have been successful (data breaches and ransomeware cases notwithstanding). However, for complex digital formats beyond the basic recordkeeping systems, file formats and particular software
platforms are at high risk of loss of access through rapid obsolescence of software and hardware. Even if the bits survive for some digital objects, the software needed to render the content may be lost, which is particularly risky for independent software producers and game designers, as well as researchers using custom software or relying on proprietary data formats that become unsupported. Digitization solves some problems of preservation and access, while introducing new and pressing challenges of digital preservation.

The trends identified in this historical review point to several new areas of inquiry for studying the preservation field. First, studying tensions and resistances related to the centralization and standardization of preservation knowledge could yield insight into understanding current cultural and political trends shaping the development of preservation tools and techniques and the work of preservationists. Efforts at centralizing and standardizing preservation knowledge have been shown to be important strategies in the preservation field, yet they can lead to tensions between larger organizations that create standards and smaller organizations that may have difficulty adopting them or may perceive that the standards do not fit with their particular organization’s existing practices, policies, or resources. Approaches from science and technology studies and organizational studies, and the subfield of the sociology of standards can be drawn on by information studies researchers to better understand how systematized and centralized forms of knowledge are shaping the field of preservation. Formal standardization projects can be studied in terms of the social processes that shape the development of a standard, beyond a technical assessment of the standard itself. Brunsson and Jacobsson (2000) suggest

Although the standards involved are often called “technical,” they are constructed in processes that appear to be anything but technical (Guillet de Monthoux 1981; Schmidt
Technological development is not linear, nor does it automatically mean that the best standard wins (Pinch and Bijker 1984; Hawkins, Mansell and Skea 1995). (p. 9)

Adopting this approach in future research could generate insight into the social processes that make particular preservation standards and approaches fail or succeed in the preservation field and how their impact is felt across institutions operating at different scales. This approach has implications for research on information practices and critical information studies.

**Implications for Studying Information Practices**

This research points to the need to study the impact of standards on local practice. Dunn (2009) suggests “when standards are used to dictate practice or to grade products, they often replace *metis* – the unwritten practical know-how that local producers gain over the years” (p. 18). Donaldson and Yakel (2013) and Donaldson and Conway (2010) studied the adoption of the PREMIS metadata standard in archives, and their findings suggest that the adoption of standards may be disruptive to local practices and existing infrastructures. Preservationists may reject standards if they believe that they cannot be integrated into their institutional contexts (Lischer-Katz, 2014). This has important implications for studying the effects of standards and centralization on community archives, small libraries, historical societies, and marginalized communities. Resistances can be identified in the local practices of preservation institutions in terms of how they position their work in relation to the standards set by dominant preservation institutions. Research in information practice can benefit from taking a sociology of standards approach because standards increasingly shape local practice in many contexts and may act as important hidden or invisible forces that influence how information practice is carried out in institutional contexts. Looking at moments in a local practice when a standard is being
considered or adopted can foreground the impact of standards on local practice and make their influence highly visible.

**Implications for Critical Information Studies**

Studying standards as instruments of power (Hanseth and Monteiro, 1997) can be used to better understand the ways that preservation knowledge shapes institutional and professional activities and contributes to social inequality. This would contribute to research in *critical information studies*, which is concerned with the ways in which information systems and infrastructures are regulated and how that shapes human affairs (Vaidhyanathan, 2006). Preservation institutions are aligned with legal and regulatory frameworks that shape the access and distribution of information resources and the work of preservation is entangled in broader power relations enforced by laws and standards at the national and international levels. Backhouse, *et al.*, (2006) studied how “power operates silently but relentlessly in the generation and institutionalization of a standard,” and identified “the power mechanisms required for a standard to evolve from an idea into an obligatory passage point for organizations and agencies” (p. 414). Some research has already been conducted on the social shaping of preservation standards, including video preservation file formats (Jones, 2019) and preservation metadata (Donaldson and Yakel, 2013). Standards can be used by large actors to shape the behaviors of smaller actors or exclude them from the market if they are unable to adopt them. A broader investigation of preservation standards and the social shaping of standardization efforts is necessary to understand how preservation knowledge circulates (Conway, 2008), and the ways in which it reenforces power structures within and beyond the preservation field. From the perspective of the sociology of standards, the production and dissemination of national and international standards can be seen as a powerful strategy for centralizing preservation knowledge and promoting it to smaller
institutions, one that may embed social biases, institutional power, and epistemological assumptions about the nature of knowledge, how and when information resources may be used, and by whom. Taking an historical approach, in conjunction with a consideration of the power dimensions of standards and archival infrastructures can support current research concerns in archival studies that interrogate and reconfigure archives and record keeping practices in order to overcome oppressive regimes of social control (e.g., Agostinho, 2019; Brilmyer, 2018; Cifor and Wood, 2017; Haberstock, 2020; Steinmeier, 2020; Sutherland, 2017, 2019; Wood, et al., 2014; Wright, 2019) and the critical analysis of digital infrastructures, including social media platforms and digitization initiatives, such as the Google Books project. From this perspective, we can see that digitizing archival materials moves them into a network of public and private protocols and economic and legal regimes that include policies and laws that shape access and use through licensing and digital rights management technologies.

*Implications for Preservation Training and Practice*

Taking an historical and cultural approach to studying the preservation field has a number of practical implications for archival education and the design of preservation infrastructure (e.g., systems, standards, policies, and networks). Instruction for preservationists in archives, libraries, and museums can integrate a historical perspective into the presentation of preservation techniques, which will help foster critical, self-reflexive approaches for emerging preservation professionals. These can help students see how preservation work is shaped by larger historical and cultural forces, and that rather than accepting preservation technologies as given, they should interrogate how techniques and tools work to embed particular values into their professional practice. For instance, a consideration of trends in the centralization of preservation knowledge can assist students in understanding the role of server farms that are operated by large technology
firms, as critical preservation infrastructure in the current landscape of digital preservation and access, which can enable them to make decisions that better align with their values when selecting data storage facilities. Thus, taking an historical-cultural perspective can better prepare students to both become more reflexive in their preservation training and practice, and careful in how they integrate new technologies into their work. By considering preservation knowledge in terms of its historical dimensions, future preservationists will be able to interpret copying technologies and other preservation tools as continuing historical traditions, making it easier to understand how technological innovation can often reinscribe earlier social values, rather than offering decisive breaks with past injustices. Moments of technological change can be viewed as opportunities for critical assessment and rethinking of preservation practice in light of changing cultural values and norms. Taking an historical-cultural view on preservation knowledge prepares students to examine their preservation work within a tradition, providing historical understanding, while at the same time enabling them to identify areas in need of radical change.

The central role currently played by digital protocols, standards, software, computing devices, digital networks, server farms, and other digital infrastructures used in the preservation field makes it essential for preservationists to comprehend the broader historical forces that have shaped (and continue to shape) preservation knowledge. Understanding these historical trends that have shaped preservation knowledge and institutional practices, means that preservation programs, systems, and policies can be designed with clearer understanding of the ethical considerations that should be taken into account.

Furthermore, critical engagement with digitization techniques can reveal new approaches to digitization that overcome existing paradigms of extracting content, proposing decolonial research methodologies that stress alternative epistemologies for preservation and dissemination
of information (Smith, 2021). Understanding the historical perspectives that have informed mainstream discourses of digitization in cultural heritage institutions can help empower indigenous communities to use digital tools in ways that support their own preservation and access approaches. Boamah and Liew (2016) argue:

In the rush to digitize and to support interoperability and universal access to indigenous knowledge, many memory institutions have applied traditional, often Anglo-American standards that do not account for the often multiple meanings and ontological perspectives associated with traditional cultural knowledge and “objects” (p. 22).

Digitization supports a broader system of digital access and control that needs to be reconsidered from the beginning to support these alternative epistemologies, non-Western ways of knowing, and promote respect for indigenous cultural heritage. Getting communities involved in the development of systems and processes is essential (Boamah and Liew, 2016). Tribal archives, libraries, and museums have a need for digitizing collections, but the circulation and access typically afforded by mainstream digitization, digital preservation, and networked access can be at odds with cultural and ethical considerations (Christen, 2015). Maina (2012) critiques the dominant LIS [Library and Information Science] information management model, which is based on acquiring, organizing and preserving recorded knowledge that is mainly generated by researchers and universities, excludes traditional knowledge that is not formally codified and is acquired not through research but through, inter alia, inspiration and life experiences. (p. 17)

Indigenous communities, other underrepresented communities, and community archives need to take charge of their own standards and best practices in order to develop methods of sharing and circulating their cultural materials in ways that are in line with their cultural protocols. Content
management systems, such as Mukurtu, built to include cultural protocols in their structure and access and permissions controls, are a step in the right direction.

Current work to use digitization technologies to support repatriation of indigenous cultural heritage from museums to tribal custody is also a promising development. However, as Maina (2012) points out, recorded information is not the only form that indigenous knowledge can take. Christen (2015) gives a case study of how 3D scanning technologies can help repatriate artifacts to tribes, while producing facsimiles, which do not have cultural significance for the tribe, and keeping them in museums for research and exhibition purposes. Whaanga, et al. (2015) point to the ways in which emerging digital technologies can help develop new ways of representing indigenous knowledge, such as through GIS (geographic information system) mapping to support Maori land management (Pacey, 2005), digital repatriation of indigenous cultural heritage using 3D scanning (Brown, 2008), and the development of databases of artifacts held by overseas museums, art galleries, and other institutions (Tapsell, et al., 2011).

Understanding the broader histories of reformatting in preservation history and its emergence within particular cultural regimes, can inform indigenous curators, as well as community archivists (e.g., Caswell, 2014; Cocciolo, 2017; Lenstra and Alkalimat, 2012; Manžuch, 2017) in deconstructing existing assumptions of these approaches and shape digital reformatting beyond its standardized and centralized constraints in order to make it suitable for their purposes and support preservation in line with cultural protocols and a diversity of community needs.

**Conclusion**

This review of the modern history of preservation knowledge identified key intellectual trends of *empirical inquiry, standardization* and *centralization* in its development, which define the

22 https://mukurtu.org/
historical context necessary for understanding digitization practices, standards, and technologies today. Considering the development of preservation knowledge and the emergence of digital reformatting as a preservation technique provides insight into how institutionalized preservation knowledge and technology shape the historical record and how information may be accessed over time. Constructing this history of preservation knowledge reveals connections between current trends in digital reformatting and broader traditions of copying as strategies for preserving recorded information, such as the practices of scribes copying manuscripts in Medieval Europe or the development of microphotography used by libraries to preserve texts in the twentieth century. As one link in the chain of custodianship from the moment of creation and the use, to storage, copying, and future re-use(s) of information resources, the particular actions of a digitizer and the policies and infrastructures of their institution, in the process of carrying out the work of digital reformatting, become embedded with the materialities and histories of these collections. Within the history of scribal mistakes and printer’s errors, the work of copying is always carried out under precarious conditions in which the re-recording of knowledge is open to the addition of new corruptions or the replication of earlier, uncorrected errors.

These historical trends help to set the stage for the emergence of digital reformatting of visual and complex formats as a field of research and practice. This study does not discuss post-2015 trends in preservation, such as current trends in the preservation of emerging media, e.g., 3D data and virtual reality (see: Cook and Lischer-Katz, 2019; Grayburn, et al., 2019; Hardesty, et al. 2020; Lischer-Katz, 2020). However, analysis of these trends can be integrated into the framework presented here. As the preservation field continues to develop and new approaches are debated and adopted, trends of centralization and standardization in preservation knowledge
will likely continue to dominate unless the field embraces new, critical approaches that interrogate the histories of copying practices, technologies, and preservation knowledge.

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