



The Oyster Model: understanding community roles in sustaining digital cultural knowledge infrastructures

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Abstract

Digital community archives and many digital humanities projects serve as critical infrastructure for community-based cultural knowledge, but they struggle with sustainability. Prior work has illuminated numerous sustainability factors for digital cultural knowledge infrastructures that are developed and maintained by communities, but there is relatively little empirical work on the roles of communities themselves. Based on a comparative multi-case study of four projects, we offer a conceptual framework—the Oyster Model—for understanding community engagement as a sustainability factor in community-based, digital cultural knowledge infrastructures. Sustainable infrastructures identify and engage a range of stakeholder groups—teams, partners, contributors, users, and allies—in different roles and adapt to dynamism and change among these groups. This model characterizes reciprocity as a facet of community-centered approaches to sustainability, to refine understanding of the mutually beneficial relationship between digital knowledge infrastructures and the groups that create and maintain them. This work aims to bridge a gap between the community archives literature and relevant work on the sustainability of digital humanities scholarship.

Keywords Digital archives · Sustainability · Community archives · Digital humanities · Digital preservation · Maintenance

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Introduction

Digital community archives and many digital humanities projects exist on a spectrum of community-driven infrastructures for cultural knowledge. Small teams and communities often build and maintain these knowledge infrastructures (KIs) to serve their own needs—for collaborative research, storytelling, communication, memory, activism, and social cohesion (Edwards 2010; Fenlon et al. 2023; Flinn et al. 2009; Palmer 2004; Rayburn et al. 2024). Digital archives, local history blogs, maps, databases of language and literature: such KIs represent the long tail of cultural stewardship outside of mainstream cultural institutions. They maintain invaluable evidence and scholarship about underrepresented groups. Yet, they tend to be very difficult to sustain—to keep viable, functional, and accessible over time (Baker and Collins 2017; Barats et al. 2020; Eschenfelder et al. 2019; Froese-Stoddard 2014; Given et al. 2024; Kernik 2024; Kumar and Kumar 2012; Laakso et al. 2021; Miller and Taylor-Poleskey 2020; Newman 2012; Sheffield 2020; Smithies et al. 2019; Wagner et al. 2024). Davis (2015), for example, found that 45% of digital humanities projects were no longer available online 10 years after they were published.

The problem of sustainability for digital cultural heritage is increasingly acute in the USA, where recent, sweeping changes to federal policies and agency structures have undermined federal support for cultural heritage and digital humanities, compromising a lifeline for many community-based KIs. Even before these developments, however, unsustainability was an entrenched problem due to systemic factors including the fragility of technical infrastructures and widespread reliance on short-term grant funding, volunteerism, and small teams. What sustainability means and entails differs from case to case and changes over time, precluding cross-cutting or long-term solutions (Du Laney 2019; Fenlon et al. 2023; Eschenfelder et al. 2016; Drucker 2021). Community KIs often lack or reject committed support from mainstream cultural and academic institutions, but even those with institutional support face mounting sustainability concerns (Eschenfelder et al. 2016; Smithies et al. 2019; Tucker 2022).

While a growing body of research has advanced our understanding of sustainability in the contexts of community archives and digital humanities, there is a key, understudied factor: the roles of communities themselves. Across the community-institutional spectrum, communities are pivotal to ensuring the endurance and impact of KIs, but the nature and specific contributions of communities are not well understood. While the literature has focused more on organizational and technical factors in sustainability, community-centered approaches are less concerned with maintaining specific formulations of projects or technical artifacts than with the impacts on communities. From a community-centered perspective, a digital cultural KI remains sustainable by responsively supporting the needs and endurance of the communities it serves (Fenlon and Muñoz 2020; Fenlon et al. 2023).

To address this gap around community-centered sustainability, we conducted a comparative, multiple case study of how communities define sustainability for

their own KIs, how they perceive their roles in sustainability, and what it means to sustain community-based cultural initiatives in community-centered ways. In this paper, we present outcomes of case studies of four projects that represent the spectrum from digital community archives to academic digital humanities projects. This research focuses on projects based in the USA, though we include projects with international teams and communities. Our previous work demonstrates the sustainability of digital cultural KIs and their communities to be mutually beneficial—each serving the endurance of the other in context-specific ways (Fenlon et al. 2023, 2021). In this paper, we continue this line of inquiry to study how groups building and maintaining these projects understand community-centered sustainability—specifically, how they imagine and plan for the roles of their own stakeholder groups in sustaining their projects.

Following reviews of definitions, prior work, and our methods, we offer a conceptual framework—the Oyster Model—for understanding the range of communities that sustain digital cultural KIs, the roles of communities in sustainability, and reciprocal benefits of their involvement. By differentiating a variety of community roles, the model refines the common understanding that engaged communities are an important aspect of sustainability for KIs in many contexts. We establish a definition of *reciprocity* in the context of community-centered sustainability, and we characterize how reciprocal benefits that communities gain from KIs may support community sustainability in turn. Communities acting in different roles carry different implications for sustainability and reciprocity. While our case studies are mostly based in the USA, findings about the nature and roles of communities (including international communities in two case studies) may resonate across geopolitical divisions. Our findings are relevant to researchers in library and information sciences, infrastructure studies, archival studies, and digital humanities with an interest in sustainability, digital preservation, and community-building and -engagement in digital cultural heritage. The Oyster Model is also relevant to practitioners—both in institutional and community settings—seeking to sustain their own works and communities.

Definitions

Prior research on sustainability for digital cultural KIs stems from multiple domains including library and information sciences, archival studies, and digital humanities scholarship. In the first section of this review, we define *community-based knowledge infrastructures*, scope the concept of *community* in relation to KIs, and characterize prior work on communities in digital cultural heritage. In the second section, we characterize *sustainability* in the context of community-based KIs and review prior work on sustainability concerns and approaches for community archives and digital humanities. Finally, we review the growing discourse on community-centered approaches to sustainability.

Communities and knowledge infrastructures

This research considers a wide range of projects based in a wide range of communities, from community archives to academic digital humanities projects. We understand such projects to comprise a type of *knowledge infrastructure* by Edwards's (2010) definition: "robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds" (p 17). We focus on KIs that gather or create, maintain, and provide access to evidence and research focused on cultural, humanistic phenomena. Their forms are wide-ranging: from digital archives or data platforms supporting research and memory about specific groups or histories to databases of texts supporting collaboration on specific literatures or languages, and beyond. As digital infrastructures, some KIs develop as bespoke constructions, while others adapt existing systems of communication and content management, such as social media or blogs. Despite their differences, these forms function as infrastructure for cultural evidence and knowledge, including data and digital primary sources, interpretation, stories, and contextual information. The KI perspective extends a substantial body of prior work that generalizes across myriad, overlapping forms of digital humanities production such as digital archives (including digital community archives), digital editions, interactive and multimedia works, databases, standards and authorities (Price 2009; Thomas 2016). These forms all represent KIs to the extent that they meet Edwards's definition, drawing people, artifacts, and institutions into networks to of knowledge creation and maintenance. We narrow our view to KIs built and maintained by communities of different kinds (as opposed to academic and cultural institutions), whether source or originary communities (as in community archives), or research communities focused on specific topics, methodologies, or tools in digital humanities more broadly.

Communities are integral to the creation and maintenance of knowledge in Edwards's definition. The "networks of people" that help constitute KIs include "enduring communities with shared standards, norms, and values" (Edwards 2010, p 17). By this account, communities—along with institutions, physical facilities, theoretical frameworks, standards and conventions, and many other aspects—are essential to the maintenance of knowledge. This research takes a broad definition of the concept of *community* as a group of people organized around a common purpose, such as a shared interest, activity, or facet of identity, shared history, or memory. This definition encompasses several relevant, foundational concepts in the social sciences, including communities of practice (Wenger 1998), virtual communities and networks (Ellis et al. 2004), research communities (e.g., Jamali et al. 2014), and community-based research (e.g., Johnston and Marwood 2017). Communities exhibit varying degrees of social cohesion, continuity of membership, size, and modes of relating.

Considering KIs in cultural heritage requires expanding our sense of community to include not only research communities, which are central to Edwards's account of KIs, but also communities based on shared facets of identity, memory, faith, place, activism, etc. (Brilmyer et al. 2019; Caswell 2014; Caswell et al. 2017a, b; Cifor et al. 2018; Flinn et al. 2009; Welland and Cossham 2019). The boundaries

between community and institutional initiatives are often unclear as academic paradigms shift to value greater community engagement. Many academic projects grow from teams and communities that span both public and academic spheres; members represent both scholars and practitioners. Even predominantly academic projects are often maintained by trans-institutional communities existing along the same community-institutional continuum as community archives (Thomer and Rayburn 2024). Despite their commonalities, research on community archives has largely diverged from research on academic digital humanities projects.

Sustainability of community-based knowledge infrastructures

Across the rich bodies of research on sustainability in digital humanities and community archives, a shared definition of sustainability rarely emerges (Maron and Pickle 2014; Edmond and Morselli 2020; Eschenfelder et al. 2016). Sustainability is difficult to define in part because the term has been used in many different disciplines to mean many different things over the past several decades (Bell and Morse 2008; Purvis et al. 2019). The concept is essentially subjective and variously emphasizes environmental, financial, social, and other aspects of systems under study. Bell and Morse (2008) offer a general definition: a sustainable system is one in which the quality of the system stays constant or improves over time. In our work, *sustainability* refers to the capacity of a KI to remain viable, responsively supporting community needs in whatever forms are useful for as long as useful (Fenlon and Muñoz 2020; Fenlon et al. 2023).

Literature review

The pragmatic challenges of sustaining digital infrastructures are well documented (ACLS 2024; Drucker 2021; Edmond and Morselli 2020; Fenlon 2020; Fenlon et al. 2023; Holmes and Takeda 2023; Maron and Pickle 2014; Rayburn et al. 2024; Sheffield 2020; Smithies et al. 2019; Zavala et al. 2017). They include reliance on short-term funding and volunteerism (Caswell 2014; Lian and Oliver 2018; Otis 2023; Paschild 2012; Sheffield 2020), the fragility and rapid obsolescence of technical infrastructures (Baker and Collins 2017; Cummings 2023; Smithies et al. 2019), and tensions arising from collaboration, growth, change, or harmful systemic legacies (Rayburn et al. 2024).

There are important distinctions between community archives and other digital humanities projects in relation to sustainability. Digital humanities projects that involve scholars at academic institutions often carry some degree of institutional support—usually seed funding or services for initial project development rather than long-term maintenance. Though the labor of digital humanities scholarship sometimes goes unrecognized or inadequately rewarded in the academy (Burton et al. 2021; Graban et al. 2013; Klein 2020; Pilsch and Ross 2022; Risam and Edwards 2018), academics—more often than exclusively community-based endeavors—have varying access to compensation, technical expertise, and technical infrastructure to

increase the longevity of cultural KIs (Newman 2012; Froese-Stoddard 2014; Lian and Oliver 2018).

Prior research has illuminated financial, organizational, environmental, and technical aspects of sustainability across community archives and digital humanities. Many initiatives demonstrate resilience without long-term financing, relying on community members' dedication and volunteerism, mutual aid from peer projects and allies, and cycles of short-term funding (ACLS 2024; Sheffield 2020; Wagner and Bischoff 2017). For community archives, recommendations for financial viability including developing earned income strategies and finding ways to demonstrate impact and value (Jules 2019). In academic digital humanities, prior work offers insights on appropriate business models, management and governance structures, institutional partnerships, and remodeling systems of labor and credit (Zorich 2008; Maron et al. 2009; Stuermer and Abu-Tayeh 2016; Pratono et al. 2020; Almas 2017; Spiro et al. 2017). On technical sustainability, the literature (mainly stemming from digital humanities) has explored the application of digital preservation and curation concepts and practices (Goddard and Seeman 2019; Miller and Taylor-Poleskey 2020; Kilbride 2015; Poole 2015), the potentials of shared infrastructure (Blanke et al. 2017; Dombrowski 2014), and the roles of preservation institutions in supporting stewardship (Clement et al. 2013; Poole and Garwood 2020; Sweeney et al. 2017; Vandegrift and Varner 2013).

There is a widely acknowledged need for systemic change and increased support for community-based initiatives from funders and institutions, for capacity-building, capital investment, equitable and open partnerships, community compensation, and inclusive funding practices (Jules 2019; Lee et al. 2023; Stevens et al. 2010; Wagner and Bischoff 2017). In addition, a growing set of practical tools and guidance aim to help communities sustain their own digital projects (e.g., Langmead et al. 2018; Fenlon et al. 2024). Nevertheless, both community-based and academic projects are too often unsustainable, in part because—relative to financial, organizational, technical, and environmental aspects—the more human, relational, and community-focused aspects of sustainability are less well understood (Tucker 2022).

Community-centered sustainability approaches

Community archives sustain themselves by drawing more peripheral communities, users, and organizations into modes of closer participation, engagement, volunteering, and donation. The literature documents diverse forms of community outreach and engagement, including developing community participation events, internship programs, social gatherings, arts-based events, exhibits, political activism and advocacy initiatives, cultivating cultural consciousness, and more (Caswell 2014; Sheffield 2020; Lian and Oliver 2018; Wagner et al. 2024). Sheffield (2020) describes how community archives adopt political and organizational strategies—of neutrality, impartiality, and charitable organization status—in part to enable them to serve as “abeyance structures,” bridges between phases of activist movements over periods of latency or community shifts (p 151). In this way, community archives serve to transfer knowledge between evolving communities and movements, engage new

communities over time, and draw contributions from peripheral groups and organizations (Sheffield 2020). Lian and Oliver (2018) describe the importance of multifaceted communication with broader publics and developing relationships with government. Newman (2012) identifies a key factor in the sustainability of community archives to be *dynamism*: a community's capacity for continued growth, future planning, and committing to change over time (p 42).

Community and institutional archives both deploy participatory approaches to foster increased connection and contribution within relevant communities. Eveleigh (2014) describes how participatory initiatives sustain institutional archives “by widening the pool of advocates for the activities of archives” (p 221). Efforts to engage users and originary communities as participants in the co-construction of archives have a long history in archival practice (Eveleigh 2014; Gilliland and McKemmish 2014; Huvila 2008, 2015; Shilton and Srinivasan 2007; Zhao et al. 2024). However, the literature also acknowledges that community engagement and participation are highly resource-intensive and carry their own sustainability concerns (Benoit and Eveleigh 2019).

Communities are a ubiquitous consideration in the digital humanities literature, but their roles in sustainability are not always clearly defined (Arthur 2014; Clement et al. 2013; Robinson 2016; Smithies et al. 2019). Prior case studies have shown how digital humanities projects engage communities through accountability and reciprocity measures (Schlotterback et al. 2022; Mahony 2017), increasing social cohesion (Mahony 2017), and considering community members' career development (Ciula and Smithies 2023). Multiple authors argue the need for peer support networks and models of mutual aid—or reciprocal exchanges of in-kind contributions of support, resources, and expertise—among community organizations (Caswell et al. 2017a, b; Jules 2019; Nowviskie 2022; Pawlicka-Deger 2022; Spiro et al. 2017).

Despite all this progress we are missing a bridge between the work on community archives and the work on digital scholarship that transcends community-institutional boundaries. In addition, there is a dearth of empirical research on how communities of different kinds understand sustainability for KIs, and how community-based initiatives conceptualize the roles of communities in their own sustainability. These are the gaps this study aims to address.

Methods

We chose a multiple case study as our method to support analysis of expected contrasts (Yin 2018) in how different cases conceptualize sustainability and implement sustainability strategies. We base our study on theoretical propositions, which stem from our review of prior work: (1) Digital humanities projects, including but not limited to digital community archives, are often community-centered and grassroots initiatives, rooted in communities of different kinds, shapes, and sizes; (2) These communities play vital roles in sustaining digital humanities projects; and (3) Sustainability means and entails different things in different contexts.

Each case represents a digital KI in development by one or more communities. One of these projects, the Lakeland Digital Archive, is a community archive in the traditional sense, while the other three projects are based in academic research communities. They span multiple disciplines and institutions internationally, and they aim to engage with communities and organizations beyond the academy. All projects have been supported by grant funding to varying degrees, in some cases significant funding. While all four have partnerships and affiliations with academic or cultural institutions, none are driven by institutional remit or supported by long-term institutional commitments. All four depend heavily on dedication and often volunteerism among their core teams, often just a few individuals. They are actively involved in numerous, diverse partnerships with other groups, communities, and organizations and are concerned about the sustainability of their projects and their digital infrastructures over time. Cases were selected for their heterogeneity and the research team's prior relationships of trust with case study affiliates. Fenlon et al. (2022) offer full descriptions of each case and its funding history and context. Here, we focus on the teams and stakeholder groups associated with each project.

Enslaved: Peoples of the Historical Slave Trade (Enslaved.org, n.d.) is a source of discovery about the history of the transatlantic slave trade. Enslaved.org is built upon a large-scale aggregation of linked open data (more than 680,000 records of people; more than 5 million data points). These data come from a core group of founding partners—scholarly historians and their digital humanities projects—along with cultural institutions and members of the general public sharing relevant family history information. The project team is based at Michigan State University's Matrix Center for Digital Humanities and Social Sciences, with key team members at a few other institutions.

The Lakeland Digital Archive is developed by the Lakeland Community Heritage Project (LCHP, n.d.), which has worked for more than a decade to document and share the history of the Lakeland community, a 130-year-old African American community located in College Park, Maryland. Lakeland thrived for decades as a self-sufficient community and as a hub for neighboring African American communities during the era of segregation, until the process of urban renewal in the 1960s demolished much of the community's landscape, displacing two-thirds of residents from their homes. Through long-running, community-led collaborations with University of Maryland faculty, especially the Maryland Institute for Technology in the Humanities, and other community partners, LCHP is prototyping a new, digital community archive, which has become a hub for a larger restorative justice initiative.

The Music Encoding Initiative (MEI, n.d.) develops standards and guidelines for encoding musical documents into machine-readable structures, to support their representation and analysis. MEI is a long-running, international, community-driven initiative led by scholars and practitioners in the field of musical research, including librarians, historians, music theorists, and developers. The international community has a governing body, which includes an elected board and a technical team that oversees the maintenance and releases updates of MEI's code base (via the development platform *GitHub*). In addition to these two volunteer-run groups, several more interest groups organize volunteers focused on specific facets of MEI's development, including pedagogy, metadata, and musical notation. These interest groups drive the

activity and continuous development of the standard and include a shifting roster of dozens of members every year. Beyond its mainly volunteer core, MEI gathers and serves a broader community of users, conference attendees, and participants in online forums including an email listserv and in the team communication platform *Slack*.

The Open Islamicate Texts Initiative (OpenITI 2024) is developing a machine-actionable corpus of premodern Islamicate texts and tools for textual analysis for Arabic, New Persian, Ottoman Turkish, Urdu, and other Islamicate languages. OpenITI forms part of an international cluster of research projects with overlapping collaborators. Another project in this cluster—the Knowledge, Information Technology, & the Arabic Book (KITAB) project—provides scholars with new tools for textual analysis. These projects engage wider research communities, including scholars in history and other humanities disciplines and researchers and technical developers focused on natural language processing. While focused on academic research communities at this stage of development, members of the project acknowledge its potential to serve a wider population of users and contributors, including teachers and more general readers of Arabic and Persian texts.

Each case study included semi-structured interviews ($n=44$ across all cases), participant observation, and analysis of documentary evidence. We conducted data collection from fall 2019 through spring 2022. (We should note that project teams and organizations have since evolved.) As summarized in Table 1, we engaged with each case differently due to varying availability and proximity among partners as well as differences among project structures, team sizes, and preferred modes of collaboration. Variations within multiple case studies, while inevitable, limit replicability or direct cross-case comparison. For example, because the cases differ in terms of organization, governance, and modes of collaboration—and we therefore interacted differently with each group—we are not able to offer analytical generalization (Yin 2018, p 38) about how specific models of collaboration, governance, or organization comparatively impact community-centered sustainability. Nevertheless, the case studies have common dimensions, and we engaged each case deeply enough to see patterns and build theory about those dimensions across cases. Per Yin's guidance on case study validity (2018, p 41), we offset the limitation posed by variation among cases by (a) gathering multiple sources of evidence in parallel for each case, including interviews with a majority of core teams, to strengthen the validity of each case on its own, and (b) working with case study partners to refine our findings and resolve disparities in perspective across cases. Table 1 provides an overview of the sources of evidence used in each case.

We conducted qualitative content analysis (Zhang and Wildemuth 2017) of interview transcripts using Atlas.ti qualitative coding software to identify themes and supporting quotations, first across individual cases and then the whole. We developed our codebook inductively, but a starting set of codes stemmed from the questions we asked and the theoretical propositions motivating those questions. Two independent coders coded each interview transcript and then met to discuss their coding until they achieved consensus (Zhang and Wildemuth 2017). Case study partners reviewed our preliminary findings through a workshop held in 2021, and we refined our analysis based on their feedback. Case study partners also review all

Table 1 Data sources in each case study

Case	Data sources
Enslaved.org Project	• Interviews: 10 participants, representing the project team • Participant-observation: one extended site visit in 2019, plus ad hoc meetings to document project workflows, conference roundtable, observation of public events • Documentation: Grant proposal narratives, website, data hub and journal, project documentation
Lakeland Digital Archive	• Interviews: 12 participants, representing the project team and members of wider community • Participant-observation: regular project meetings (in-person and virtual), digitization events, conferences and public outreach events, class projects for 2+ years • Documentation: Team Slack channel, website, beta version of digital archive, Airtable base, documentary, publications, news articles, grant proposal narratives
Music Encoding Initiative	• Interviews: 16 participants, representing members of governing board, technical team, working groups, and wider community • Participant-observation: MEI conferences, working group meetings, virtual discussions • Documentation: MEI organization Slack space, website, community documentation, project descriptions and relevant publications
OpenITI project	• Interviews: 6 participants, representing core project team, overlapping with team members of closely related projects • Participant-observation: two-day workshop and team working meeting in 2020, conference roundtable, observation of conference talks • Documentation: Grant proposal narratives, website, GitHub space, public project documentation, relevant publications

publications associated with this work. In quotations provided in our findings, we use alphanumeric participant identifiers to distinguish quoted participants, wherein the first letter of the identifier refers to the relevant case study (EXX for Enslaved.org participants, LXX for Lakeland participants, MXX for MEI participants, and IXX for OpenITI participants).

The Oyster Model

Community archives, digital humanities projects, and other community-based cultural KIs serve multiple communities at once. The teams responsible for these efforts perceive these communities and their multiplicity as key to the sustainability of their projects. Even the core community of any given project—the group(s) of active participants or users that are most closely associated with the project's objectives—is not singular, homogeneous, or monolithic. In each case study, participants characterized a wide range of groups involved in project sustainability to varying degrees.

At the heart of each project in our study is one or more intersecting teams. Beyond these teams, all projects engaged or planned to engage other groups in support of project sustainability. These other groups ranged in terms of their size

and their nebulousness, from small teams to broader communities. Our participants also described groups in terms of their positioning and prior stakes in the project, evincing in each case an array of groups radiating outward in their relative proximity to, involvement in, and benefit from each project.

In this analysis, we distill from our findings a conceptual framework for understanding how projects engage a variety of communities as stakeholders to varying degrees (Fig. 1). This framework is vital to a community-centered approach to sustainability. The model characterizes how different modes of engagement help sustain KIs. We lightheartedly dub this model the “Oyster Model”, evoking the organic stratification of an oyster shell.

The groups depicted exist along a spectrum of involvement with the KI, from close partnership to anticipated (but not active) involvement. Figure 2 illustrates a generalized example of the communities that might be involved with sustaining a community-centered KI. This figure is generalized from the specific examples of groups developed for each case study. We elaborate these categories below, offering examples from each of our cases.

There are no firm boundaries between groups. Communities overlap, and people and groups move among the strata in shifting relationships to the core team or the KI itself. One MEI participant described an ebb and flow among users, contributors, and partners in the project, describing MEI as a passionate community whose members sometimes depart for periods of time but tend to return (M06). We saw the same dynamism among groups across all cases, especially among users and contributors.

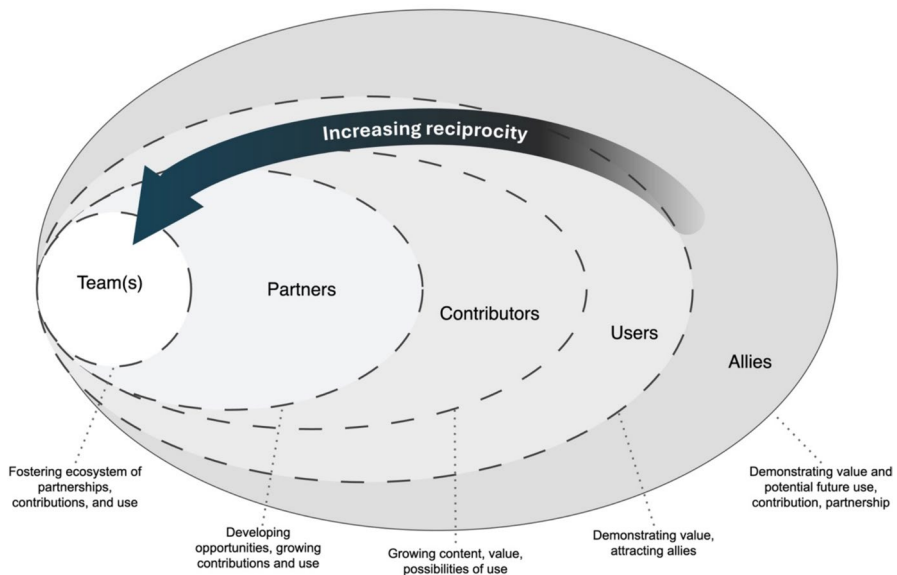


Fig. 1 Oyster Model of community engagement toward sustainability

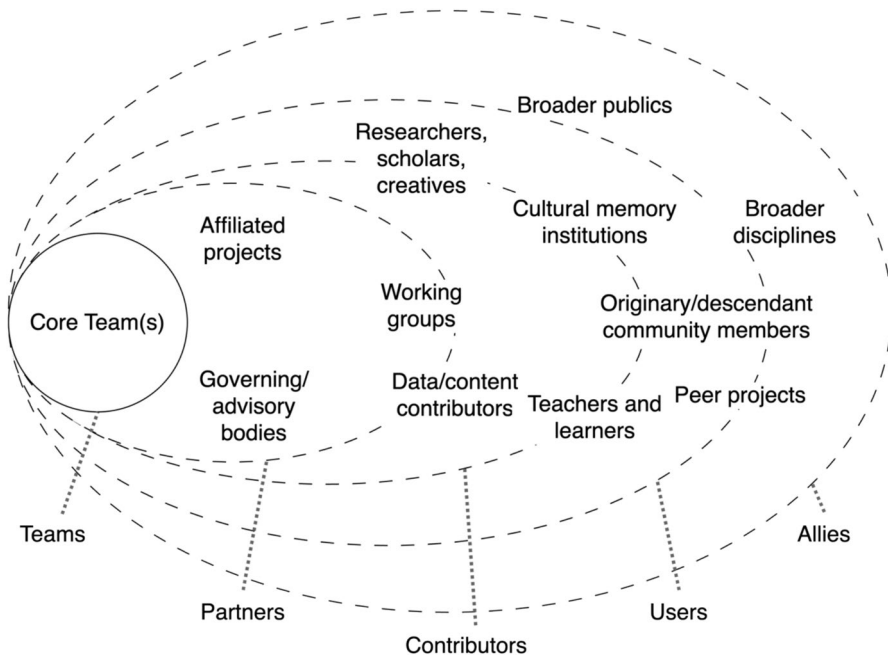


Fig. 2 Examples of abstract communities at different levels of engagement with KI

Teams, partners, contributors, users, allies

The Oyster Model offers five categories to distinguish stakeholder groups: *teams*, *partners*, *contributors*, *users*, and *allies*. Each group brings unique types of labor, expertise, or investment to sustain the KI over time. Understanding the differentiated roles of these stakeholder groups, as well as the relationships among them, is essential to understanding the dynamics that shape KI development and continuity. For each case study, we provide examples of relevant communities in Table 2 (Partners and Contributors) and Table 3 (Users and Allies).

Teams

Teams are the core group(s), usually small and tight-knit, involved closely in development and maintenance activities that sustain each project. They form the nucleus of development and sustainability activities, coordinating and facilitating all other community efforts. In turn, they benefit directly from the project in various ways, both material and immaterial, as individuals and as collectives.

Partners

Partners are groups and communities that contribute to development, maintenance, or supplemental activities supporting project sustainability. Examples of partners

Table 2 Examples of partners and contributors involved in each case

Case	Example partners	Example contributors
Enslaved.org	• Historians and digital history projects, founding partners, partnering both on data sharing and data model • Genealogy company partnering on data sharing, data model • Select cultural institutions partnering on data sharing, data model • Educational institutions partnering on fellowship programs • Community organizations with direct ties to descendant communities • Maryland Institute for Technology in the Humanities • Other scholars and students at University of Maryland, for archive development, teaching • City of College Park, for restorative justice initiative	• Historians with relevant data to add to the Enslaved.org data hub • Cultural institutions with relevant primary sources or data • Family historians with relevant sources or information • Individual members of descendant communities with relevant sources or information to add
Lakeland		• Members of Lakeland community and diaspora with materials or stories to share • Students participating in fellowships and class projects to improve the Archive
MEI	• MEI working groups, goal-directed teams developing aspects of MEI standard, training, etc • Conference organizing committees • Software development communities, which develop software leveraging MEI to benefit broader user communities	• City of College Park, providing historical sources • MEI contributors/editors, who offer occasional contributions to MEI standard or documentation • MEI conference presenters, who conduct research on or with MEI and related tools
OpenITI	• Advisory boards for specific research projects stemming from OpenITI, who give guidance and direction • Peer projects developing OCR and HTR tools • Peer projects involved in digital Islamicate Studies research • Open source software development communities leveraging or adding to OpenITI advancements	• Data contributors, including individual scholars with relevant primary sources and derived data • Cultural institutions with relevant primary sources and derived data

Table 3 Examples of users and potential allies in each case

	Example users	Example allies
Enslaved.org	• Historians • Family historians • Descendants of the enslaved • K-12 teachers and learners • Higher ed teachers and learners	• Broader publics with an interest in slavery and its continuing impacts • Communities involved in racial activism and advocacy work
Lakeland	• Wider College Park residents • Local government • University of Maryland faculty/students • Current Lakeland residents • Members of diaspora community and descendants	• Route One Corridor Communities • Peer community archives nationally involved in restorative justice efforts • Regional cultural institutions
MEI	• MEI conference attendees • Wider MEI user community, both research and preservation • Indirect users of MEI-based software systems • Higher ed teachers and students	• Scholars and students in wider musicological enterprise • Cultural heritage and AV preservation communities • Peer musicology infrastructure projects
OpenITI	• Researchers and scholars in a range of relevant disciplines relying on OpenITI data • Technologists involved in OCR and HTR development drawing on OpenITI advancements • Teachers and students in higher education relying on data/sources for teaching and learning	• Wider humanistic disciplines undertaking parallel methodological development, or seeking similar disciplinary cultural change to accommodate such development • Interested publics, including Arabic- and Persian-language readers of primary texts in the corpus

identified in each case are given in Table 2. Collaborating directly with core teams, partners contribute to process as much as product, helping determine new directions for project development. Our cases demonstrated a diverse, evolving array of partnerships geared toward different goals. Partner groups may be small and tight-knit (as in the case of external partner projects) or looser-knit and distributed (as in the case of advisory boards). They help sustain projects by contributing to their growth or vitality, by multiplying project objectives and opportunities. Partners collaborate to attract new resources, such as content or grant funding. As one Enslaved.org participant described:

...part of the sustainability of this project is our partners—be they professional historians, archivists, or librarians, or folks who specialize in museums or historical site preservation—are participating in writing grants with us, and then creating datasets... -E08

Partners create new opportunities for the development or impact of KIs, including spinoff research or teaching and learning programs. They bring their own communities and expand outreach to new ones, fostering growth among potential contributors, users, and allied communities, which feeds back into sustainability. In turn, partners often derive immediate benefits from collaboration, in the form of material or career benefits or advancement of their own, related projects or objectives. One OpenITI participant, for example, described how the project discovered a mutually beneficial partnership:

...we'll be contributing something to what they're doing and it'll also actually be making our job easier. And in the process, hopefully it's bringing us together and so we'll be thinking in the future about what other grand ways that we can push the broader project forward together -I02

Contributors

Contributors are groups external to the project that contribute to project development, maintenance, or supplemental activities through structures or mechanisms put in place by the core team. Their contributions support the project in prescribed ways. Often by donating materials, resources, or labor to increase or enhance the contents of a KI, these groups tend to contribute more in the way of content than process. By improving the KI and its contents—for example, toward gathering a critical mass of materials or improving description of those materials—contributors help grow active and potential user communities. Like users, contributors demonstrate significant engagement and interest to decision-makers, including funders, administrators, and potentially other users.

Often loose-knit, abstract, or virtual assemblies rather than tight-knit communities, contributors have a voice in project development only insofar as the project seeks and implements their feedback. Sometimes contributor feedback speaks for broader communities of use, even serving as gateways for garnering contributions from a broader set of users. In the MEI project, for example, one participant described how contributors highlight opportunities for revision or correction in the

MEI standards or documentation, the artifacts at the heart of this KI. The democratic process of change draws users into contributor roles: "...the community approach, it's very healthy. It makes things lengthy to get into the schema...you are developing these things for actual people that are going to use it...So it's really important to have the feedback from the community" (M08). These groups derive benefits from contribution to the project and its sustainability that are most often immaterial, such as advancing personal or research goals of individual contributors.

Users

Users constitute the primary rationale for a project and its sustainment. Because these projects often grow as grassroots initiatives from the needs and interests of communities or teams, the core team members, partners, and contributors are often users at the same time. Consideration of user needs and interests, and engagement with user groups, tend to be at the forefront of sustainability priorities. Users' activities and feedback are often inspiration for project directions and development. Users also sustain community-based infrastructures in part through their individual transactions with the system, which accumulate into signals of value through user analytics or feedback mechanisms.

Users do not usually constitute *communities* in the true sense. As a collective, users are more often an abstraction, a diverse and dynamic set of individuals, perceived as an aggregate from a project perspective and loosely defined around their main occupation, identity, or need in relation to a project: historians, primary and secondary school teachers (designated in the USA by shorthand "K-12," for Kindergarten through 12th grade), originary community members and descendants (such as members of Lakeland and their descendants), etc. Users often have loose or no cohesion as a group. They engage with a project to serve their own particular needs, whether in relation to research, teaching, learning, memory, connection, activism, arts, etc. They come and go as they need. For some members, the KI may be essential to their objectives; for others, the benefits are fleeting.

Allies

Allies (Table 3) encompass at least three distinct groups, described and exemplified in detail below:

Advocates: Those that advocate or act on behalf of a KI in some way, without actively partnering with, contributing to, or using it;

Potential allies: Groups with a perceived interest in or relation to the project, who are anticipated to become users, contributors, or partners over time;

Represented communities: Groups that are implicated in the project because they or their knowledge are somehow represented within the KI, including originary and descendant communities, members of identity groups represented in the KI, etc.

Allies encompass potential future users, contributors, and partners. They are often part of the larger cultural or academic ecosystem in which a KI is situated. They may be aware of and experience effects of the work of the KI. For some participants, serving future, unknown needs of potential allies demanded a flexible and responsive approach to project development. At the same time, the KI's use may generate ripples of impact that affect a field more broadly, impacting trends in the application of specific methodologies or the prevalence of certain types of evidence. One OpenITI participant, for example, described how:

the project was engineered to be as flexible as possible, so that you could actually use the corpus for whatever research questions you may have in mind. ...what I hope is that OpenITI will be used by most people in the field: all people in the field who work with texts, contributing new texts to it, using the texts that are available, using the results of different kinds of analysis ... this is a catalyst for moving the field into the digital age -I04

Represented communities, as a distinctive subgroup of allies, have a special relationship to project sustainability, not only because they are central to the project's rationale (like users), but because participants perceive ethical obligations to these groups. They drive the shape of a project and its sustainability even in cases where they are not or cannot be directly involved in partnership or contribution. Taking this obligation seriously, including by drawing potential allies from originary communities into roles of direct, equitable partnership and contribution, was a core value for two cases. The Lakeland community operationalizes this value in a highly intentional approach to community-university partnership (Gross and Corbin Sies 2023). Multiple Enslaved.org participants described the centrality of their project's Statement of Ethics (Enslaved.org, n.d.) and its development process to their vision for the project's future: "the ethics statement looks to make visible our commitment to the enslaved people, our commitment to the project, our next steps, and our hope to get involved with [descendant] communities" (E07). Acknowledging the legacies of the harm of slavery, another participant described how consideration of descendant communities drives the project in many ways:

...one thing we're interested in when we think about sustainability is descendant communities. And we think about that when we're accepting and peer-reviewing datasets ... What's the thinking behind this dataset? Have descendant communities been involved? Have they voiced an opinion? What language do we use in describing the people in data sets? -E08

The reciprocal benefits for allied groups are not usually immediate or obvious, but core teams factor those benefits into their sustainability planning nonetheless as they consider how to draw allies closer to their projects. For example, multiple Lakeland participants expressed hope that they could engage other historically African American communities in various models of partnership. One participant, referring to other neighborhoods and municipalities along US Route One that are engaged in archiving and local history efforts, described a hope that

they would eventually partner with Lakeland to share experiences and practices: “these other communities are trying to preserve their history and make it available to future generations. That says to me that there should be greater cooperation” (L08).

Reciprocity toward community-centered sustainability

KIs rely on collaboration, participation, and shared purpose, drawing strength from their social foundations as much as their technical ones. This section explores the reciprocal relationships that emerge between KIs and their communities of engagement, foregrounding the ways in which different stakeholder groups—partners, contributors, users, and allies—support sustainability through their varied forms of labor, advocacy, and interaction. Drawing on the typology of stakeholder roles, we demonstrate that sustainability is not a unidirectional process of resource input, but rather a dynamic ecology of exchange in which benefits and responsibilities circulate.

Table 4 offers examples of the roles that communities in different categories play in the sustainability community-centered KIs. In addition, Table 4 describes benefits that potentially or ideally accrue to those communities in turn, by virtue of their engagement with the KI. For all communities, participation does not only carry potential benefits; it also brings along risks, as described below.

Reciprocity was seen to increase with closer proximity to the core teams, so that partners gain more benefits and simultaneously contribute more to the sustainability of projects than users or allies. While users gain benefits from KIs as individuals, sustaining a KI does not necessarily correlate to sustaining its communities of users because, as we describe above, user “communities” are often abstractions. The benefits are therefore *mutual* but not *reciprocal*. The distinction is this: the relationship of benefits between the project and users is not *correlative* in the same way as it is for partners and contributors. In other words, there is not necessarily a correlation between sustaining a project and sustaining a community of users. Sometimes users do form true communities, as in the case of projects with user bases that comprise small, niche, and pre-existing communities (such as the Lakeland community in the case of the Lakeland Digital Archive). Some projects also include social facilities that foster connections among users—ranging from comment functions to discussion forums or even sometimes organized gatherings.

Many participants understood the sustainability of their efforts to be contingent upon drawing people and groups toward the core of the project. For many participants, sustainability planning included diversifying groups and people involved and drawing them inward. One Lakeland participant articulated a vision shared by several others: “strategically a part of my vision for the next phase would be efforts to cooperate up and down [the Route One] corridor, and getting other communities, other stakeholders, involved or increasing the involvement of existing and current stakeholders” (L08). Another confirmed this view, albeit thinking of communities in a different radius, and highlighting their anticipated diversity:

Table 4 Community roles in sustainability and reciprocal benefits

	Roles in infrastructure sustainability	Reciprocal benefits
Partners	• Collaborating with core team to develop or maintain project • Creating opportunities for growth in content, objectives, and, resourcing • Drawing in new contributor, user, and allied communities	• Material benefit (funding, etc.) and career advancement for individual members • Growing communities for respective partners as collectives • Advancing dovetailing objectives or research interests for collective
Contributors	• Providing labor and content to enhance the value of the project • Advocating for project or demonstrating engagement, interest, and value to decision-makers • Adding content and value helps grow user communities	• Fulfilling individual objectives, e.g., intrinsic motivations, personal interest, social connection • Participating in or giving to research generally or cultural efforts of visibility, significance, impact (e.g., finding a long-term home for one's collected stories, data, heritage) • Fulfilling diverse individual or group needs/goals for use, related to research, memory, social connection, teaching, learning, creative endeavors, etc
Users	• Advocating for project or demonstrating engagement, interest, and value to decision-makers and potential allies • Providing feedback or indicators of use that inform development • Active use helps attract allied groups	
Allies	• Active advocacy for or passive representation of potential value of KI • Potential to become users, contributors, partners in future	• Increasing representation and public awareness of communities and their histories, in some cases bolstering reparative or restorative justice efforts

it will change uses in that I see it...as incoming [University of Maryland] students of color seeing the archive and saying, ‘Okay, let me try to get off campus housing in this community so I can work closely with them over four years.’ A single parent or ... family comes into the community just wanting to get involved in the place where their children are soon to be growing up for the next 18 years. So it’s going to have different uses and different reasons...All good things, just different -L06

The strategies that participants had planned reflected the diversity of the groups they hoped to attract. Across all projects outreach strategies included workshops and training to spread awareness of the KI, ancillary social events, educational programs at K-12 and higher education levels, internships and community fellowships, exhibits, involving creative performances and the arts to bring the KI into view for wider audiences, creating more interactive or broadly accessible interfaces or modes of interaction, community digitization days, etc. Their planning extended to the projects’ structures of governance and cultures, toward creating accessible pathways for people into use and thereafter into contribution and potentially partnership. One MEI participant, for example, identified sustainability as part of their community-driven culture, wherein the “overall structure of the community is very flat” meaning that even “board members see themselves as members of the community.” (M15).

A key benefit of the Oyster Model is that partners, contributors, and users all help draw in groups and people that are further afield, so that sustainability is not only incumbent on the core team. One OpenITI participant, for instance, imagined sustaining one of the project’s technical platforms: “Its best chance of survival is creating an active community ... using this tool set in the classroom and workshops and things like that. And if that becomes a practice, and is then emulated by other teachers and researchers, then there’s a chance” (I01). Other participants hoped to foster cultures of reflexivity among their users, drawing them into contributor roles: “this reflex of them giving back, it’s not necessarily there yet. I hope that it could come at some point. I think that would greatly help us being more sustainable” (I06).

Discussion

Our goal has been to refine the common understanding that engaging communities is an important aspect of sustaining KIs of all stripes. We have developed the concept of *community-centered sustainability* and identified one set of factors that characterize it—specifically, different modes of community engagement relying on reciprocal sustainability benefits between communities and KIs. Our study also aims to expand how we understand communities in community-driven KIs, by connecting work on community archives to predominantly academic but still community-engaged cultural projects in the digital humanities.

By contributing to a cultural KI, communities gain benefits that serve their wellbeing and, in some cases, their sustainability as a collective. In other words, community efforts to sustain the KI help sustain communities in turn. For this reason, we find *reciprocity*, in the context of community-centered sustainability,

to entail not only *mutuality* but also *correlation*. The sustainability of communities and their KIs are correlated, particularly for groups closer to the core teams. We have discussed in previous work how this is true for core teams of projects (Fenlon et al. 2023), but this analysis shows the pattern extending to groups more distant from the center.

Our findings build upon a broad base of prior work in community and participatory archives, digital humanities, and other relevant areas. We see confirmation of many sustainability factors—both pros and cons—in prior work on community archives. Our contribution is to confirm their applicability to a broader range of community-based KIs, including not only community archives but also more diverse digital humanities initiatives. These factors include how community-based initiatives seek to draw contributors and allies inward, and how initiatives leverage cultural resources to promote community activism and wellbeing (Caswell 2014; Sheffield 2020; Lian and Oliver 2018; Wagner et al. 2024). In addition, we recognize dynamism (Newman 2012, p 42) as an outstanding quality among our cases, highlighting their respective commitments to growth, change, future planning—not only in how they envision their stakeholders but how they hope to engage and serve them.

As with all conceptual frameworks, the Oyster Model is necessarily reductive. Complex social realities defy categorization: groups themselves are dynamic; many groups may be understood to span or blur the boundaries; and groups move between categories over time. While acknowledging this dynamism, the Oyster Model aims to bring into sharp relief the roles of communities acting in different capacities. While prior research established the importance of communities in general, the differentiation in the Oyster distinguishes between fundamental contributions, modes of engagement, and reciprocal benefits among a broader range of communities than is often imagined to be implicated in sustainability.

The five-part division is less interesting for its classificatory merit than for its functional characterization of roles. When a given community is acting in the role of a partner, that partnership carries different benefits to sustainability than when the same group is acting in the role of contributor or user or allied group. In addition, the model highlights differences that have implications for building relationships in practice. Groups functioning in each role or category are dissimilar in terms of how they are best understood and engaged, especially in terms of the reciprocal benefits they gain from engaging in community KIs. These differences are essential to sustainability planning. Through analytic generalization (Flick et al. 2014), we suggest that the framework is generally relevant to community-based cultural KIs as a key aspect of KI sustainability, even as specific constellations of community support will vary case by case.

Our findings around the distinction between contributorship and partnership resonate with Eveleigh's (2014) framework of participatory archiving initiatives, in which types of initiatives are distinguished in part by how they structure or organize contributions—whether organically, or via more closed-ended mechanisms. In Eveleigh's model, projects that deploy open-ended models of organization and closely engage community collaborators exemplify a “remodeling of archival practice...to break down, or at least redraw, the boundaries between archivists and participants” (p 221). In these terms, contributors move closer to

how we define “partners” in the Oyster Model as they go beyond contributing content via prescribed mechanisms and “are invited to input into the *processes* of participation” (Eveleigh 2014, p 222).

How our participants understand the potential benefits to their communities echoes an extensive body of prior work on motives for participation in crowd-sourcing initiatives (Hedges and Dunn 2018; Bible and Reza 2023; Daugavietis 2021). In crowd science and open-source development efforts, motives for participation include (but are not limited to) intrinsic interest, subject matter interest, social benefits, contributing to science, speeding up research progress on matters of personal interest, etc. (Franzoni and Sauermann 2014, pp 12–13), advancing personal skills, altruism, a sense of obligation, reputation-building, and enhancing job prospects (Oreg and Nov 2008). Our findings suggest that participant motivations in community cultural initiatives may encompass a still broader spectrum of reciprocal benefits, including motivations specific to cultural work, and not only individual but collective motivations (e.g., among partnering teams). Work on sustainable development, resilience, and cultural heritage across disciplines offers leads for future research on this broader range of benefits and motives. For example, in the domains of rural sociology and human geography, Beel et al. (2017) have studied how community-led cultural activities reinforce community resilience.

Our work builds on concepts of reciprocity and mutual benefit for communities and institutions as a principle of archival practice (Brilmyer et al. 2019; Punzalan and Marsh 2022) and academic research (Caswell et al. 2021; Rhodes and Carlsen 2018). Community needs can and often do misalign with institutionalized notions of sustainability or sustained access to digital heritage (Wagner et al. 2024). For our partner communities, the end goal was less to sustain cultural artifacts in themselves, and more to use existing community resources toward advancing domain knowledge and empowering communities in different ways. The Oyster Model’s perspective on reciprocity is not transactional, but instead reflects a network of collaboration, resonating with prior work on epistemic possibilities of treating research as a generous exchange (Rhodes and Carlsen 2018). In the exchanges, connections, and collaborations modeled in the Oyster Model, digital manifestations of community heritage are just one possible outcome.

Our study also aims to add nuance to how we understand communities that transcend the community-institutional divide, and the relationships of reciprocity that exist between them, their own KIs, and other communities. Indeed, our study sheds light on how the community-institutional dichotomy, while relevant and important, often belies a deeper relationality in community-driven initiatives that cross institutional boundaries (Lee et al. 2023). In addition, our study suggests that communities are actively forming supportive peer networks, in line with tenets of community-centered sustainability articulated in previous work (Caswell et al. 2017a, b; Jules 2019; Nowviskie 2022). However, they could use more support for this. Our study of allies as a category of stakeholder is a ripe space for exploration of how communities identify and extend their peer networks, and draw allies into partnerships, to promote various facets of KI sustainability.

Conclusion

We offer the Oyster Model as a conceptual framework for understanding community engagement as a sustainability factor in community-based KIs. Our model shows how sustainable initiatives think well beyond users to a broader base of stakeholders, imagining and investing in partners, contributors, users, and allies, understanding their distinct roles, and—critically—committing to dynamism, or change and growth, among these groups. By differentiating categories of community roles, the framework identifies the nuance and diversity associated with community-centered sustainability and reciprocity in practice. The model aims to support digital humanities projects and community archives, helping them inventory community support and engage a greater variety of current and future stakeholders in more strategic ways, particularly in planning reciprocal benefits to communities.

Our model characterizes reciprocity as a spectrum of mutual benefits among these groups and the KIs that they surround and support. Ranging from relationships of basic, mutual benefit to those which are also correlative—in which the sustainability of communities and of the KI bolster one another—we aim to expand understanding of reciprocity in relation to sustainability. And yet we acknowledge the pervasive challenges and unsustainable aspects of this work. Outreach efforts are resource-intensive, and not often adequately accounted for in the scope of limited project funding. Projects remain highly dependent on key personalities, including creators and subsequent champions who are adept at community-building (Baker and Collins 2017; Sheffield 2020). And engagement with community-based KIs carries some risks along with benefits for many communities (Fenlon et al. 2021).

We have identified areas ripe for future investigation, both for ongoing analysis of our case studies and through our planned next phases, which include a study of community-institutional partnerships. There are several other dimensions of community-centered sustainability identified in our previous work (Fenlon et al. 2022), which we plan to develop further, including how communities define “completeness” for their projects and how they manifest resilience to disruption and change. We aim to understand more about emerging and alternative roles for libraries, archives, museums, and academic institutions in supporting community-centered approaches to cultural sustainability. In future work, we hope to connect our findings to cross-disciplinary theoretical developments on sustainable development, community partnerships, and community resilience.

We chose the oyster as a metaphor for superficial reasons at first—just noting the stratification in our initial conceptual diagrams. In retrospect, however, comparison to the oyster was apt. The distinctive bands of an oyster shell are formed by the oyster’s stages of growth, during which it draws calcium from the water around it and in turn secretes calcium carbonate to grow its shell, all while providing significant benefits to the surrounding marine ecosystem. This is a compelling metaphor for reciprocity, for how the core teams sustaining KIs strengthen them by disseminating the benefits from the inside outward, anticipating and

designing not only to benefit users, but also partners, contributors, and allies. As they become more sustainable, community-based cultural KIs will become more prominent features within a diversified ecosystem of cultural stewardship. And as those projects build connections to one another and to mainstream cultural institutions to form networks of support, they bolster their own sustainability. If it is not too much of a stretch, we liken this vision for the more sustainable future of the digital cultural record to an oyster reef, a healthy ecosystem of interrelated structures, formed and sustained by a diversity of active communities, and sustaining those communities in turn.

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Declarations

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