1-1-2023

The digital environmental humanities (DEH) in the anthropocene: Challenges and opportunities in an era of ecological precarity

John Ryan

Lydia Hearn
Edith Cowan University

Paul Arthur
Edith Cowan University

Ryan, J., Hearn, L., & Arthur, P. (2023). The digital environmental humanities (DEH) in the anthropocene: Challenges and opportunities in an era of ecological precarity. Digital Humanities Quarterly, 17(3).
http://www.digitalhumanities.org/dhq/vol/17/3/000714/000714.html

DHQ: Digital Humanities Quarterly
Preview
2023
Volume 17 Number 3

The Digital Environmental Humanities (DEH) in the Anthropocene: Challenges and Opportunities in an Era of Ecological Precarity

John Ryan <john_dot_c_dot_ryan_at_scu_dot_edu_dot_au>, Southern Cross University https://orcid.org/0000-0001-5102-4561
Lydia Hearn <l_dot_hearn_at_ecu_dot_edu_dot_au>, Edith Cowan University https://orcid.org/0000-0003-2554-156X
Paul Arthur <paul_dot_arthur_at_ecu_dot_edu_dot_au>, Edith Cowan University https://orcid.org/0000-0002-1494-0533

Abstract

Researchers in the complementary fields of the digital humanities and the environmental humanities have begun to collaborate under the auspices of the *digital environmental humanities* (DEH). The overarching aim of this emerging field is to leverage digital technologies in understanding and addressing the urgencies of the Anthropocene. Emphasizing DEH's focus on natural and cultural vitality, this article begins with a historical overview of the field. Crafting an account of the field's emergence, we argue that the present momentum toward DEH exhibits four broad thematic strains including perennial eco-archiving; Anthropocene narratives of loss; citizen ecohumanities; and human-plant-environment relations. Within each of the four areas, the article identifies how DEH ideas have been implemented in significant projects that engage with, envision, re-imagine, and devise communities for environmental action and transformation. We conclude with suggestions for further bolstering DEH by democratizing environmental knowledge through open, community-engaged methods.

Introduction

A hand-colored lithograph from the mid-nineteenth century features the common brushtail possum (*Trichosurus vulpecula*), an Australian marsupial illustrated by artists H. C. Richter and Elizabeth Gould (see Figure 1). Naturalist John Gould included this illustration in his monumental three-volume compilation *The Mammals of Australia* (1863), the first major survey of Australian mammals, some of which have declined dramatically in number or become extinct since its publication. In also depicting what appears to be a small banksia, a kind of wildflower common throughout Australia, the image suggests the ecological interactions between the native marsupial and the endemic plant. An engrossing visual record of environmental history and interspecies relations, the illustration and many others are freely available through the Biodiversity Heritage Library [BHL 2021]. By "collaboratively making biodiversity literature openly available to the world as part of a global biodiversity community" [BHL 2021, ¶1], this open-access platform exemplifies the digital environmental humanities put into practice for engendering communities of action — in this instance, oriented toward biodiversity awareness and protection in Australia. While revealing early Anglo-European modes of visually representing Australian fauna, lithographs such as these today have the potential to catalyze ecological awareness and change, promote an appreciation of the country's exceptional biodiversity, and serve as educational launching points for exploring the entangled histories of animals, plants, people, landscapes, ecologies, and technologies in Australia and elsewhere.

Figure 1. Hand-colored lithograph of the common brushtail possum (*Trichosurus vulpecula*, formerly *Phalangista rulpina*) from *The Mammals of Australia* (1863) by John Gould (author) and H. C. Richter (artist). Image credit: Creative Commons Public Domain via Biodiversity Heritage Library and Wikimedia Commons.

This article provides a broad, comprehensive overview of current developments and prospective paths in the *digital environmental humanities* (abbreviated as DEH throughout). It begins by calling attention to DEH's focus on natural and cultural vitality — or what theorists of heritage term "biocultural diversity" [Bridgewater and Rotherham 2019] — in an era of pervasive environmental decline. We turn retrospectively to a synopsis of the growth of DEH over the last decade as an integrative area of scholarship synthesizing the companionable aims of the digital and environmental humanities. Key theoretical and methodological elaborations of DEH — as well as recent developments in the field — will be delineated. Assembling a narrative of the field's emergence, we argue that the current acceleration of DEH in response to the Anthropocene context reveals the following four broad thematic focal areas: 2

1. Perennial eco-archiving (through the work of the Long Now Foundation)
2. Anthropocene narratives of loss (*What is Missing?*)
3. Citizen ecohumanities (*Atlas of Living Australia*)
4. Human-plant-environment relations (*Native American Ethnobotany Archive*)

Within each area, we identify the ways in which DEH ideas and practices have been implemented in these especially illustrative projects that engage with, envision, re-imagine, and devise communities for environmental action and transformation. We conclude with recommendations for supporting and strengthening work in DEH by further democratizing biocultural knowledge via open, community-engaged, participatory approaches. Throughout the article, we view DEH as conceptualized within university contexts but extending beyond the academy to encompass the work of community organizations and concerned individuals. Furthermore, in selecting the four case studies above, we necessarily exclude related projects of relevance to DEH such as Anna L. Tsing and colleagues' *Feral Atlas: A More-Than-Human Anthropocene* (2021), an archive of field reports from artists, humanists, and scientists on feral ecologies that continue to resist human control and have spread widely. 3

DEH in the Anthropocene

DEH encompasses diverse histories, theories, debates, practices, techniques, and projects internationally [Chang 2021] [Cohen and LeMenager 2016] [Jørgensen 2014] [Posthumus, Sinclair, and Poplawski 2018]. As a case in point, Figure 4

2 represents central Perth, Western Australia, illustrating how the area might have appeared in circa 1829, a year of intensive colonial activity during which James Stirling explored the Swan River and Charles Fremantle seized the area for the British Crown. In 2014, an interdisciplinary research team based at Edith Cowan University in Perth produced the visualization using GIS (Geographic Information System) and three-dimensional modelling techniques incorporating an array of source materials including Noongar (Aboriginal Australian) narratives, nineteenth-century Swan River Colony maps, aerial photography, European settlers' accounts, artists' impressions, literary representations, and geological and vegetation charts [Ryan, Brady, and Kueh 2019]. Given its inclusion in a public exhibition on wetlands at Perth Town Hall in 2014, followed by a permanent digital presence on the state museum website [Western Australian Museum 2021], this reconstructed perspective of central Perth offers a graphic means to consider the city's historical development and envisage opportunities to prevent the further loss of Perth's extant wetlands. The "Re-imagining Perth's Wetlands" project is an example of the multifaceted, multidisciplinary, community-focused, and often-participatory orientation of DEH through initiatives aiming to broaden public awareness of the interlinked cultural and ecological urgencies of the present. Work in DEH has the potential to energize political, social, and community transformations including, as this case demonstrates, the conservation of rapidly disappearing urban wetland environments. In contrast to landscape visualizations such as this, other initiatives use different methods including the archival conservation of biocultural heritage through open-access, participatory digital platforms (see, for instance, GeoHumanities 2018 and Herbaria 3.0).

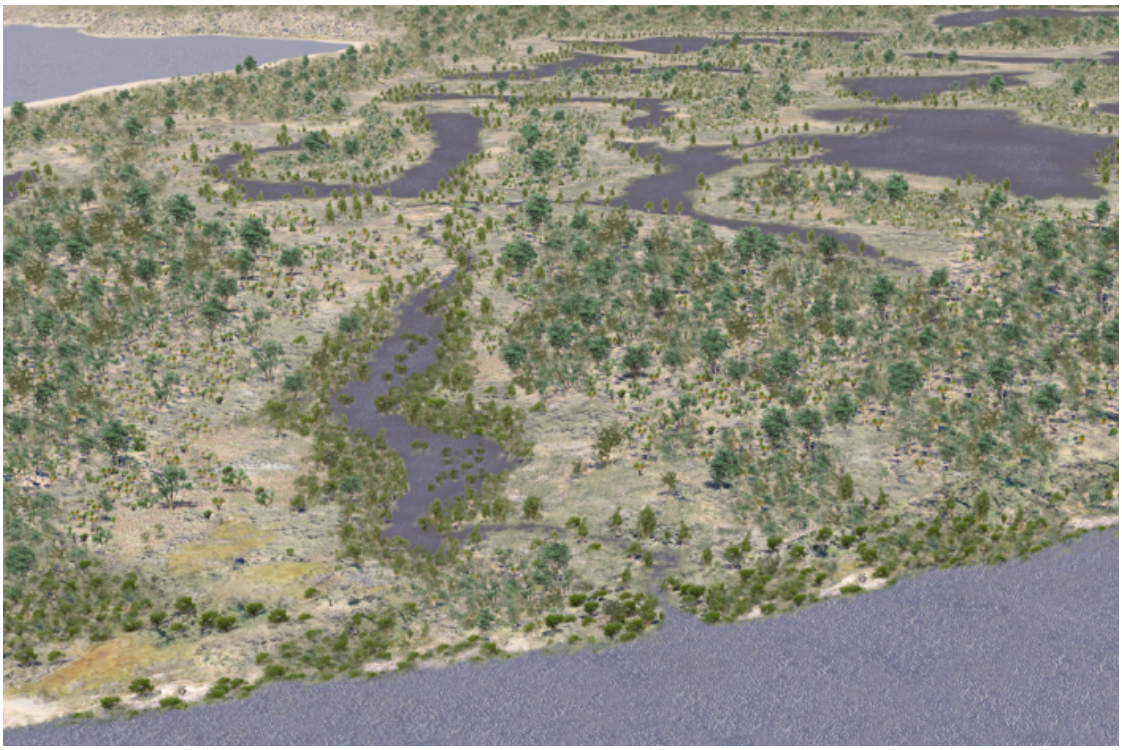

Figure 2. Reconstructed view of Perth circa 1829 looking west from the Claise Brook entry to the Swan River across the lakes of central Perth. Image credit: Edith Cowan University (2014).

DEH responds to the exigencies of the Anthropocene. As a provisional unit of the *Geological Time Scale* — a system of chronological dating based on changes in geological strata over vast periods of time — the Anthropocene "reflects profound and ongoing Earth System change" [Zalasiewicz et al 2019, p. 331]. Mounting geophysical data differentiates the Anthropocene from its precursor, the Holocene, beginning roughly 11,650 years ago. Geochronologists locate the historical boundary between epochs in the Great Acceleration — the rapid upsurge in human population — and the first nuclear bomb detonations, both in the mid-twentieth century [Zalasiewicz 2015]. The Anthropocene "represents a major change in trajectory of the Earth system from the more or less stable conditions that have seen human civilization develop and expand over the past few thousand years" [Zalasiewicz 2019, p. 500]. Nevertheless, the increasing circulation of the Anthropocene neologism has provoked proposals for alternative designations — from Capitalocene,

Chthulucene, Homogenocene, and Myxocene to Plantationocene, Planthroposcene, Symbiocene, Thanatocene, and, even, Bandwaggonocene. Environmental historian Jason W. Moore (2017), for instance, advocates the term *Capitalocene* to acknowledge the vast networks of human and nonhuman labor exploited under global capitalism while Science and Technology Studies scholar Donna Haraway (2016) employs *Chthulucene* to foreground the "ongoing multispecies stories and practices of becoming-with in times that remain at stake" [Harway 2016, ¶24]. What's more, anthropologist Natasha Myers (2017) has proposed *Planthroposcene* as "an aspirational episteme and way of doing life in which people come to recognize their profound interimplication with plants […] The Planthroposcene is a call to change the terms of encounter, to make allies with these green beings" (pp. 299–300). As these lexical confutations suggest, a pressing task of the environmental humanities has been the formulation of novel vocabularies sufficient to articulate the formidable effects of rapid ecological change on shared natural-cultural thriving.

Key Developments in the Digital Environmental Humanities: 2011–2016

6 In the Anthropocene context, DEH confronts global precarities of climate disruption, biodiversity loss, environmental injustice, Indigenous peoples' diminished land rights, and the weakening of biocultural knowledge networks in the wake of ecological degradation. With its approximately ten-year history, DEH remains an emergent — and, even, contingent — area of scholarship and activism that brings the technological and digital expertise of the digital humanities (DH) into dialogue with the ecological and biospheric concerns of the environmental humanities (EH). During the five-year period between 2011 and 2016, DEH made considerable progress toward integrating the digital and environmental spheres of interest represented by its constituent fields. In 2011, members of the Munich-based Rachel Carson Center began the *Ant Spider Bee* blog "to engage academics and practitioners in exploration, discussion, and reflection about digital practices, methodologies, and applications in environmental humanities work" [Rachel Carson Center 2011, ¶1]. The blog's third section "Bee", for example, features short articles reflecting on current advances and outlining notable projects in the field. As astrophysicist Chris Lintott (2015) explains in his contribution to "Bee", digital tools such as Zooniverse, "the world's largest and most popular platform for people-powered research" [Zooniverse 2021, ¶1], harness the considerable potential of citizen research across disciplines — from identifying endangered animals recorded in camera trap images to analyzing nineteenth-century mariners' weather logs in order to comprehend climate change implications in the present.

7 Alongside the *Ant Spider Bee* forum, one of the field's earliest initiatives was the Digital Environmental Humanities Network, or DEHN. With funding from Canada's Social Sciences and Humanities Research Council, the DEHN convened a pivotal workshop in September 2013 at McGill University "to bring digital and the environmental humanities scholars together to showcase work that had already been done at the intersection of these two fields and to concretize the possible emergence of a new field" [Posthumus, Sinclair, and Poplawski 2018, p. 159]. Consolidating interest in the DEH nexus, the workshop included digital humanists as well as scholars specializing in particular areas of the environmental humanities, namely, ecocriticism and environmental history. At the time of writing, although listed as a research cluster on the McGill University website, the network appears largely inactive, illustrating the broader challenges of sustaining DEH initiatives over time in the light of research funding contingencies and ongoing institutional privileging of disciplinary specialization [Environment and Society Portal 2021] [Jørgensen 2014, p. 106].

8 Also in 2013, the editors of *Environmental Humanities* — the field's premier journal published since 2012 in an open-access format — in partnership with the Environmental and Society Portal at the Rachel Carson Center, issued a call for papers for a special issue "The Digital / Environmental Humanities Nexus: Challenges and Opportunities" [Rachel Carson Center 2013]. Although it appears to have never eventuated — or could have been diverted into other publications, projects, or forums — the issue promised "to reflect on intersections between digital and environmental humanities from a variety of perspectives [as well as to] enrich understandings of the extent to which digital technologies and resources are informing current environmental humanities scholarship" [Rachel Carson Center 2013, ¶3]. In one of the first DEH-related articles published in *Environmental Humanities*, entitled "The Armchair Traveler's Guide to Digital Environmental Humanities" (2014), environmental historian Finn Arne Jørgensen develops a persuasive argument for ongoing collaborative efforts between the history of technology, the environmental humanities, and the digital humanities.

Between 2014 and 2016, DEH gained further standing as a focus of digital humanities conference presentations and special issues of academic journals. At the 2014 Digital Humanities Australasia (DHA) conference, for instance, environmental humanist (and an author of the current article) John C. Ryan presented “FloraCultures: The Nature of a Biodiversity Archive for Plant-Based Cultural Heritage”, characterizing the “eco-digital humanities” as a “possibility” [Ryan 2014(a)]. The presentation considered the use of digital archival technologies for the conservation of botanical — or plant-based — cultural heritage in Perth, Western Australia. A city of remarkable floristic diversity, Perth also faces formidable conservation challenges, including urban and suburban development in addition to the spread of native plant pathogens, exacerbated by climate precarities [Ryan 2014(b)]. As plants vanish, so do the irreplaceable heritage values associated with them. In advocating DEH as a response to botanical diversity loss, the presentation theorized *environmental poiesis* as the making of digital artifacts informed by ideas of environmental ethics, ecological justice, ecofeminism, sustainability, bioregionalism, biodiversity conservation, and multispecies thinking. 9

Special issues on DEH in the literary criticism journals *Green Letters* [Dobrin 2014] and *PMLA* [Cohen and LeMenager 2016] brought much-needed critical attention to the potential for dialogue between the digital and environmental humanities. Contributors to the *PMLA* issue addressed concepts from language ecology to digital affect in addition to projects from the *Icelandic Saga Map* to the online journal of Indigenous writing, *Dawnland Voices 2.0*. During this period, as well, key conceptual analyses, notably Bethany Nowviskie’s “Digital Humanities in the Anthropocene” (2015), broadened the theoretical scope of the DEH debate. Nowviskie (2015) suggests that DEH orient toward the environmental and human implications of digital research — from the socio-political influence of device manufacturers to the carbon footprints of ostensibly low-impact digital projects. For Nowviskie and others, DEH entails addressing head-on the omnipresent urgencies of the Anthropocene, not the least of which is the widespread loss of nonhuman beings, species, and biodiverse ecosystems. 10

Theoretical and Methodological Tenets: Technology, Story, Ecology, Temporality

As a whole, the major theoretical and methodological elaborations of DEH attempt to synthesize the strengths — while redressing limitations — of the digital and environmental humanities as discrete fields [Chang 2021] [Cohen and LeMenager 2016] [Cummings, Roh, and Callaway 2020] [GeoHumanities 2018] [Jørgensen 2014] [Ladino 2018] [Linley 2016] [Nowviskie 2015] [Posthumus and Sinclair 2014] [Posthumus, Sinclair, and Poplawski 2018] [Sinclair annd Posthumus 2017] [Travis and Holm 2016]. This section briefly addresses four areas of focus within current conceptualizations of DEH as an emergent, integrative, and transdisciplinary field of research and practice: technology, story, ecology, and temporality. The capacity of DEH to address these four deeply entangled areas — often simultaneously — demonstrates its potential in the present epoch. 11

In an early elaboration of the field, Stephanie Posthumus and Stéfan Sinclair (2014) characterize DEH as “a new and burgeoning area that still remains largely undefined, but that asserts the importance of the humanities in responding to the ecological crisis while leveraging new tools and technologies” (p. 254). From their perspective, DEH brings the tools and methods of DH to bear on concerns within EH; conversely, EH’s planetary and political focus helps to elucidate aspects of digital tool-making and critique central to DH. For Posthumus and Sinclair (2014), EH promotes sustainable societal interactions with the natural world whereas DH has remained less critical of techno-scientific practices that carry the potential for ecological harm. In turn, DH problematizes what Posthumus and Sinclair identify as EH’s inherent bias against technocentric — and, even, technocratic — salves to social, cultural, linguistic, and environmental challenges. Moreover, DH’s long historical outlook on the emergence of technologies introduces critical considerations — “the possibility of new interactions, new collaborations” [Posthumus and Sinclair 2014, p. 260] — to the environmental humanities whereas, complementarily, EH’s emphasis on telling the stories of the natural world can transform the making of “digital archives, electronic editions and data visualisations” (p. 269). Posthumus and Sinclair propose *digital ecology* as a concept that, by reconciling the entrenched binaries of hardware/software, computer/user, and real/virtual, discloses how digital environments facilitate novel interpretations of material environments, and vice versa. 12

Posthumus and Sinclair’s privileging of stories and storytelling aligns with Jørgensen’s (2014) assertion that DEH centers on “new forms of storytelling and presentation” (p. 110). Indeed, innovations in new media technologies facilitate 13

the emergence of multi-dimensional stories about the relations between people, nonhumans, landscapes, and technologies. In his analysis of the Norwegian Broadcasting Corporation's "slow travel" series of digitally-enhanced television programs, Jørgensen (2014) argues that "distant natures, those that are not experienced through the body but distributed through data and media, need different modes of analysis and storytelling" (p. 109). At the same time, environmental humanists assert that biocultural values take shape through the stories individuals and communities tell about nature as well as the stories that nature tells about itself [Griffiths 2007]. As environmental historian Tom Griffiths (2007) explains in a seminal overview of the environmental humanities, "The stories we live by determine the future. So, in harnessing the power of narrative, in listening to, rediscovering and generating true stories, we change the world" [Griffiths 2007, ¶2]. In similar terms, ecomusicologist Kate Galloway (2017) emphasizes the narrative possibilities of DEH for embracing the integral role of technology in comprehending and communicating ecological issues. Methods of aural-digital storytelling — audio-recorded soundwalks, multi-modal sound maps, and crowdsourcing techniques — expand audiences to comprise academics as well as community members grappling with the direct impacts of climate change, ecosystem degradation, and related urgencies. In particular, storytelling modes that incorporate the body and the multiple senses can engage the public more compellingly in environmental debates. For Galloway (2017), the creation of digital-narrative objects that "circulate in an open-access format and often contain research materials contributed by a research collective" constitutes an embodied, participatory process of social knowledge formation (p. 52).

14

DEH introduces ecological concerns to DH and, reciprocally, digital concerns to EH through the analysis of human-technological impacts on the biosphere. Margaret Linley (2016) characterizes this recalibration as "the ecological turn in the digital humanities" (p. 411). Having an environmental orientation that centralizes nature-culture-technology intersections, DEH encourages "advocacy, engagement, action, and participation as well as an ethics of responsibility, sustainability, and conservation" [Linley 2016, p. 427]. Most crucially, DEH approaches ecology not as a metaphor, figuration, or abstraction but as a material certainty that shapes the lived experiences of humans and others. Echoing Posthumus and Sinclair's elaboration of *digital ecology*, other scholars have proposed the term *digital Anthropocene* to signify the conjunction of the digital revolution, climate catastrophe, and social, political, and economic precarities [Travis and Holm 2016]. While developing digital and environmental competencies, DEH facilitates generative exchanges across the arts, humanities, social sciences, and sciences [Travis and Holm 2016, p. 203].

15

Correspondingly, Sidney Dobrin's (2014) theorization of *digital environments* calls into question the assumption that environmental crisis originates in technology and, more specifically, technological excess or technology-gone-astray. For Dobrin (2014), digital environments are "themselves natures and environments in and with which humans and non-humans forge relationships" (p. 205). As such, DEH presents a framework "emphasising the role of the humanities in responding to ecological crisis while also embracing new technologies and tools" [Dobrin 2014, p. 206]. To be sure, recent theory and practice in DEH has grown along the three axes of technology, story, and ecology, particularly in relation to the growing urgency of climate disaster and ecosystem collapse. Open-access resources such as NASA's Global Climate Change portal offer downloadable time-lapse visualizations, for instance, of ice mass loss in Greenland between 2002 and 2020 (see Figure 3). Similarly, the Smithsonian Institution National Museum of Natural History's "Eruptions, Earthquakes, and Emissions" (E3) application presents a time-lapse visualization of 250,000 volcanic eruptions and earthquakes since 1960 [Smithsonian Institution 2013]. Originating in the sciences, these and other digital environments — to invoke Dobrin's term — constitute invaluable storytelling platforms for EH-related research, pedagogy, and outreach in response to the Anthropocene.

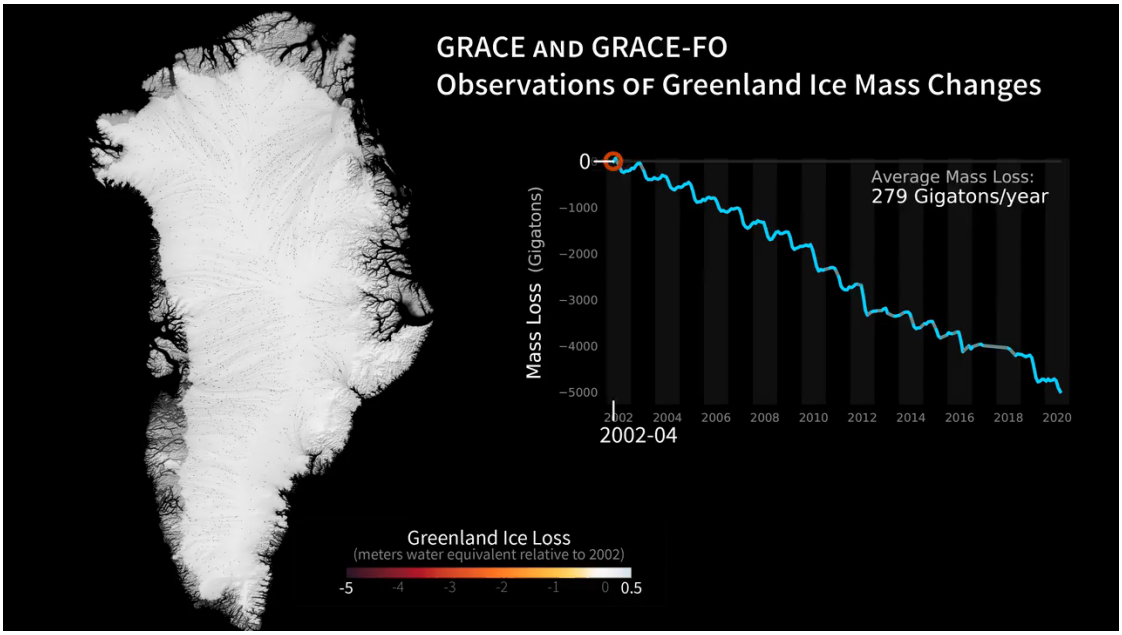

Figure 3. Visualization of Greenland ice mass loss 2002–2020. Image credit: Global Climate Change (NASA).

16

In many ways, the ten-year evolution of the landmark collection *Ant Spider Bee: Chronicling Digital Transformations in Environmental Humanities* [Coulter, Hardenberg, and Jørgensen 2021(a)] parallels the development of DEH. The open-access book is the outcome of the eponymous blog begun in 2011 "to collect and reflect on ways technology was transforming the epistemologies, methods, and dissemination of environmental humanities research" [Coulter, Hardenberg, and Jørgensen 2021(c), p. 10]. Both the book and the blog demonstrate the ongoing interweaving of EH and DH theories and methods within the DEH nexus. Published by the Rachel Carson Center for Environment and Society — as noted, a leader in DEH globally — the collection comprises forty-two short, reflective chapters arranged in five sections:

1. Evolution
2. Engagement: New Voices
3. Mediations: New Forms
4. Metamorphoses: New Natures
5. An Experiment in Collecting and Curating

The editors characterize the *Ant Spider Bee* initiative — from its origins as a blog to its present dissemination as a book — as an experiment in long-term collecting and curating. Cognizance of the longue durée and, by extension, deep temporality, underlies the project's ethos of curation: "As the use of digital technologies to gather and process knowledge becomes increasingly natural, we hope that *this digital time capsule* will offer insights about the past, for the future" [Coulter, Hardenberg, and Jørgensen 2021(b), p. 229] (emphasis added). As suggested in the following discussion of perennial eco-archiving and, specifically, the work of The Long Now Foundation, a deep temporal outlook is integral to the digital environmental humanities.

Perennial Eco-Archiving: Deep Time Awareness and the Longue Durée of DEH

17

Environmental humanists stress that understanding the implications of the Anthropocene for the future of life on Earth necessitates grappling with deep time as both a bewildering abstraction and an embodied immediacy [Ginn et al 2018]. Representing Earth or geological history, deep time is a sense of time that registers in *millionennia* — millions of years — instead of millennia. In the Anthropocene context, paleobiologist Jan Zalasiewicz (2017) calls attention to "a peculiarity of geological time, which is that, at heart, it is simply time — albeit *in very large amounts*" (p. 124) (emphasis

added). As a recent specialization within the environmental humanities, the paleoenvironmental humanities (or PEH) emphasizes the value of deep time narratives, ranging from hopeful stories of human-non-human resilience to tragic accounts of biocultural collapse. PEH responds to the urgency of engendering deep time awareness in the environmental humanities through empirical investigation of archaeological materials. The aim is "to reframe the wider discourse on climate change in terms of our quickly expanding deep-time knowledge and to demonstrate that humans can neither be characterized as beings fundamentally divorced from nature" [Hussain and Riede 2020, p. 7]. Considering the challenge of comprehending deep, geological time, the objectives of PEH are estimable. In *Timefulness* (2018), for example, geologist Marcia Bjornerud proposes the term *chronophobia* to signify the innate human aversion to deep time. For Bjornerud (2018), the perils of "temporal illiteracy" (p. 7) are formidable. As an antidote to chronophobia, *timefulness* situates human culture in Earth history, promoting deep time consciousness.

18 Developed with respect to deep time, the idea of *perennial eco-archiving* refers to temporally-expansive, *timeful* archival work that preserves knowledge of language, society, and environment. Perennial archiving involves high-resolution data, archiving servers, and other long-term conservation techniques and technologies [Andro 2018, p. 122]. Perennial eco-archiving, then, applies comparable digital strategies to curate, conserve, and disseminate nature-culture interconnections, especially as related to theories and practices of sustainability. As a case in point, the Digital Matters Lab at the University of Utah adopted a four-year focus on sustainability in order to contribute to current debates within the digital humanities while addressing ecological challenges particular to Utah including long-term drought, water rights, air quality, and access to public lands [Cummings, Roh, and Callaway 2020]. The sustainability emphasis galvanized attention to issues of durability, temporality, and scale: "Sustainability not only prompts us to think of the durability of digital projects, but also asks us *to think differently about the timescales on which we usually consider technology*; instead of thinking in processing times and milliseconds, sustainability might prompt us *to consider the millennia that our e-waste takes to degrade*" [Cummings, Roh, and Callaway 2020, ¶22] (emphasis added). The theme invited researchers to interrogate ecological issues — that is, to think in terms of environmental sustainability — while also critically considering the longevity of digital-activist projects. As an example of DEH research concerned with the longue durée, the Digital Matters Lab project highlights the integrated digital-environmental inflections of the term *conservation* — that, rather than oppositional, digital and environmental conservation can go hand-in-hand. The *digital environments* resulting from DEH collaborations help to dismantle the longstanding division between the digital (disembodied, technological, abstract) and the ecological (corporeal, material, relational).

19 The *timeful* work of The Long Now Foundation concretizes the notion of perennial eco-archiving while highlighting some challenges surrounding the idea. The Foundation is a nonprofit dedicated to advancing long-term thinking at the scale of 10,000 years [The Long Now Foundation 2021(a)]. The organization's temporally-ambitious work includes "The Clock of the Long Now", "a 10,000 year monument to long-term thinking," and "The Rosetta Project", "a living archive of 1,500 human languages" [The Long Now Foundation 2021(b)]. The latter is "a global collaboration of language specialists and native speakers working to build a publicly accessible digital [and post-digital] library of human languages" [The Long Now Foundation 2021(b)]. "The Rosetta Project" responds to the looming problem of digital obsolescence and the pressing need to devise new archival techniques with long purviews. Techno-linguistic innovations such as the Rosetta Disk address the likelihood that global language loss will triple within forty years, marked by the extinction of one language on average per month [Bromham et al 2021]. To avert the catastrophic disappearance of nearly 1,500 languages by the century's end, language documentation, multilingual education programs, and other community-based initiatives are required urgently [Bromham et al 2021]. Toward this aim, the Rosetta Disk offers a post-digital solution. The three-inch diameter nickel disk encodes 14,000 pages of linguistic information microscopically on its surface. Rather than a digital encryption, however, each page constitutes an image, allowing the information to be retrieved through optical magnification. What's more, the Rosetta Wearable Disk is a miniaturized version of the language archive, measuring merely two centimeters in diameter and designed to be worn comfortably on the human body — as an embodied, mobile repository of language, culture, and environment.

20 "The Rosetta Project" illuminates the overlays between linguistic, cultural, and biological diversity. As global biological diversity decreases, linguistic and cultural diversity decline in response. This co-occurrence of linguistic and biological diversity underscores the importance of integrated, multidisciplinary strategies for conserving species, habitats, and

languages concurrently [Gorenflo et al 2012]. Understood in this context, environmental relations inhere within the project's emphasis on "traditional culture," "cultural diversity," and "cultural and linguistic diversity" [The Long Now Foundation 2021(a), ¶9]. Simply put, the project reminds us that culture and nature are intrinsically related rather than diametrically opposed. Another perennial eco-archiving initiative of The Long Now Foundation — one with a deep-time, post-digital orientation comparable to "The Rosetta Project" — is the Clock of the Long Now. Under construction inside a mountain in western Texas, the clock will keep time for the longue durée of the Anthropocene. With more than 3.5 million possible sonic combinations, the device will yield a unique chime each day for ten thousand years. Incorporating principles of longevity, maintainability, transparency, evolvability, and scalability, the clock problematizes the short-term thinking underlying the global environmental crisis [The Clock of the Long Now 2021]. While foregrounding deep-time consciousness, the Clock of the Long Now — sequestered in the mountain area it has transformed materially through its construction — remains remote, inaccessible, and haunted by its own monumentalism. Although ambitious, the project appears to lack the participatory, community-minded focus that we see as essential to the digital — and, for that matter, post-digital — environmental humanities.

21 Recognizing the geophysical implications of decisions, actions, and behaviors, the Anthropocene underscores the material-digital imbrications between human bodies, technological transformations, and ecological systems. Through its fostering of time-consciousness and temporal literacy, DEH imparts immediacy to the "human/digital/planetary interface" [Dawson 2021, p. 311]. Illustrated by the work of The Long Now Foundation, perennial eco-archiving, in particular, raises the crucial question, "How does understanding the digital [and post-digital] contribution to environmental crisis relate to digitally [and post-digitally] understanding environmental crisis?" [Dawson 2021, p. 311]. As eco-archives with very long temporal purviews, "The Clock of the Long Now" and "The Rosetta Project" draw attention to post/digital materialities. In other words, developed in digital environments, both projects anticipate post-digital urgencies of linguistic, cultural, and ecological loss. Weaving between the environmental and digital, these and other deep-time-oriented DEH platforms have the potential to "inspire more sustainable behaviors" [Gould 2016, p. 3]. It is within this context that DEH also provides a vibrant basis for communicating Anthropocene narratives of loss, recovery, and hope especially through the engendering of affect.

Anthropocene Narratives of Loss, Recovery, and Hope: Engendering Affect

22 Affect is a potent confluence of feelings, senses, and memories with the capacity to energize the Anthropocene narratives of DEH. Arguing for the significance of affect in the digital environmental humanities, ecohumanists such as Jennifer Ladino focus on the ways in which digital environments facilitate affective responses to biocultural loss. From Ladino's (2018) standpoint, DEH enables us to reimagine "how to represent, cope with, and deploy loss in the service of a more just present and perhaps even a livable future" (p. 189). Employing multimodal and multisensory strategies to communicate Anthropocene precarities, DEH embraces the transformative potential of affect, understood as "the powerful, visceral, pre- or even non-cognitive feelings that arise and are transmitted in both virtual and actual environments" [Ladino 2018, p. 189]. Consider, for instance, the affective work of the Climate Stories Project (2023), an online platform for sharing firsthand accounts of climate change through oral histories. In contrast to this project's predominant focus on human experience, one of the aims of DEH is to understand how digital objects and environments narrate *other beings' lives* and, in doing so, nurture cross-species empathy [Ladino 2018, p. 199].

23 To be certain, Ladino's ideas reflect the impact of the *affective turn* on the environmental humanities and cognate fields. Conceptualizations of affect in human geography, literary studies, social psychology, and other scholarly areas highlight the intercorporeal phenomenon of bodies being affected by — and reciprocally affecting — other bodies within ecological systems. Over the last twenty years, the field of critical affect studies has taken shape through the writings of Adam Frank, Brian Massumi, Eve Sedgwick, and other scholars. Interchangeable neither with emotion nor embodiment — but instead marked by the concurrence of both across time and space — affect has been described as "modulated intensities" [Ahern 2019, p. 1] and "embodied capacities — phenomena that arise and circulate as intensities among assemblages" [Bladow and Ladino 2018, p. 6]. Informed by affect theory, critical environmental approaches to cultural texts, digital objects, and social formations come to address what Karen Barad (2007) terms *intra-action* or "*the mutual*

constitution of entangled agencies" (p. 33) (italics original). For, as Bladow and Ladino (2018) further contend, "bodies, human and nonhuman, are perhaps the most salient sites at which affect and ecocriticism come together" (p. 3). The preceding theoretical points imply that affective digital environments similarly offer "salient sites" — narrative nexuses — to which human and nonhuman agents contribute "*entangled agencies*".

24 As Ladino (2018) observes, an affective framework is vital to understanding the *What Is Missing?* memorial as representative of DEH work that confronts biocultural loss while attending to the potential for ecological recovery and community hope. Envisioned by American landscape architect and sculptor Maya Lin — who in 1981 also designed the Vietnam Veterans Memorial in Washington D.C. — the project is "a global memorial to the planet" dedicated, in particular, to species affected by the sixth mass extinction in global geological history [What Is Missing? 2021]. Also known as the Holocene or Anthropocene extinction, the sixth mass extinction is marked by more frequent incidences of biological extermination within the context of rapid ecological loss accelerating since the nineteenth century. As a result of human activities, species extinction rates are much faster now in comparison to the "normal" background rates of the last ten million years with, for example, an estimated four-hundred vertebrate species becoming extinct over the last century [Ceballos, Ehrlich, and Raven 2020]. Understood as a digital platform for telling stories of extinction and recuperation, *What Is Missing?* is a nexus of objects (artworks, images, audio recordings, maps, cultural histories, and first-hand accounts) concerning animals, plants, birds, reptiles, and amphibians with imperiled futures. Users navigate the memorial according to the categories "species," "habitat," and "anthro," where the latter facilitates exploration of the ecological successes and failures associated with particular cultures, regions, and places.

25 As a case in point, *What Is Missing?* features a short narrative of Wood's cycad (*Encephalartos woodii*), a plant species endemic to South Africa but which is presently extinct in the wild. Considered among the rarest plants in the world, the cycad exists ex situ in the form of clones of a male specimen collected from the wild in the early twentieth century. The memorial includes this intriguing biocultural history as a launching point for further delving into the cycad's story:

> In 1895, a single clump of this cycad was discovered by John Medley Wood on the edge of a forest in South Africa. In 1903, Wood sent his deputy, James Wylie, to collect some of the smaller offsets for cultivation in the Durban Botanic Garden, where they survive to this day…It is not known what drove Wood's cycad to extinction in the wild, or indeed if it ever was abundant. [What Is Missing? 2021]

Accompanied by an image of the species from Royal Botanic Gardens, Kew, the narrative of Wood's cycad implicates colonialism in botanical extinctions globally [Schiebinger 2007]. There is also the account of the Franklin tree (*Franklinia alatamaha*), native to the state of Georgia in the U.S. Although extinct since the early-nineteenth century, the tree is now cultivated ornamentally. An illustration from the late-eighteenth century by naturalist William Bartram visually links the decline of the Franklin tree, in part, to widespread colonial prospecting of plant species.

26 Lin's digital memorial entreats users to "learn about what is being lost, what is being done to help, and what each one of us can do" [What Is Missing? 2021]. Encouraging users to contribute personal memories of species, habitats, and places, the project exemplifies — at least in its ethos and design — a participatory digital environmental humanities. The Map of Memory, in particular, solicits contributions of individual stories, accounts, and anecdotes toward the ideal of assembling "a collective memory of the planet" [What Is Missing? 2021]. With an austere black-and-white design suggestive of mourning, grief, and other Anthropocene affects, Lin's digital memorial elegizes the loss of more-than-human life while invigorating optimism for rescuing species on the brink of extinction. The project's reach, nevertheless, remains limited by technical impediments, notably the beta version of the portal (at time of writing) with broken links and navigational glitches that impede narrative flow and disrupt users' engagement with the material. What's more, much of the content originates in other open-access platforms, namely Wikimedia Commons, raising concerns about the memorial's long-term viability within the larger digital ecosystem. As evident in other DEH initiatives (for instance, Herbaria 3.0), the project's aim is impressive but ultimately shrouded by questions of durability, continuity, and usability. For the memorial to grow organically in response to the ongoing extinction crisis — in other words, to become a viable and enduring platform — *What Is Missing?* might aim to become part of a wider online-offline community concerned with extinction and devoted to environmental justice. Engaging the public as participants in — and contributors to — the

digital environmental humanities is critical work, as seen in relation to citizen ecohumanism and the example of the *Atlas of Living Australia*.

Citizen Ecohumanities: Crowdsourcing, Community Co-Production, and DEH

27 According to a set of principles developed by the European Citizen Science Association in partnership with other international organizations, citizen science engages "citizens in scientific endeavor that generates new knowledge or understanding" and results in "a genuine science outcome" [Robinson et al 2018, p. 29]. Usually associated with astronomy, biology, ecology, public health, and allied fields, citizen science addresses immediate issues while facilitating public participation in research and policymaking [Hecker et al 2018, p. 2]. Interacting with communities as participants in research, citizen scientists often become emissaries of their fields, translating technical findings into public discourse and advocating for science's transformative role in society. As a result, citizen science has become integral to open scholarship as a framework for disseminating research outcomes with minimal barriers to access and for engaging the public in scientific practices [Hecker et al 2018, p. 8]. In this regard, Muki Haklay (2018) distinguishes between micro-engagement and deep engagement, arguing that public participation should be recognized at multiple levels — from the occasional assistance of untrained volunteers to substantial, ongoing contributions by citizens with established expertise in the field (p. 61).

28 In response to the steady growth of theory and practice in citizen science, the concept of *citizen humanities* has developed in recent years [Adamson 2017] [Adamson, LeMenager, and Sandilands 2018] [Hedges and Dunn 2017] [Heinisch et al 2021]. Citizen humanities entails citizen-inspired and citizen-engaged research in the humanities, particularly archaeology, history, and linguistics as well as interdisciplinary work that crosses between the arts, humanities, social sciences, and natural sciences [Heinisch et al 2021]. On-site and in digital environments, citizen humanists apply humanities methods including collecting, curating, interviewing, transcribing, and annotating [Heinisch et al 2021, pp. 99] [Heinisch et al 2021, p. 114]. Expanding research capacity through a community orientation, citizen humanists play "a crucial role in preserving and enriching cultural heritage" [Heinisch et al 2021, p. 115]. Mark Hedges and Stuart Dunn (2017) emphasize community co-production in the citizen humanities while, for Joni Adamson (2017), citizen-engaged projects "complement what we mean by citizen science and contribute to the most important conversations about how to respond to global and local environmental change" (p. 117). Integrating research and activism through crowd-sourcing and narrative techniques, DEH offers a timely framework for conducting citizen humanities "by staging different kinds of stories, oscillating between scales, and involving diverse participants in unfolding and recording nonhuman phenomena" [Cohen and LeMenager 2016, p. 341].

29 Building on principles of citizen science and citizen humanities, *citizen ecohumanities* denotes the engagement of the public — broadly, inclusively, and ecocentrically defined — in work that attempts to understand, document, and disseminate place-based knowledge of human-nature relations. Extending Barad's (2007) idea of *intra-action*, we further conceptualize *the public* to include multispecies communities of human and other-than-human members contributing knowledge, expertise, and skills toward a specific research outcome. Community-engaged work in the citizen ecohumanities moves beyond a singular focus on building ecological awareness mentioned, for example, earlier in this article in reference to the Biodiversity Heritage Library. In *Climate Change as Class War*, as a case in point, Matthew T. Huber (2019) observes that the sustainability movement tends to elevate the value of public awareness in climate mitigation. In contrast to the dominant approach, Huber maintains that environmentalist discourse needs to foreground the material advantages of climate mitigation efforts. While DEH certainly engenders biocultural awareness, there also exist manifold opportunities to develop projects in the citizen ecohumanities with more immediate and tangible impacts on communities.

30 An example of the citizen ecohumanities with a significant and ongoing crowdsourcing element is the *Atlas of Living Australia*, or ALA, hosted by the Commonwealth Scientific and Industrial Research Organization (CSIRO) as "a collaborative, digital, open infrastructure that pulls together Australian biodiversity data from multiple sources, making it accessible and reusable" [Atlas of Living Australia 2021(b), ¶1]. Regarded as Australia's most comprehensive biodiversity database — and one of the world's premier biodiversity data platforms — the ALA provides conservation

information to federal, non-government, educational, and community organizations. Established in 2010 by the Australian Government's National Collaborative Infrastructure Strategy, the ALA is an aggregated, open, Creative Commons-based infrastructure supplying data to over 80,000 researchers annually [Belbin et al 2021, p. 2]. In December 2021, the ALA held approximately 102 million records and 10,000 datasets on 111,000 species. Data includes taxonomic classification, geographical distribution, and conservation status as well as photographs, background information on natural history collections, traditional Aboriginal Australian ecological knowledge, and other diverse data categories [Belbin et al 2021, p. 2]. Broad in historical scope, the earliest data comes from the late 1600s while thousands of species distribution, or occurrence, records are contributed each day.

31 According to the UN Biodiversity Convention, Australia is a megadiverse country with unusually high levels of species endemism resulting from millions of years of biogeographical isolation. With the majority of species endemic to the continent, native plants represent a significant portion of Australia's megadiversity. The country's outstanding biodiversity, however, remains increasingly vulnerable to climate variability, habitat degradation, invasive species, coastal pollution, population growth, and other factors [Convention on Biological Diversity 2021]. As biodiversity declines, its cultural, social, and community values also become endangered. Accordingly, environmental humanists for instance, [Ryan 2014(b)] argue that biodiversity data also encodes humanistic data about species, such as *Nuytsia floribunda*, the Western Australia Christmas tree, a plant only found in the south-west corner of the state [Atlas of Living Australia 2021(a)]. As a case in point, vernacular plant names disclose botanical histories and shifting social perceptions of certain species over time. Anglo-European colonists, for example, applied the name "cabbage tree" to *Nuytsia floribunda* because of the strong, acrid, somewhat rotten smell emitted when the trunk was cut often during the process of clearing land for agriculture and settlement. In contrast, Wudjari Noongar (Aboriginal) nomenclature such as *moodjaar* inscribe longstanding cultural traditions centralizing the tree. Furthermore, scientific reports from all historical periods often include cultural accounts of human-environment relations, allowing users of biodiversity data archives such as ALA to grasp not only the science of species but also their ecohumanistic resonances in culture, society, history, politics, and Indigenous communities.

32 As an illustration of citizen science with vast potential for citizen ecohumanism, the ALA collaborates with citizen groups such as Climate Watch as data procurement partners to identify current distribution patterns of Australian species. Climate Watch is a global, citizen science-based initiative focused on assessing the environmental effects of climate change. The open-access platform aims "to empower policymakers, researchers, media, and other stakeholders with the open climate data, visualizations and resources they need to gather insights on national and global progress on climate change" [Climate Watch 2021, ¶1]. In conjunction with well-established crowdsourcing platforms like Climate Watch, the ALA could develop a companionable focus on biocultural data about Australian species, thereby further empowering and inspiring communities to act on behalf of the environment and pursue environmental justice. A promising emphasis for the ALA to adopt is citizen ecohumanism, for instance, allowing users to contribute first-hand narrative accounts of Australian species comprising, among other things, memories of species' historical occurrences, affective responses to the decline of plants locally, references to artistic and literary depictions of animals, and Indigenous cultures' knowledge of bushfoods. This heterogeneous biocultural information could be solicited, collated, and made available on a separate digital platform — a strategy developed by the Floracultures project in response to the open-access Florabase repository of scientific information about Western Australian plants [Ryan 2014(b)]. In this way, a complementary platform would facilitate the preservation of Australian biocultural data that might otherwise not be formally recorded during the procurement of occurrence records.

Human-Plant-Environment Relations: Digital Stories from the Botanical Humanities

33 The study of human-plant-environment relations historically has been the domain of ethnobotany. Leveraging social scientific methods in researching plants, the interdisciplinary field of ethnobotany examines the material and immaterial — physical and spiritual — interconnections between people and flora in places over time [Balick and Cox 2020] [Schultes and Reis 1995]. Since its emergence in the 1890s at the crossroads of botany and anthropology, ethnobotany has focused largely on the classification, uses, and perceptions of flora in traditional, preindustrial societies, especially

Native America and Aboriginal Australia. Utilitarian in emphasis, ethnobotany empirically investigates the uses of plant species as foods, medicines, fibers, dyes, materials, ornaments, decorations, and totems. Alongside ethnobotany, over the last decade in particular, the field of human-plant studies — increasingly called "the botanical humanities" — has taken shape through the work of cultural theorists, philosophers, literary critics, ecologists, and biologists [Ryan 2023]. Botanical humanists problematize dominant Western characterizations of plant life as the passive, sessile, and silent backdrop to human activities. Scholarship in this area addresses a range of ethical concern, from the social consequences of genetically manipulating seeds to the moral implications of plant sentience for mainstream agriculture.

34 While clearly embedded in the ethnobotanical paradigm, the *Native American Ethnobotany Database*, or NAED, also exemplifies the digital environmental humanities — or what could even be called the digital botanical humanities — in practice well before the circulation of the term. Illustrating the values of durability and evolvability in open-access DEH, the project demonstrates the movement from analog to digital archival strategies for understanding human-plant-environment networks and making ethnobotanical knowledge broadly available. Released in the late 1990s in partnership with the University of Michigan-Dearborn, the online repository of Native American uses of plants currently contains around 45,000 data items related to 4,000 plant species and 300 Native American cultures [Native American Ethnobotany Database 2021]. Beginning in the mid-1970s, however, the database's earliest components were developed using edge-punched index cards. In 1977, a print-based forerunner of the archive with about 5,000 items was converted to a database management platform known as Taxir and dubbed *American Medical Ethnobotany: A Reference Dictionary*. Developed over a decade with assistance from the National Endowment for the Humanities, the National Science Foundation, and UM-Dearborn, an expanded version named Medicinal Plants of Native America was released in 1986 by the Museum of Anthropology at UM. This iteration comprised roughly 18,000 items detailing the therapeutic uses of 2,000 plant species by 123 Native American cultures. In 1998, moreover, a book version of the database was published as *Native American Ethnobotany* [Moerman 1998]. Then, in 2003, with the further support of the National Science Foundation, another update became available, linking species in NAED to the U.S. Department of Agriculture's PLANTS Database and enabling users to access photos, distribution maps, conservation status, and other information [USDA 2021]. The database's evolution since the 1970s points to the value of multidisciplinary exchange in DEH, for example, in the diverse funding bodies and supporting institutions that have made the project possible.

35 By highlighting the relationships between North American plants and Native American cultures through an open-access medium, NAED can be understood as a precursor of the digital environmental humanities. The database features culturally-salient tree species such as the Pacific silver fir (*Abies amabilis*), the traditional uses of which were first documented by ethnobiologist Nancy Turner in the early 1970s. In total, NAED enumerates twenty-seven uses of *A. amabilis* by seven cultures. The Bella Coola people of British Columbia, for instance, applied Pacific silver fir as an eye medicine, gastrointestinal aid, throat aid, and tuberculosis remedy, whereas the Oweekeno used the tree as a medicine for colds. Each entry lists the scientific name, common name, plant family, use category, and use sub-category for each species along with notes such as "liquid pitch mixed with mountain goat tallow and used for infected eyes" in reference to the Bella Coola treatment of eye diseases with Pacific silver fir. As a research tool, NAED supplies complete bibliographic details for each entry's source, guiding users seeking further ethnobotanical information about particular plants and cultures. By clicking the hyperlinked names "Bella Coola" and "Oweekeno", moreover, users can access all species with recorded uses by these cultures.

36 The case of the *Native American Ethnobotany Database* underscores the potential for DEH to engage with new technologies — including pre- and post-digital forms — an issue also raised in our discussion of perennial eco-archiving and the work of The Long Now Foundation. The platform *Mukurtu*, for instance, is a community-driven content management system that enables Indigenous communities to preserve and disseminate their digital heritage in keeping with cultural protocols. In response to worldwide movements toward decolonization and reconciliation, Mukurtu presents a dynamic digital environmental humanities tool for managing ethnobiological data and extending the ambit of longstanding databases such as NAED [Christen 2019]. Notwithstanding its accessibility, adaptability, and durability, NAED presents a non-participatory mode of telling stories about the botanical world. Furthermore, the project reinscribes the historical authority of ethnobotany as the foremost scholarly paradigm for understanding human-plant relations and, specifically, the culturally-sensitive botanical knowledge of Indigenous people. As a counter example,

Herbarium 3.0 offers a user-based platform for disseminating stories of plants, people, and places by pairing “historical herbarium specimens with contemporary stories about plants to […] restore the layered histories of plant-human interactions” [GeoHumanities 2018, ¶3]. Reimagining the herbarium tradition of botanical science as interactive and open-ended, Herbaria 3.0 is a collaboration between plant biologists, environmental humanists, and researchers in science pedagogy designed to foreground the significance of vegetal life in an era of climate disturbance and species dislocation. As the organizers remark, “these stories can draw our attention to the intertwined nature of human-plant relationships. Turning to these relationships helps us to remember plants and reconnect with them, acknowledging the pivotal role plants play in our lives” [Herbaria 3.0 2021(b)]. Toward this aim, narratives are organized into three categories: Story Garden, Stay-At-Home Stories (with a pandemic focus), and Root Stories. The Story Garden Map depicts the geographical distribution of stories, the majority of which are located in North America. The entry consulted, “Musing from Under a Moss Leaf”, dated June 17, 2021, uses a specimen plate of the common hair moss (*Polytrichum commune*) from the Oxford University Herbarium as a starting point for meditating on the evolutionary and ecological importance of this diminutive species. Overall, however, Herbaria 3.0 appears underpopulated — its potential not yet realized — calling attention to the critical issue of sustaining public participation in DEH initiatives over time.

Conclusion: Bolstering the Digital Environmental Humanities

37 The strains elaborated in this article — perennial eco-archiving, Anthropocene narratives of loss, citizen ecohumanities, and human-plant-environment relations — illustrate the range of work currently falling within the scope of the digital environmental humanities. Whereas projects such as Herbaria 3.0 and the *Atlas of Living Australia* engage members of the public centrally as knowledge-bearers and knowledge-contributors, “The Clock of the Long Now”, *Native American Ethnobotany Database*, and others largely preclude community participation. This section offers some recommendations for bolstering DEH’s critical capacity by democratizing biocultural knowledge via community-responsive, narratively-based, transdisciplinary strategies. In embracing diverse theories and practices, DEH brings decolonial, arts-based, and practice-led models into dialogue with qualitative and quantitative approaches.

38 One of DEH’s foremost aims should be to foster inclusive participation in open-access digital environments. This begins by generally recognizing the value of citizen ecohumanism and encourages the development of novel approaches to sustaining long-term community contributions. Possible strategies include integrating emerging and established social media platforms into projects; using DEH infrastructure as a basis for designing learning programs tailored to different educational levels, from undergraduate training to professional development; and creating on-site and virtual skill development workshops to facilitate content contributions to particular projects, for instance, through the writing of Anthropocene narratives, the collecting of biocultural data through interviews, or the analysis of historical documents using crowdsourced annotations. Harnessing data through ethnographic techniques, text mining, data visualization, geographic information systems, and other methods, environmental humanists — academic specialists and citizen ecohumanists alike — can open up “new research questions, scales of analysis, visualizations, audiences, and means of interaction” [Woodruff Library Humanities Team Exhibit 2021, ¶1].

39 As the field progresses, DEH will need to examine the ethical implications of converting nature into data. In this context, Sean Cubitt characterizes the datafication of nature as the “remaking of nature as data” in which habitats and more-than-human beings are interpreted no longer as corporeal phenomena but as data representing those phenomena [Cubitt 2017, p. 163]. Cubitt observes that, in order to become data, nature must be reduced to “common arithmetical form” [Cubitt 2017, p. 159]. Indeed, datafication risks diminishing the material urgencies surrounding the preservation of species in their habitats. Nonetheless, in relation to DEH, Alenda Chang stresses that the environmental humanities has the potential to return “the material world to often immaterial theories and histories of technology” [Chang 2021, pp. 384–85]. The stronger emphasis on materiality afforded by DEH will enable practitioners to address issues such as the energy demands of digital activities, the disposal of electronic waste, and the transformation of embodied beings into datasets [Chang 2021, p. 388].

40 DEH should also aim to engage diverse communities in various ways. Postcolonial advances in the digital humanities emphasize the telling of new stories in decolonized spaces allowing communities to share their own knowledge. For Roopika Risam (2019), postcolonial DH entails “designing new workflows and building new archives, tools, databases,

and other digital objects that actively resist reinscriptions of colonialism and neocolonialism" (p. 4). Postcolonial DH, moreover, centralizes "politically, ethically, and social justice-minded approaches to digital knowledge production" [Risam 2019, p. 4]. Extending postcolonial critique to DEH is crucial, as well, given the underrepresentation of Indigenous cultures and the Global South in the digital humanities [Gomez 2019] [Noble 2019]. These points become even more critical in light of projects like the *Native American Ethnobotany Database* and "The Clock of the Long Now", disseminating the traditional knowledge of marginalized communities and incurring physical alterations to Indigenous peoples' lands, respectively.

41 DEH might also strive to balance critiques of the techno-utopianism dominating current studies of environmental sustainability with the uptake of emerging technologies such as virtual and augmented reality, artificial intelligence, machine learning, and quantum computing. As DEH scholars have observed since that field's inception over a decade ago, DH's long historical perspective on new technologies is pertinent to EH. By extending humanities approaches to the ecological and technological issues of the Anthropocene, DEH contributes to contemporary debates about ecology, media, and technology while advocating for new ways of thinking about the humanities [Posthumus, Sinclair, and Poplawski 2018]. DEH should thus maintain a critical stance on its adoption of interactive post/digital tools to research and communicate ecological concerns [Posthumus, Sinclair, and Poplawski 2018, p. 168].

42 Informed by the arts, humanities, social sciences, and natural sciences, DEH can become more inclusive and innovative. In broad agreement with other DEH theorists, Alenda Chang (2021) contends that "an EH perspective could show digital humanists how to broaden the scope and stakes of their work while mitigating some of the oversights characteristic of technical solutions, in particular false abstraction from the physical world and the valorization of speed — whether of innovation, development, or deployment — over deliberation" (p. 379). Facilitating collaboration between academics, activists, artists, writers, community stakeholders, and knowledge-bearers, DEH offers an adaptable framework supporting more inclusive scholarship in which disciplinary interactions underlie innovation.

43 As an inclusive scholarly-activist framework, DEH calls attention to ecological concerns at DH events, and, conversely, digital issues at EH events. This could entail establishing digital environmental humanities working groups or special interest groups within professional structures, including, for example, the Alliance of Digital Humanities Organizations (ADHO) and its Constituent Organizations. Equally, digital working groups within leading environmental humanities organizations such as the American Society for Environmental History and the Association for the Study of Literature and Environment would reinforce digital concerns and awareness throughout different areas of EH. Increasingly inclusive and activist in emphasis, DEH is well-positioned to continue to address Anthropocene urgencies while imagining possibilities for human and more-than-human flourishing.

Acknowledgements

44 John C. Ryan acknowledges funding from the Biodiverse Anthropocenes program, the University of Oulu, and Academy of Finland Profi6 336449.

Works Cited

Adamson 2017 Adamson, J. (2017) "Gathering the Desert in an Urban Lab: Designing the Citizen Humanities", in J. Adamson and M. Davis (eds) *Humanities for the Environment: Integrating Knowledge, Forging New Constellations of Practice*. Routledge, New York, pp. 106–119.

Adamson, LeMenager, and Sandilands 2018 Adamson, J., LeMenager, S. and Sandilands, C. (2018) "Citizen Humanities: Teaching Life Overlooked as Interdisciplinary Ecology", *Resilience: A Journal of the Environmental Humanities*, 5(2), pp. 96–121.

Ahern 2019 Ahern, S. (2019) "Introduction: A Feel For the Text", in S. Ahern (ed.) *Affect Theory and Literary Critical Practice: A Feel For the Text*. Cham, Switzerland: Springer Nature, pp. 1–21.

Andro 2018 Andro, M. (2018) *Digital Libraries and Crowdsourcing*. Hoboken, NJ: Wiley.

Atlas of Living Australia 2021(a) Atlas of Living Australia. (2021) "Nuytsia floribunda (Labill.) R.Br. ex G.Don". Available at: https://bie.ala.org.au/species/https://id.biodiversity.org.au/node/apni/2889663.

Atlas of Living Australia 2021(b) Atlas of Living Australia. (2021) “What Is the ALA?” Available at: https://www.ala.org.au/about-ala/.

BHL 2021 B.H.L. (2021) “Inspiring Discovery Through Free Access To Biodiversity Knowledge”. Available at: https://www.biodiversitylibrary.org/.

Balick and Cox 2020 Balick, M.J. and Cox, P.A.P. (2020) *People, and Culture: The Science of Ethnobotany*. 2nd edn. Boca Raton, FL: CRC Press.

Barad 2007 Barad, K. (2007) *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke University Press.

Belbin et al 2021 Belbin, L. et al. (2021) “The Atlas of Living Australia: History, Current State and Future Directions”, *Biodiversity Data Journal*, 9(e65023), pp. 1-35,. Available at: https://doi.org/10.3897/BDJ.9.e65023.

Bjornerud 2018 Bjornerud, M. (2018) *Timefulness: How Thinking Like a Geologist Can Help Save the World*. Princeton, NJ: Princeton University Press.

Bladow and Ladino 2018 Bladow, K. and Ladino, J.K. (2018) “Toward an Affective Ecocriticism: Placing Feeling in the Anthropocene”, in K. Bladow and J.K. Ladino (eds) *Affective Ecocriticism: Emotion, Embodiment, Environment*. Lincoln, NE: University of Nebraska Press, pp. 1–22.

Bridgewater and Rotherham 2019 Bridgewater, P. and Rotherham, I.D. (2019) “A Critical Perspective on the Concept of Biocultural Diversity and Its Emerging Role in Nature and Heritage Conservation”, *People and Nature*, 1(3), pp. 291-304,. Available at: https://doi.org/10.1002/pan3.10040.

Bromham et al 2021 Bromham, L. et al. (2021) “Global Predictors of Language Endangerment and the Future of Linguistic Diversity”, *Nature Ecology and Evolution*, December 16. Available at: https://doi.org/10.1038/s41559-021-01604-y.

Ceballos, Ehrlich, and Raven 2020 Ceballos, G., Ehrlich, P.R. and Raven, P.H. (2020) “Vertebrates on the Brink as Indicators of Biological Annihilation and the Sixth Mass Extinction”, *PNAS: Proceedings of the National Academy of Sciences of the United States*, 117(24). Available at: https://doi.org/10.1073/pnas.1922686117.

Chang 2021 Chang, A.Y. (2021) “Pitching the ‘Big Tent’ Outside: An Argument for the Digital Environmental Humanities”, in D. Kim and A. Koh (eds) *Alternative Historiographies of the Digital Humanities*. Goleta, CA: Punctum Books, pp. 377–397.

Christen 2019 Christen, K. (2019) “‘The Songline Is Alive in Mukurtu’: Return, Reuse, and Respect”. Edited by L. Barwick, J. Green, and P. Vaarzon-Morel. *Archival Returns: Central Australia and Beyond*. Honolulu, HI: University of Hawai'i Press.

Climate Stories Project 2023 Climate Stories Project. (2023) “About Climate Stories Project”. Available at: https://www.climatestoriesproject.org/about.html.

Climate Watch 2021 Climate Watch. (2021) “About”. Available at: https://www.climatewatchdata.org/about/description.

Cohen and LeMenager 2016 Cohen, J.J. and LeMenager, S. (2016) “Introduction: Assembling the Ecological Digital Humanities”, *PMLA*, 131(2), pp. 340–346.

Convention on Biological Diversity 2021 Convention on Biological Diversity. (2021) “Australia: Main Details”. Available at: https://www.cbd.int/countries/profile/?country=au.

Coulter, Hardenberg, and Jørgensen 2021(a) Coulter, K., Hardenberg, W.G. and Jørgensen, F.A. (2021) “An Experiment in Collecting and Curating”, in K. Coulter et al. (eds) *Ant Spider Bee: Chronicling Digital Transformations in Environmental Humanities*. Munich: Center for Environment & Society, pp. 226–229.

Coulter, Hardenberg, and Jørgensen 2021(b) Coulter, K., Hardenberg, W.G. and Jørgensen, F.A. (eds) (2021) Ant Spider Bee: Chronicling Digital Transformations in Environmental Humanities, Spider & Cloud /. Munich: Rachel Carson Center for Environment & Society.

Coulter, Hardenberg, and Jørgensen 2021(c) Coulter, K., Hardenberg, W.G. and Jørgensen, F.A. (2021) “Preface”, in K. Coulter et al. (eds) *Ant Spider Bee: Chronicling Digital Transformations in Environmental Humanities*. Munich: Center for Environment & Society, pp. 9–12.

Cubitt 2017 Cubitt, S. (2017) *Finite Media: Environmental Implications of Digital Technologies*. Durham, NC: Duke University Press.

Cummings, Roh, and Callaway 2020 Cummings, R., Roh, D.S. and Callaway, E. (2020) “Organic and Locally Sourced:

Growing a Digital Humanities Lab with an Eye Towards Sustainability", *Digital Humanities Quarterly*, 14(3).

Dawson 2021 Dawson, T. (2021) "The Weight of The Digital: Experiencing Infrastructure with InfraVU", in O. Rossier, C. Miya, and G. Rockwell (eds) *Right Research: Modelling Sustainable Research Practices in the Anthropocene*. Cambridge, UK: Open Book Publishers, pp. 309–327.

Dobrin 2014 Dobrin, S.I. (2014) "Introduction: Frontier 2.0." in *Green Letters: Studies in Ecocriticism*. Available at: https://doi.org/10.1080/14688417.2014.972139.

Environment and Society Portal 2021 Environment and Portal, S. (2021) "DEH: Digital Environmental Humanities". Available at: https://www.environmentandsociety.org/mml/deh-digital-environmental-humanities.

Galloway 2017 Galloway, K. (2017) "Making and Learning with Environmental Sound: Maker Culture, Ecomusicology, and the Digital Humanities in Music History Pedagogy", *Journal of Music History Pedagogy*, 8(1), pp. 45–71.

GeoHumanities 2018 GeoHumanities (2018) "Collaborative Digital Environmental Humanities: Herbaria 3.0". Available at: http://geohumanitiesforum.org/collaborative-digital-environmental-humanities-herbaria-3-0/.

Ginn et al 2018 Ginn, F. et al. (2018) "Introduction: Unexpected Encounters with Deep Time", *Environmental Humanities*, 10(1), pp. 213-225. Available at: https://doi.org/10.1215/22011919-4385534.

Gomez 2019 Gomez, A. (2019) "The Making of the Digital Working Class: Social History, Digital Humanities, and Its Sources", in M.K. Gold and L.F. Klein (eds) *Debates in the Digital Humanities*. Minneapolis, MN: University of Minnesota Press, pp. 399–404.

Gorenflo et al 2012 Gorenflo, L.J. et al. (2012) "Co-occurrence of Linguistic and Biological Diversity in Biodiversity Hotspots and High Biodiversity Wilderness Areas", *PNAS: Proceedings of the National Academy of Sciences of the United States*, 109(21), pp. 8032-8037,. Available at: https://doi.org/10.1073/pnas.1117511109.

Gould 1863 Gould, J. (1863) "The Mammals of Australia". John Gould, London.

Gould 2016 Gould, A.S. (2016) "Restor(y)ing the Ground: Digital Environmental Media Studies", Networking Knowledge, 9(5), pp. 1–19.

Griffiths 2007 Griffiths, T. (2007) "The Humanities and an Environmentally Sustainable Australia", *Australian Humanities Review*, 43.

Haklay 2018 Haklay, M. (2018) "Participatory Citizen Science", in S. Hecker et al. (eds) *Citizen Science: Innovation in Open Science*. London: Society and Policy, UCL Press, pp. 52–62.

Harway 2016 Haraway, D. (2016) "Tentacular Thinking: Anthropocene, Capitalocene, Chthulucene", *e-flux Journal*, 75.

Hecker et al 2018 Hecker, S. et al. (2018) "Innovation in Open Science, Society and Policy: Setting the Agenda for Citizen Science", in S. Hecker et al. (eds) *Citizen Science: Innovation in Open Science*. London: Society and Policy, UCL Press, pp. 1–23.

Hedges and Dunn 2017 Hedges, M. and Dunn, S. (2017) *Academic Crowdsourcing in the Humanities: Crowds, Communities and Co-production*. Cambridge, UK: Chandos Publishing.

Heinisch et al 2021 Heinisch, B., Oswald, K., Weißpflug, M., Shuttleworth, S., and Belknap, G. (2021) " Citizen Humanities" in Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R. and Wagenknecht, K. (eds) *The Science of Citizen Science*. Cham, Switzerland: Springer, 97–118.

Herbaria 3.0 2021(a) Herbaria (2021) "Herbaria 3.0: Everyone Has a Story To Tell About a Plant, What Is Yours?" Available at: https://herbaria3.org/.

Herbaria 3.0 2021(b) Herbaria (2021) "What is Herbaria 3.0?" Available at: https://herbaria3.org/about-herbaria-3-0-2/.

Huber 2022 Huber, M.T. (2022) *Climate Change as Class War: Building Socialism on a Warming Planet*. London: Verso Books.

Hussain and Riede 2020 Hussain, S.T. and Riede, F. (2020) "Paleoenvironmental Humanities: Challenges and Prospects of Writing Deep Environmental Histories", *WIREs Climate Change*, 11(e667), pp. 1-18,. Available at: https://doi.org/10.1002/wcc.667.

Jørgensen 2014 Jørgensen, F.A. (2014) "The Armchair Traveler"s Guide to Digital Environmental Humanities', *Environmental Humanities*, 4, pp. 95–112.

Ladino 2018 Ladino, J.K. (2018) “What Is Missing? An Affective Digital Environmental Humanities”, *Resilience: A Journal of the Environmental Humanities*, 5(2), pp. 189–211.

Linley 2016 Linley, M. (2016) “Ecological Entanglements of DH”, in M.K. Gold and L.F. Klein (eds) *Debates in the Digital Humanities*. Minneapolis, MN: University of Minnesota Press, pp. 410–437.

Lintott 2015 Lintott, C. (2015) “Digital Citizen Science: Creating Meaning for the Zooniverse”. Available at: https://www.antspiderbee.net/2015/11/05/digital-citizen-science-creating-meaning-for-the-zooniverse/.

Moerman 1998 Moerman, D.E. (1998) *Native American Ethnobotany*. Portland, OR: Timber Press.

Moore 2017 Moore, J. (2017) “The Capitalocene, Part I: On the Nature and Origins of Our Ecological Crisis”, *The Journal of Peasant Studies*, 44(3), pp. 594-630. Available at: https://doi.org/10.1080/03066150.2016.1235036.

Myers 2017 Myers, N. (2017) “From the Anthropocene to the Planthroposcene: Designing Gardens for Plant/People Involution”, *History and Anthropology*, 28(3), pp. 297-301. Available at: https://doi.org/10.1080/02757206.2017.1289934.

Native American Ethnobotany Database 2021 Native American Ethnobotany Database (2021) “History”. Available at: http://naeb.brit.org/about.

Noble 2019 Noble, S.U. (2019) “Toward a Critical Black Digital Humanities”, in M.K. Gold and L.F. Klein (eds) *Debates in the Digital Humanities*. Minneapolis, MN: University of Minnesota, pp. 27–35.

Nowviskie 2015 Nowviskie, B. (2015) “Digital Humanities in the Anthropocene”, *Digital Scholarship in the Humanities*, 30, pp. 4-15,. Available at: https://doi.org/10.1093/llc/fqv015.

Posthumus and Sinclair 2014 Posthumus, S. and Sinclair, S. (2014) “Reading Environment(s): Digital Humanities Meets Ecocriticism”. *Green Letters: Studies in Ecocriticism*, 18(3) pp. 254–273. Available at: https://doi.org/10.1080/14688417.2014.966737.

Posthumus, Sinclair, and Poplawski 2018 Posthumus, S., Sinclair, S. and Poplawski, V. (2018) “Digital and Environmental Humanities: Strong Networks, Innovative Tools, Interactive Objects”, *Resilience: A Journal of the Environmental Humanities*, 5(2), pp. 156–171.

Rachel Carson Center 2011 Rachel Carson Center (2011) “About Ant Spider Bee”. Available at: https://www.antspiderbee.net/about/.

Rachel Carson Center 2013 Rachel Carson Center (2013) “Call for Papers: The Digital / Environmental Humanities Nexus: Challenges and Opportunities”. Available at: https://www.antspiderbee.net/2013/05/08/call-for-papers-the-digital-environmental-humanities-nexus-challenges-and-opportunities/.

Risam 2019 Risam, R. (2019) *New Digital Worlds: Postcolonial Digital Humanities in Theory, Praxis, and Pedagogy*. Evanston, IL: Northwestern University Press.

Robinson et al 2018 Robinson, L.D. et al. (2018) “Ten Principles of Citizen Science”, in S. Hecker et al. (eds) *Citizen Science: Innovation in Open Science*. London: Society and Policy, UCL Press, pp. 27–40.

Ryan 2014(a) Ryan, J.C. (2014) “FloraCultures: The Nature of a Biodiversity Archive for Plant-Based Cultural Heritage”, Presentation at Digital Humanities Australasia: Expanding Horizons, University of Western Australia Conference, March.

Ryan 2014(b) Ryan, J.C. (2014) “Natural Heritage Conservation and Eco-Digital Poiesis: A Western Australian Example”, *Media International Australia*, 153, pp. 88–97.

Ryan 2023 Ryan, J. C. (2023) “Passive Flora? Reconsidering Nature’s Agency through Human-Plant Studies” in Osterhoudt, S. and Sivaramakrishnan, K. (eds), *Sustaining Natures: An Environmental Anthropology Reader*. Seattle, WA: University of Washington Press.

Ryan, Brady, and Kueh 2019 Ryan, J. C., Brady, D. and Kueh, C. (2019) “Where Fanny Balbuk Walked: Re-imagining Perth’s Wetlands”, in Ryan, J. C. and Chen, L. (eds) *Australian Wetland Cultures: Swamps and the Environmental Crisis*. Lanham, MD: Lexington Books, pp. 163–174.

Schiebinger 2007 Schiebinger, L. (2007) *Plants and Empire: Colonial Bioprospecting in the Atlantic World*. Cambridge, MA: Harvard University Press.

Schultes and Reis 1995 Schultes, R.E. and Reis, S. (eds) (1995) in *Ethnobotany: Evolution of a Discipline*. Portland, OR: Dioscorides Press.

Sinclair annd Posthumus 2017 Sinclair, S. and Posthumus, S. (2017) “Digital? Environmental: Humanities”, in U.K. Heise,

J. Christensen, and M. Niemann (eds) *The Routledge Companion to the Environmental Humanities*. London: Routledge, pp. 369–377.

Smithsonian Institution 2013 Smithsonian Institution. (2013) *Eruptions, Earthquakes & Emissions* Available at: https://volcano.si.edu/E3/.

The Clock of the Long Now 2021 The Clock of the Long Now. (2021) “The Clock of the Long Now”. Available at: https://longnow.org/clock/.

The Long Now Foundation 2021(a) The Long Now Foundation. (2021) “Projects”. Available at: https://longnow.org/projects/.

The Long Now Foundation 2021(b) The Long Now Foundation. (2021) “The Long Now Foundation”. Available at: https://longnow.org/.

The Rosetta Project 2021(a) The Rosetta Project . (2021) “About”. Available at: https://rosettaproject.org/about/.

The Rosetta Project 2021(b) The Rosetta Project. (2021) “The Rosetta Project: A Long Now Foundation Library of Human Language”. Available at: https://rosettaproject.org/.

Travis and Holm 2016 Travis, C. and Holm, P. (2016) “The Digital Environmental Humanities: What Is It and Why Do We Need It? The NorFish Project and SmartCity Lifeworlds”, in C. Travis and A. Lünen (eds) *The Digital Arts and Humanities: Neogeography, Social Media and Big Data Integrations and Applications*. Cham, Switzerland: Springer, pp. 108–204.

Tsing et al 2021 Tsing, A.L. et al. (2021) “Feral Atlas: The More-Than-Human Anthropocene”. Available at: https://feralatlas.org.

USDA 2021 United States Department of Agriculture. (2021) “PLANTS Database”. Available at: https://plants.usda.gov/home.

Western Australian Museum 2021 Western Australian Museum (2021) “Reimagining Perth”s Lost Wetlands’. Available at: https://museum.wa.gov.au/explore/wetlands.

What Is Missing? 2021 What is Missing? (2021) “What Is Missing? A Global Memorial to the Planet”. Available at: https://www.whatismissing.org/.

Woodruff Library Humanities Team Exhibit 2021 Woodruff Library Humanities Team Exhibit (2021) “Digital Environmental Humanities: Using Information Age Tools to Understand the Anthropocene”. Available at: https://scholarblogs.emory.edu/environmental-humanities-exhibit/digital-environmental-humanities/.

Zalasiewicz 2015 Zalasiewicz, J. (2019) “Commentary on the ‘Anthropocene in Chile’ Manifesto”, *Environmental Humanities*, 11(2), pp. 498–500.

Zalasiewicz 2017 Zalasiewicz, J. (2015) “When Did the Anthropocene Begin? A Mid-Twentieth Century Boundary Level Is Strategically Optimal”, *Quaternary International*, 383, pp. 196-203,. Available at: https://doi.org/10.1016/j.quaint.2014.11.045.

Zalasiewicz 2019 Zalasiewicz, J. (2017) “The Extraordinary Strata of the Anthropocene”, in S. Oppermann and S. Iovino (eds) *Environmental Humanities: Voices from the Anthropocene*. London: Rowman & Littlefield, pp. 115–131.

Zalasiewicz et al 2019 Zalasiewicz, J. et al. (eds) *(2019) The Anthropocene as a Geological Time Unit: A Guide to the Scientific Evidence and Current Debate*. Cambridge, UK: Cambridge University Press.

Zooniverse 2021 Zooniverse (2021) “About”. Available at: https://www.zooniverse.org/about.