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Chapter 11
Integration of the Arts and Humanities with Environmental Science in the LTER Network

Mary Beth Leigh, Michael Paul Nelson, Lissy Goralnik, and Frederick J. Swanson

Abstract A broad spectrum of arts and humanities activities has emerged organically within the Long Term Ecological Research (LTER) program including disciplines such as philosophy and ethics, creative writing, and the visual, multimedia, musical, and performing arts. The majority of LTER sites now hosts activities that integrate the environmental sciences with the arts and humanities (eSAH). These programs serve important functions central to the LTER mission, including, but not limited to, public engagement, outreach, and education. Some LTER eSAH programs additionally consider these activities as steps toward the aspirational goal of helping society address grand social-ecological challenges of the twenty-first century, challenges that science alone cannot overcome. The arts and humanities can offer critical dimensions to this mission and to outreach, education, and general edification, such as awakening and engaging ethics, values, empathy, and wonder in individuals and societies. In this chapter, we reflect upon eSAH efforts across the LTER network, including their history, value to LTER's mission, challenges, and aspirations and share case studies of eSAH activities from several LTER programs, including their objectives, organizational models, audiences, and outcomes.

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11.1 Introduction

Arts and humanities activities are components of the majority of Long-Term Ecological Research (LTER) programs. These activities cut across all the relevant areas of the humanities and creative arts, and include consideration of philosophical and ethical themes, creative writing, visual arts and film-making, multimedia exhibits, and musical and performing arts. They have arisen organically from within LTER programs in the service of a variety of missions, including public engagement, outreach, and education. These arts and humanities efforts, together with the environmental science activities within LTER programs, complement each other as methods for understanding the world. Like the ecosystems in which they evolved and the scientific emphases of each site's community of researchers, the LTER network's multiple arts and humanities programs vary in terms of the disciplines involved, the organizational models employed, the goals of their integrative efforts, and the audiences engaged. While the majority of programs focus on integrating the environmental sciences, arts, and humanities (eSAH) for the purposes of engagement, outreach, and/or education, some programs now share a common aspirational goal of pursuing interdisciplinary integration for the benefit of society, whether for enrichment, understanding, community building, and/or developing problem-solving capacity (Goralnik et al. 2017).

In this chapter, we reflect upon eSAH efforts across the LTER network, including their history, value to LTER's mission, challenges, and aspirations. To provide context for this work and highlight some of the contributions, we also share case studies of eSAH activities from several LTER programs, including their objectives, organizational models, and audiences. These programs have become interwoven with LTER's mission and goals, especially as related to outreach, education, and public understanding of environmental problems and ecological science. We argue that this growing network of eSAH programs represents important linkages between science and society that contribute to the aspirational goal of addressing major social-ecological challenges.

11.2 LTER eSAH Activities: Origins

Although the arts and humanities have since emerged within LTER, they were not specifically mentioned in the National Science Foundation's (NSF) establishment of the LTER network in 1980 (Swanson 2015). But, following the establishment of LTER, NSF Program Officer James T. Callahan (1984) emphasized the importance

of long-term research not only for providing continuity in research, but for using this research to understand and address anthropogenic disturbance, thereby situating problem-solving and outreach as central to LTER objectives. Callahan credits the creation of the National Environmental Policy Act of 1969 (NEPA), as well as other federal agency initiatives, for laying the foundation for LTER's mission, by mandating that "it is the continuing policy of the Federal Government…to use all practicable means and measures…to create and maintain conditions under which man and nature can exist in productive harmony."

Since prescriptive conservation is inherently a fusion of understanding how the world works (science) and why the world is valuable (humanities/ethics), LTER's articulated origin as one focused on environmental problem solving opens the door to eSAH efforts. An additional factor contributing to the presence of eSAH activities within LTER is the fact that such activities were already underway within research sites that existed prior to the establishment of LTER (in 1980) that were later incorporated into the LTER (Swanson 2015). Starting in the 1950s, NSF sponsored an Antarctic artist and writer residency program that continues to be active today, including in association with McMurdo Dry Valleys LTER. In other cases, arts and humanities activities were initiated by the sites themselves. At Harvard Forest (HFR) in the 1930s, large and detailed dioramas were created to depict landscape change in Central New England from 1700 to 1930. These dioramas still serve as a central feature of Harvard Forest's visitor center, where the arts continue to help communicate ecosystem science to the public. Harvard Forest also hosts a long-running artist-in-residence program that continues to the present day.

The interest in eSAH in the LTER network is situated in a much larger national and international trend of interactions between the environmental sciences, arts, and humanities. In the twentieth–twenty-first centuries, environmental science, arts, and humanities interactions and collaborations have emerged in academic, nonprofit, and federal agency contexts (for current examples, see: artists-in-labs[1]; Brown University[2]; Cape Farewell[3]; Climarte[4]; IHOPE[5]; SciArt Center[6]; SymbioticA[7]; The Institute for Figuring[8]; Dixon et al. 2011b; Ingram 2011; Jacobson et al. 2007; Muchnic 2013). Other formalized networks of ecologically oriented research sites (e.g. biological field stations and marine laboratories) have hosted arts and humanities activities, while US National Park properties have also established formalized artist residency programs focusing on eSAH engagement with place. Collectively, the presence of these many programs has contributed to the groundswell of eSAH

[1] https://www.transartists.org/air/artists_in_labs_projects.7686.html

[2] https://arts.brown.edu/theme/arts-environment-2017-2020

[3] https://capefarewell.com/

[4] https://climarte.org

[5] http://ihopenet.org/

[6] https://www.sciartinitiative.org/

[7] http://www.symbiotica.uwa.edu.au/

[8] http://www.theiff.org/

activities of which the LTER eSAH activities are a part. While the applications and objectives differ across programs, scholars argue that bridging disciplines in this way facilitates emotional engagement or care for the natural world in ways that can impact appreciation, respect, and inspiration (Demaray 2014; Dixon et al. 2011a, b; Houtman 2012; Jacobson et al. 2007; Kimmerer 2016; Muchnic 2013; Patterson 2015; Root-Bernstein 2003; Swanson et al. 2008).

11.3 LTER eSAH Activities: Growth

Since the establishment of the LTER network, eSAH activities have emerged and gained traction widely across the network. Our 2013 survey of LTER Principal Investigators (PIs) found that 21 out of the total of 24 LTER sites hosted some kind of arts and/or humanities activities at that time (Goralnik et al. 2015). This network-wide activity reflects a wider trend nationally and internationally in engaging arts and humanities alongside scientific endeavors.

Modern scientific enterprises are focused narrowly on their respective disciplinary methods and practices. Engaging with other disciplines and integrating scientific work with other disciplines, especially disciplines different from the sciences, such as the arts and humanities, both benefit from and require active cultivation. A common feature across many programs is the presence of one or more multidisciplinary LTER researcher(s) already working in the sites, who might identify as or already collaborate with musicians, artists, writers, or dancers. These contributors find value in the work beyond their disciplines and have a passion for advancing eSAH work (Swanson 2015). Often these individuals create and build eSAH programs, serving as bridges or translators of this work for those working in disparate disciplines, building multidisciplinary communities and engaging broader audiences in the local/regional area. Successful programs are often characterized by alliances and partnerships with other institutions with strong existing memberships and outreach capabilities, such as museums, journals, and arts associations, which may enhance sustainability and extend networks.

Connections among active LTER-based eSAH programs have served to facilitate the emergence and growth of new programs across the network. In some cases, LTER-based eSAH programs were developed under the mentorship of more established LTER eSAH programs. For example, H.J. Andrews Experimental Forest LTER (AND) created a writer's residency in 2004 through collaboration with the Spring Creek Project for Ideas, Nature, and the Written Word at Oregon State University. As one example of growth facilitation, eSAH leaders from the existing writer's program at AND LTER visited Bonanza Creek LTER (BNZ) to co-facilitate that site's first field excursion for artists and writers in 2007, which then grew into BNZ's integrative *In a Time of Change* program.

To introduce a wider public to LTER eSAH activities, as well as provide opportunities for LTER programs to learn from each other, representatives from active programs have hosted workshops and panels at LTER All Scientists Meetings since 2006, and at several Ecological Society of America (ESA) and the American

Geophysical Union (AGU) annual meetings. LTER eSAH organizers also presented exhibits of cross-network eSAH work in the National Science Foundation's headquarters in Arlington, Virginia, in 2012 and 2013. The 2012 exhibit *Long Term Ecological Reflections: Bridging Science, the Arts, and Society* was also displayed at the ESA Meeting in Portland, Oregon, and at Oregon State University (in 2012). Additionally, organizers regularly share digital exhibits at the LTER All Scientists Meetings prior to plenary lectures and/or in poster halls.

Many eSAH activities associated with LTER sites are captured under the umbrella title *Ecological Reflections*, a heading that also includes non-LTER-based programs (e.g., biological field stations) with related eSAH structures and goals, and provides an additional resource for more broadly exploring the diversity of activities that have emerged. The Ecological Reflections website (www.ecological-reflections.com) communicates LTER eSAH work with a wider public and facilitates community-building within active programs, including beyond-LTER sites that share similar interests. The website includes information about eSAH programs and goals, as well as links to websites of participating projects.

Finally, LTER eSAH organizers have advanced scholarship on eSAH more broadly. In 2015, LTER-affiliated eSAH organizers convened an NSF-funded workshop in collaboration with organizers within the Organization of Biological Field Stations (OBFS) and the National Association of Marine Laboratories (FSMLs), Sagehen Creek Research Station, and the Nevada Museum of Art in Reno, Nevada. The 2.5-day workshop hosted 25 invited participants, including eSAH organizers, artists, scientists, humanists, and funding agency program officers, for a series of presentations, discussions, and a field trip to Sagehen Creek Research Station. The meeting was documented with a blog post (http://artsciconverge.blogspot.com/2015/07/artsciconverge-nsf-workshop-in-reno-nv.html). The workshop led to the development of the ArtSciConverge network, which describes the collaboration of LTER Ecological Reflections, OBFS, and other programs that wish to promote eSAH activities and scholarship.[9]

11.4 Value of eSAH to LTER Programs, Ecological Science, and Society

11.4.1 Perceived Value of eSAH in the LTER Network: Empathy and Observation

In summer 2013, we surveyed LTER Principal Investigators (PIs) to explore the nature and extent of arts and humanities engagement that their sites had hosted, and to understand the perceived benefits and challenges of this work (Goralnik et al. 2015). Of the 21 sites that had hosted some kind of eSAH inquiry (out of the 24 total

[9] Some of these activities can be viewed through the associated social media hashtag, #ArtSciConverge

LTER sites at that time), 19 agreed or strongly agreed that this inquiry was both relevant for and important to LTER sites. Respondents were offered 13 potential values[10] that arts and humanities might contribute to LTER sites, derived from the literature (see Demaray 2014; Dieleman 2008; Dixon et al. 2011b; Houtman 2012; Jacobson et al. 2007; Kimmerer 2016) and interpreted through the lens of general academic goals (e.g., plays a role on grants). Five values consistently ranked the highest: (1) *Fosters outreach and public engagement*, (2) *Is good in and of itself*, (3) *Inspires creative thinking,* (4) *Provides opportunities for education,* and (5) *Broadens our understanding of the natural world*.

While several of these outcomes are instrumental to the LTER mission and goals, (e.g., outreach and education), others hint at an emergent, less tangible contribution of this work, including its capacity to inspire creative thinking and broaden our understanding of the natural world, as well as the intrinsic quality of being good in and of itself. These suggested values allow for a less scripted, more open role for creative inquiry in the LTER Network, whereby arts and humanities might contribute something new and worthwhile that has its own shape and purpose, in addition to or rather than just supporting the science in a service capacity. This perspective is perhaps akin to science driven by discovery and wonder, whereby we create space for unexpected outcomes rather than aim for particular objectives. That the survey participants, most of whom were scientists and LTER PIs, were open to values like this was somewhat surprising and encouraging, given the trend within art-science interactions to employ the arts merely as a means to scientific ends (Jeffreys 2018; Stevens and O'Connor 2017), e.g., as an instrument for the purposes of illustration, outreach, or education.

Respondents were also provided with a list of 12 statements[11] drawn from explicit mission statements and goals that were stated on the LTER website, and from implicit objectives of the LTER network drawn from commitments to long-term, place-based inquiry. Participants were asked to rank the relative contribution of arts and humanities inquiry to these objectives of the LTER Network. In line with the earlier question about perceived value, respondents associated arts and humanities inquiry most closely with Network goals related to (1) *Outreach* and (2) *Communication*. But what was surprising was the relatively high ranking of (3) *Relationship Building – To develop empathetic relationships with the natural world and stimulate inspiration, awe, and wonder*, and (4) *Human Dimensions – To understand human drivers on natural systems, investigate the impacts of ecosystems on humans, and explore human perceptions of and attitudes about the natural world*.

[10] (1) Markets the science, (2) Stimulates collaboration, (3) Develops observational skills, (4) Contributes to environmental problem-solving, (5) Fosters outreach, (6) Provides opportunities for education, (7) Plays a role on grants, (8) Is good in and of itself, (9) Enables interdisciplinary scholarship, (10) Broadens our understanding of the natural world, (11) Stimulates empathy, (12) Enhances the science, (13) Inspires creative thinking.

[11] (1) Understanding, (2) Synthesis, (3) Information, (4) Legacies, (5) Education, (6) Outreach, (7) Conservation, (8) Communication, (9) Environmental Impact, (10) Relationship building, (11) Long-term Ecological Research, (12) Human dimensions.

Eleven sites (of 24), nearly half, ranked these responses >80%, above the fifth-ranking contribution, *Education* (Goralnik et al. 2017).

In 2015, we followed up the original survey with phone interviews with 14 LTER PIs and two outreach and education coordinators (see Goralnik et al. 2017). These interviews aimed to investigate the suggestion that LTER PIs recognized non-utilitarian value in the contributions of arts and humanities inquiry across the network or at their own sites, specifically related to empathy. Empathetic relationships with the natural world imply responsibility, a kind of reciprocity embedded in deep respect; they also suggest imagination, wonder, and awe, shown in the literature to provide entrance to empathy (Lorkowski and Kreinovich 2015; Piff et al. 2015), which are certainly qualities that can be associated with ecological research, but are not often the kinds of outcomes ecologists promote about their research. The interviews probed how PIs thought (a) empathy was relevant for Network activities, and (b) how arts and humanities might contribute this kind of value.

Results showed that awe and wonder are powerful drivers of many of the scientists' own careers. One explained:

> I think that a lot of environmental scientists get into what they do because of a sense of wonder, and we, as educators, can do well to think more deeply about that when offering [educational] opportunities … because we tend to forget that the root of what we are doing is deeply rooted [in a] sense of curiosity and appreciation for the natural world that I know for myself was really the reason why I chose to do what I do.

Another summed up what he understands is a central motivation for many scientists:

> [P]eople … want to understand how this unbelievably terrific system works, and what it does and what can cause it to unravel and what are the responses to disturbance and resiliency …. I think that's very important. To me it is fundamentally an emotional thing.

Several interviewees were uncomfortable with the language of empathy related to their own work, primarily because they worried about the appearance of advocacy interfering with the objectivity of their work. But all participants told stories about the beautiful, curious, amazing things they studied. These stories all imply a kind of awe, wonder, or empathy for the natural world that guides and nurtures their research.

Nearly all respondents also explained that inspiration, awe, and empathy are outcomes their LTER sites were either already accomplishing or should be doing. In some cases, respondents went as far as to say that these outcomes are a hidden LTER objective, a duty to the public, and an important part of education. Most agreed that arts and humanities can facilitate inspiration, awe, and wonder, especially by sharing LTER science with people beyond the site. One PI explained that "I see the value of the humanities [as] inspiring people that maybe don't have that natural curiosity or natural wonder […who might be] more likely to get inspired by a beautiful sculpture or painting than by a Ph.D. scientist espousing the virtue of ecological theory." Another explained: "[Y]ou can throw a bunch of data at people all you want, but they're not going to change their minds just because they have the

information, right? They need to be touched in some way…. Sometimes art does that."

There was also a sense in the interviews that something more impactful, or perhaps less outward facing, than outreach was happening when scientists engage with artists and humanists in LTER sites. One PI explained:

> With scientists, we're looking at the nuts and bolts of what's going on in the environment. Most scientists still conceive of the environment as a machine, and it's hard to talk about the environment as a holistic entity, which is the kind of thing you gain empathy with. That's, I suppose, a role for the arts and humanities, to educate scientists about the environment.

This comment is striking because often in these kinds of eSAH collaborations we find artists benefitting from the interaction with the scientists, and then using their medium to share science stories with other audiences. There are fewer examples of the ways the arts and humanities are nurturing the science or scientists directly. Providing new avenues of observation and attentiveness is one way arts and humanities interactions can benefit scientists and their practice. Another PI echoes this suggestion:

> One of the things I see in linking arts and humanities is it … enhances and sharpens the power of observation of scientists, for example, that it gets us out of our box and our computers filled with data and it really gets us out there and appreciate the beauty of nature and the perception of the natural surroundings.

These PIs echo the wider conversation about arts, humanities, and science collaborations related to emotion and observational capacity (see Burns 2015; Goralnik and Nelson 2015; Goralnik and Nelson 2017; Mann 2017; Reilly et al. 2005). Beyond being a direct benefit to scientific practice and public engagement, there is also the chance that when we see with new eyes, we potentially acquire new problem-solving capabilities, as well.

11.4.2 Impacts of LTER eSAH Work in the Public Sphere

Data from participant surveys collected at the BNZ LTER site's *In a Time of Change* eSAH gallery exhibits demonstrate that eSAH activities can achieve the kinds of public engagement outcomes PIs identified as worthwhile contributions of eSAH activities. In August 2013, we surveyed audiences at *In a Time of Change: Trophic Cascades*, an eSAH exhibit documenting the yearlong collaboration of artists, storytellers, and writers with scientists in Denali National Park and BNZ LTER in Fairbanks, Alaska. Opening night attendance at this show was 280 visitors, and total attendance during the 3-week run was 1820. We collected 94 surveys, most on opening night. In addition to questions about the exhibit's impact on participant knowledge and attitudes related to predators and ecosystem health, participant motivations, and overall participant reactions to the show, we asked two questions about the role of art in building awareness about environmental issues.

Of the 91 people who responded to the survey, more than 97% agreed or strongly agreed that art can be an effective way to understand ecosystems and the role of humans in the natural world. They also agreed that art can be an effective mechanism for building public awareness and understanding of important issues. While this does not yet describe the problem-solving capability of these kinds of collaborations, the audience's reactions to this exhibit reflect the potential of this work to engage a broad public in social-ecological issues. Additionally, open-ended responses about the most thought-provoking elements of the show reflect PI interview responses about empathy and awe, as well as the artist capacity to capture a holistic perspective that can be inspiring or eye opening for viewers.

One participant explained that the show "helped me…empathize with the hunted," while another shared "the artist perspective brings a wholeness to the world." A third explained that she, "stood in awe, surrounded by the power of words and images to evoke deep feelings of amazement at the precarious balance of the natural world." Participants regularly invoked words like awe, amazement, unexpected, and fascinated. All of these qualities open doors to empathetic awareness.

We also collected audience surveys at a second *In a Time of Change* eSAH multimedia exhibit in 2017 in Fairbanks, Alaska, "Microbial Worlds." There were over 900 visitors at this opening, a notably well-attended Fairbanks art event, and we received 109 survey responses. Again, we asked about knowledge, attitudes, and motivations; we were also curious about the impact of these eSAH collaborations on problem-solving capacity. In an open-ended question, analyzed with an emergent coding protocol (Vaismoradi et al. 2013), we asked participants: *What is the role of arts (if any) in capturing your attention about important issues?* Respondents identified arts and humanities as an effective tool for capturing attention about issues because of its immediate impact, ability to make the familiar unfamiliar, emotional resonance, and approachability. They described these impacts as an opportunity to invite broader audiences to the table, bring people together, educate, and create awareness. One participant shared, "[eSAH collaborations let] the idea behind the art sink in more because you feel emotion when viewing art, and thus you feel emotion toward the issue being addressed."

We also asked participants: *What role (if any) do arts-humanities-science collaborations play in environmental problem-solving?* Respondents explained that eSAH collaborations demand engagement, exercise mental muscles, and provoke innovation. These collaborations can impact creativity and connection, inspire wonder, make issues personally felt, broaden the audience for the issues, and change viewers' perceptions. "They bring environmental problems into the home to make an abstraction out of a concrete problem and make a concrete object out of an abstract concept," shared one participant.

In general, these collaborative exhibits demonstrate that eSAH work gets people in the room to engage with LTER science and environmental issues. There are some self-identified learning gains, and a good deal of emotional engagement with the pieces and the ideas. There is wonderful conversation and relationship building, the kinds of social interactions that are necessary to engage in broad scale problem

solving. And there is potential for awareness, attitude shifts, and even empathy. More research is necessary to assess these outcomes directly.

11.5 Challenges and Future Directions

While arts and humanities in the LTER network is largely perceived to be a value-adding contribution to site activities, supporting eSAH programs and collaborations is not without challenge. The 2013 survey asked participants to rank 11 provided potential challenges[12] of hosting arts and humanities inquiry in LTER sites. Participants consistently ranked three challenges at the top: (1) funding, (2) time or available labor, and (3) available expertise. These were anticipated responses, because LTER sites are grant-funded and most research, regardless of discipline, requires similar resources, including funding, labor, and time. What was encouraging about these responses is that they are, in many ways, surmountable hurdles, not specific to arts and humanities inquiry, therefore requiring skills most researchers already possess. Grants exist, experts are available, schedules and appointments can be restructured.

These kinds of challenges, though, also open the door to potentially deeper challenges. For example, the transformative capacity of these collaborations can potentially be hindered by forcing work into certain boxes in response to financial pressures or grant structures (Bieler 2014), or by requiring deep interdisciplinary work to function within traditional disciplinary research outcomes and institutional expectations (Holm et al. 2013). Prescribing the shape, scale, and outcomes of these collaborations with overly structured objectives likely limits their potential. The greater goal of these kinds of deep interdisciplinary collaborations, scholars contend, is to transcend horizontal knowledge sharing between the disciplines to allow for something new and emergent – something potentially transformational – to arise (Brown et al. 2017; Gabrys and Yusoff 2012; Jones et al. 2010).

11.5.1 Potential Value of eSAH: Social-Ecological Problem Solving

We suggest that many environmental challenges are the product of a relationship between humans and the natural world characterized by declines not so much in knowledge about nature, but rather, empathy with, humility in the face of, and sense of wonder about our world. We propose that an emergent property can result from

[12] (1) Funding, (2) Time, available labor, (3) Available expertise, (4) Clear vision or goals, (5) Lack of alignment with research, (6) Scheduling, (7) Limited relationships, (8) Limited space, (9) Challenging to find collaborators, (10) Little on-site interest, (11) Not in LTER purview.

the intersection of the environmental sciences, arts, and humanities: a holistic understanding of nature and environmental change that incorporates scientific knowledge as well as values, emotions, and aesthetics. It is through such shared understanding that societies can begin to address environmental challenges that lie ahead. The current paradigm for addressing grand environmental challenges recognizes the need to bridge the biological, physical, social, and political sciences to tackle these complex problems (Berkes et al. 2002; Ostrom 2009), but commonly overlooks the role of the arts (writ large to include the visual and performing arts, and other media) and humanities (writ large to include creative writing, philosophy, ethics, etc.). The arts and humanities, however, offer critical dimensions such as ethics, values, empathy, and wonder.

If we desire fully formed positions on how we ought to respond to grand social-ecological challenges, it is only from the combination of facts (science) and values (arts and humanities) that society can reach conclusions about what should be done to address those challenges. There is a growing recognition that a new paradigm is needed; one in which authentic relationships among the environmental sciences, arts, and humanities are revitalized to bring together the combined expertise and ways of knowing of these diverse disciplines to connect humans more deeply with their environment (Brown et al. 2017). This reintegration has the potential to generate a more unified approach to solving the ecological and social crises of the twenty-first century (Snow 1959; Frodeman 2010; Nisbet et al. 2010). However, methods for achieving interdisciplinarity across such large epistemological divides have yet to be well developed (Wilson 1999). Given the existence of a well-established scientific community, and a burgeoning community of artists and humanities scholars in their midst, the LTER program is poised to lead this critical eSAH effort.

Swanson et al. (Chap. 8, this volume) note that, although arts and humanities programs were not embedded in the programs with the intent of affecting policy outcomes, public perception may have been shaped in part by eSAH work in creative writing and the visual arts. Since early in the twentieth century, for example, Harvard Forest has offered public expression of change and legacies of land use in the New England landscape through dioramas and text. This appreciation of landscape forms a basis for public support of the Wildlands and Woodlands regional forest conservation strategy. The acid rain/air pollution issue deeply informed by work at Hubbard Brook came to the public eye in part through photographic work in dead and dying forests in New England. The awe-inspiring beauty and complexity of old-growth forests in the Pacific Northwest captured the public's imagination during the ca. 1990s "forest war" over the future of federal forestry through photography and compelling writings, some of which were set in the Andrews Experimental Forest where the science basis for understanding that ecosystem was based. Going forward, it will be interesting to see how arts and humanities embedded in LTER programs, coupled with the science, will be posed to contribute to society's ability to cope with looming environmental challenges.

11.6 Highlights of LTER Site-Based Programs and Projects

H.J. Andrews Experimental Forest and LTER The Andrews Forest LTER is located in Oregon and involves both Oregon State University and the U. S. Forest Service. Its arts and humanities program commenced in 2002 through collaboration with the privately-endowed Spring Creek Project for Ideas, Nature, and the Written Word, and with support from the U. S. Forest Service and private donors. Echoing the LTER science model, the Long-Term Ecological Reflections program brings creative writers, visual artists, composers, and humanities scholars into the forest with the objectives of conducting place-based arts/humanities inquiry and outreach to the public. The residents are encouraged to engage with the place, reflect on ecological and human change over a 200-year period of time, and archive and share their works through *The Forest Log* on the Spring Creek website.[13] Over the course of 100 residencies, works have appeared in *Orion* and *The Atlantic*, as a chapter in a finalist for the 2019 Pulitzer nonfiction book prize, in an image-essay in the online journal *terrain.org*, and through art exhibits and performances in eight Oregon cities, among other outlets.

A compilation of works by 35 writers and scientists from the Andrews Forest Reflections program is represented in *Forest Under Story* (Brodie et al. 2016). Charles Goodrich introduces the book in his essay "Entries into the Forest":

> Trying to comprehend what these forests *mean* can be bewildering. We may intuit and celebrate the wholeness of the forest, but we know it in pieces and threads, by its species and cycles, its products and processes. We come to know the forest via the paths laid down in stories, stories told in anecdotes, photographs, essays, and poems, or in hypotheses, data, and graphs. All these stories are entries into the forest, paths that others have made and which we may follow, perhaps to discover new insights and entice others to enter too.

The essays and poems that follow, including Robin Wall Kimmerer's "Interview with a Watershed" (written in 2004, see excerpt below), explore mysteries and surprises in the forest, our kinship with other beings, the soul of the science enterprise. Writers give voice to feelings scientists do not articulate – empathy, hope, love. In a "gratitude duet" the poet thanks the scientist for persistent, deep inquiry into how one particular facet of the world works; the scientist thanks the poet for approaching the world with such an open mind. This resonance is just beginning to unfold.

Excerpt from "Interview with a Watershed" by Robin Wall Kimmerer, in *Forest Under Story* (Brodie et al. 2016):

> It's a hopeful thing when scientists look to the land for knowledge, when they try to translate into mathematics the stories that water can tell. But it is not only science that we need if we are to understand. Lewis Thomas identified a fourth and highest form of language. That language is poetry. The data may change our minds, but we need poetry to change our hearts.

[13] https://liberalarts.oregonstate.edu/centers-and-initiatives/spring-creek-project/programs-and-residencies/long-term-ecological-reflections/forest-log

> Rich though they are, conversation, mathematics, and poetry are but human languages. And I think there is another language, the forgotten language of the land. Its alphabet is the elements themselves, carbon, hydrogen, oxygen, nitrogen. The words of this language are living beings, and its syntax is connection. There is a flow of information, a network of relationship conveyed in the rising sap of cedars, in tree roots grafted to fungi, and fungi to orchids, orchids to bees, bees to bats, bats to owls, owls to bones, and bones to the soil of cedars. This is the language we have yet to learn and the stories we must hear, stories that are simultaneously material and spiritual. The archive of this language, the sacred text, is the land itself. In the woods, there is a constant stream of data, lessons on how we might live, stories of reciprocity, stories of connection. Species far older than our own show us daily how to live. We need to listen to the land, not merely for data, but for wisdom.

Bonanza Creek Experimental Forest and LTER Bonanza Creek Experimental Forest and LTER involves collaboration between the University of Alaska and the U. S. Forest Service, and is located in interior Alaska. Established in 2007, the *In a Time of Change* program provides opportunities for competitively selected artists to engage with scientists on programmatic themes (e.g., climate change, wildfire, predator control, microorganisms), with each one-to-two-year project culminating in the production of original art exhibits, performances, and/or literary readings for the public. Through a series of group field trips, lectures, and hands-on activities, the participating artists and scientists exchange knowledge and perspectives and build cross-disciplinary relationships. Analyses of audience survey data revealed that exhibit attendance led to increased knowledge about the ecosystem, changed attitudes, and the cultivation of empathy for the natural world that can enable pro-environmental behavior (Goralnik et al. 2017). Participating artists and writers have credited their participation in *In a Time of Change* programs with long-term impacts on their work and with the formation of lasting collaborative relationships with scientists and other artists.

In the collaborative arts-humanities-science exhibit *Microbial Worlds* (itoc.alaska.edu), fourteen artists and writers magnified the physical beauty of microbes and illuminated the many roles they play in human and environmental health. The artistic media represented includes collage (Fig. 11.1), painting, sculpture, tile, printmaking, textile art, artist books, writing, and multimedia works. The exhibit was the culmination of over 1 year of monthly interactions between artists and a total of over 30 scientists through lectures, hands-on lab and field activities, as well as independent research and one-on-one collaborations. Since premiering in February, 2017, in Fairbanks, Alaska, the exhibit has actively toured within and beyond the state of Alaska.

Harvard Forest LTER Hosted by Harvard University and located in Petersham, Massachusetts, the Harvard Forest has a deep history of incorporating environmental literature, history, photography, and fine art with scientific research to characterize past landscapes, depict future scenarios, communicate complex scientific concepts, and educate a range of audiences. The detailed, 1930s-era dioramas of the Fisher Museum transcend typical boundaries among art, history, and science and effectively convey the conceptual foundation for much of the Forest's work. They

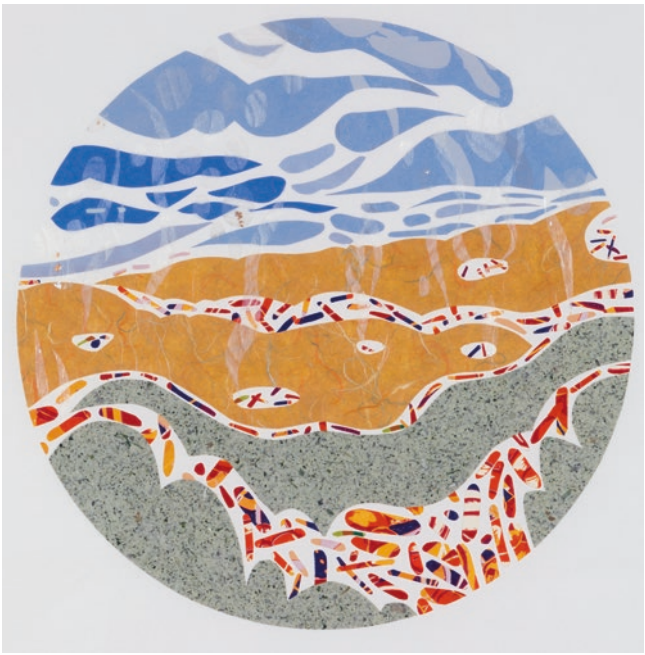

Fig. 11.1 *Impermafrost,* collage by Gail Priday (2017). Created as part of BNZ's "*In a Time of Change: Microbial Worlds*" project. Additional information and works by the fourteen participating artists can be viewed at itoc.alaska.edu. (Photograph by Todd Paris)

are visited by thousands of students, scientists, decisionmakers, land managers, and members of the public each year – and seamlessly provide rich footing in landscape-based inquiry for scientists and non-scientists alike. In the modern era, the Forest community incorporates artists, writers, and humanities scholars in three main ways: (1) interdisciplinary workshops and exhibits for students and the public, which provide creative entry points into complex global change topics; (2) the highly competitive Bullard Fellowship Program, endowed to support advanced work by any practitioner (including artists, writers, and historians) who shows promise to make an important contribution to forest-related subjects; and (3) an emerging effort to archive and analyze site-based artistic products as data.

Hemlock Hospice (Fig. 11.2) was a 2017–2018 art-science collaboration between Bullard Fellow David Buckley Borden and Harvard Forest Senior Ecologist Aaron Ellison. An 18-sculpture public art series embedded for a year into one of the Forest's main research tracts, it focused viewers on the death of eastern hemlock, a foundation tree in eastern forests now slowly vanishing from North America as it is weakened and killed by an invasive insect. In creating the sculptures (made primarily from discarded material from past ecological experiments) and in collaborating with filmmakers on a companion documentary, Borden and Ellison sought to encourage empathetic conversations among all caregivers for our forests—ecologists and artists, foresters and journalists, students, naturalists and citizens—while

Fig. 11.2 *Exchange Tree*, one of eighteen Hemlock Hospice field installations at Harvard Forest that highlights the death and disappearance of eastern hemlock trees from North America due to invasive insects. 8×10×12.5 feet. Wood and acrylic paint. 2017. Collaborators: David Buckley Borden, Aaron Ellison, Salvador Jiménez-Flores, and Saluo Rivero. Additional works and information at https://harvardforest.fas.harvard.edu/hemlock-hospice. (Courtesy of David Buckley Borden)

fostering social cohesion around ecological issues. The exhibit was featured in the *Boston Globe*, *Living on Earth*, *Orion*, and *SciArt Magazine*; in addition to leading guided tours of the installation, the creators have given dozens of presentations at universities, galleries, and conferences. Visitors' written responses to the sculptures in the field provided long-term data now being analyzed.

Konza Prairie Biological Station Konza Prairie Biological Station, part of Kansas State University located at Manhattan, Kansas, is one of the six initial LTER sites, and includes both intact and restored tallgrass prairie. This ecosystem type has high conservation value since most tallgrass prairie was converted to production agriculture and existing landscapes are threatened by global change, woody encroachment and fragmentation. Arts and humanities activities benefit from and contribute to the research station's mission of long-term ecological research, education, and conservation. Primary among these activities are the creation of original creative work, especially painting and drawing, photography, and literature. Both university-based and independent artists explore the prairie's complexity, natural history, climatic vulnerability, and other topics. Some from outside the region come for short-term artist residencies; others conduct longer-term projects. In addition, artists and writers offer public outreach through presentations of their work, including art exhibitions and readings and lectures by resident authors and writers.

Fig. 11.3 Kansas State University Associate Professor of Art Erin Wiersma develops drawings for "KonzaDrawings" by dragging paper through recently burned prairie at Konza Prairie LTER. (Photograph by David Mayes)

Illustrative of the long-term art activities at the Biological Station is "Konza Drawings," a series of land drawings using burned plant matter during the seasonal prescribed-burn treatments of the prairie's watersheds (Fig. 11.3). In conjunction with the experimental and conservational burn regime, Erin Wiersma, Associate Professor of Art at Kansas State University enters the watersheds and works with the charred vegetative matter by pulling, rubbing, dragging, and lifting paper through the recently-burned prairie. The images she creates record the landscape patterns resulting from the varying burn treatments, fire intensities, and vegetative composition from each locale. Her intention is to "bridge art and conservation and create a greater public awareness of the land," she says. Her work has been featured in a lecture at the Mariana Kistler Beach Museum of Art on the Kansas State University campus, the Robischon Gallery in Denver, Colorado, and through public programming. Upcoming exhibitions include Galerie Fenna Wehlau in Munich, Germany, and Mid-America Art Alliance in Kansas City, Missouri.

Virginia Coast Reserve LTER The *Art & Ecology* program at Virginia Coast Reserve LTER, which involves the University of Virginia and studies Virginia's coastal ecosystems, provides professional development for K-12 art and science teachers through a weekend immersion in the coastal systems of Eastern Virginia. Since its founding in 2012, the program has used the shared dependence on observation to interweave art techniques with ecology lessons. Observational Drawing is taught in the spring; Plein Air Painting is taught in the fall. Contributed artists' statements reveal a heightened sense of natural dynamics and environmental fragility

gained from "participating" in an ecosystem during the artistic endeavor to capture its image. Virginia Coastal Reserve artists and scientists have also begun closing their eyes to focus on the emerging theme of listening experiences and sounds as data. Ecoacoustic listening and reflective activities have captivated researchers with deep experience in the systems of the coastal reserve. Similar listening experiences are being envisioned as a new approach to outreach on changing coastline issues. Recent collaborations between music and environmental science graduate students contributed to studies of oyster reef productivity and resulted in musical compositions using reef sounds.

Donna Dixon Aliff, a 2012 *Art & Ecology* program participant and a teacher at York County Middle school, shared her experience: "Artists and scientists both harbor a passion for what they see and record as changes take place in their world". Elementary school teacher and 2014 participant Laura McGowan echoes her, "The world needs scientists to find out how things work, but it also needs artists to interpret the workings, and the beauty, of our world". Thanks to the ongoing *Art & Ecology* program, comparing paintings (e.g., Fig. 11.4) from the same marsh site over nearly a decade is beginning to reveal signs of marsh migration and forest die off with sea level rise and salt-water intrusion. Together, artists and scientists are capturing the process.

11.7 Conclusions

The two-pronged mission of LTER is infused with aspirational language focused on conserving and protecting the natural world (https://lternet.edu/vision-mission/):

- LTER envisions a society in which exemplary science contributes to the advancement of the health, productivity, and welfare of the global environment that, in turn, advances the health, prosperity, welfare, and security of our nation
- Thus, LTER's mission is to provide the scientific community, policy makers, and society with the knowledge and predictive understanding necessary to conserve, protect, and manage the nation's ecosystems, their biodiversity, and the services they provide.

The environmental challenges we currently face, however, are not just problems of science. That is, they are not just problems concerning the empirical facts (biophysical or social) of the working world now and into the future. Our challenges are as much the result of certain philosophical and ethical assumptions about what humans are, what the world is, and what an appropriate relationship between the two looks like. And they are just as much problems of the imagination as well. We seem tragically unable to imagine our way out of our current challenges. It seems easier, in fact, to imagine a complete cultural apocalypse than it does to imagine a world without fossil fuels. The arts and humanities prompt us not only to understand the origin of our grand environmental challenges, but they also serve as the wellspring of our imagining a future that fulfills the mission of LTER.

Fig. 11.4 Plein Air oil painting of a seaside marsh by Donna Dixon Aliff of York County Middle School. This work was created in 2012, the first year of *Art & Ecology*. It is part of a collection that has been displayed at local, regional, and national venues, including UVA's Science Library and the Eastern Shore's Barrier Islands Center cultural museum

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