

ESA CENTENNIAL PAPER

Confluence of arts, humanities, and science
at sites of long-term ecological inquiry

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Abstract. Over the past century, ecology, the arts, and humanities diverged, but are now converging again, especially at sites of long-term, place-based ecological inquiry. This convergence has been inspired in part by the works of creative, boundary-spanning individuals and the long-standing examples of arts-humanities programs in intriguing landscapes, such as artist and writer residencies of the National Park Service and the National Science Foundation's Antarctic program. In the past decade many US biological field stations, marine laboratories, and Long-Term Ecological Research sites have substantially increased the presence of arts and humanities in their programs for reasons both practical (e.g., public outreach, increasing student and class offerings) and fundamental (e.g., foster creativity within individuals and research teams, collect a record of artistic/humanities engagement with place). Motivations include communicating about science agencies' missions, the scientific process, and science discoveries to the public who support the research work. The overarching accomplishment of this work has been to advance near-term "science outreach," but some of this work can be viewed as "basic" arts and humanities in the sense that its impacts won't be known for a long time. A next challenge is for interdisciplinary teams to address complex problems, which falls in the "intellectual merit" realm of the National Science Foundation evaluation criteria. The growing body of works at the ecology-arts-humanities interface will be a valuable resource for future study of science-society-nature relations. These efforts potentially contribute to initiatives emerging from the ecological sciences community that seek greater connection with society—initiatives promoting sustainability and stewardship, and the practice of science citizenship, such as development of future scenario projects and regional conservation plans. Despite the large number of programs undertaking these collaborations, their existence is a well-kept secret with little representation on individual site websites and no organized network to support the work. The strong, grassroots emergence of arts, humanities, and science collaborations at sites of long-term ecological inquiry signals a recognition that these are places of cultural as well as scientific work. Their appearance late in ESA's first century may foreshadow an important role for such endeavors in the next century of ESA.

Key words: art; artists in residence; field stations; humanities; long-term ecological research; marine laboratories; writers in residence.

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INTRODUCTION

The human instinct to treat seamlessly what

we today distinguish as science, arts, and humanities has expression at least as deep as the Paleolithic cave paintings of western Europe



and Indonesia (Guthrie 2005). Great individuals, such as Michelangelo and Leonardo de Vinci, and 19th century natural history explorations, such as the voyage of the Beagle, embody this integration. Leading American conservation thinkers of the past century or two unified understanding of natural history with eloquent writing, based on sustained inquiry in inspiring and even humble places. John Muir had the monumental muse of the High Sierra, Henry David Thoreau the modest woodlot by Walden Pond, Aldo Leopold the old fields around his shack in degraded farm lands of sand country Wisconsin, Edward Ricketts the Great Tidpool close to his Cannery Row lab. Many amazingly creative contemporary individuals are producing a wealth of works bridging science, arts, and humanities, based in part on sustained, place-based inquiry. Examples include PhD-credentialed scientists who are acclaimed for their wide-ranging writings (e.g., Pyle 2000, Nadkarni 2008, Haskell 2012, Kimmerer 2013) and poets and essayists who strongly embrace science (e.g., Deming 1994, Sanders 2009). The enduring objective has been to understand the natural world and ourselves, and to share that knowledge for the betterment of others.

Science, arts, and humanities were once inseparable, then quite separated, and now, perhaps, reintegrating (Miller 2014). A recent surge of interest in linking arts and sciences is manifest in many forms, such as the frequent appearance of articles and reviews in *Science* that touch on the arts, the numerous art-science laboratories and environmental humanities programs sprouting up around the world, the Dance Your PhD competition, and the growing art-science programs based at National Endowment for the Arts. A rich variety of the arts and humanities is involved—visual arts, dance, song, all forms of creative writing, environmental ethics, history, and more. The motivations for promoting these science-arts interactions have been wildly diverse: achieve science outreach, stimulate creativity within individuals and interdisciplinary teams, and just have fun by unleashing creative urges, to name a few. New challenges and opportunities are on the horizon, such as mustering scientist-artist teams to tackle important, complex problems.

Among the sciences, ecology is especially well

suited for linking science, arts, and humanities to help connect people with the land. Unlike astronomy and nanotechnology, ecology embraces space and time scales directly accessible to human experience. The subject matter of ecology has strong, natural public appeal because it bears on species conservation, land stewardship, and use of natural resources. Interesting landscapes of ecological study, both wild and constructed, can be powerful stages for shared experiences and conversations with the public. Sustained, place-based inquiry that is an important feature of ecological research and education forms fertile ground for dissolving disciplinary boundaries. To the well-argued ecological reasons for investing in long-term ecological research (Callahan 1984), we can add the benefit of the time to build personal and interdisciplinary relationships that can mature and bear fruit. Infrastructure provided by investment in environmental sciences and education provides a foundation for engagement of arts and humanities—field facilities, field experiments, science-inspired stories, and cadres of inter-disciplinary scientists, students, and support staff. Field experience can be personally transformative, as the student Maud Brown stated in 1910 reflecting on returning from a collecting venture at the Iowa Lakeside Laboratory, “Little did I realize as I stepped ashore that I had reached a turning point in my life” (Lannoo 2012:10).

These factors and the accomplishments of creative, multi-disciplinary individuals have inspired the engagement of artists and humanists in many places dedicated to public appreciation of the natural world and to ecological research and education. US National Park Service (NPS) lands attracted artists in the 19th century even before their establishment as parks. The US National Science Foundation (NSF) supported the participation of artists and writers beginning in early stages of science programs in Antarctica in the 1950s. In contrast, involvement of artists and writers in programs at biological field stations, marine laboratories, and sites in the NSF-supported Long-Term Ecological Research (LTER) (*public communications*, <http://www.lternet.edu/>) network has been a grassroots effort, based on the initiative of single individuals and individual sites, which has grown dramatically in the past few years. Despite this

enthusiastic, widespread embrace of ecology-arts-humanities collaborations at dozens of sites, the programs are rather poorly known and the intensity of interaction among sites is quite limited.

In this essay I offer an overview of properties of these collaborations in their different institutional and geographic settings, which influence the roles of place, the strength of arts-science collaborations, and the nature of their outreach programs. I begin by introducing and contrasting the ecology-arts-humanities confluence at NPS, NSF-Antarctic, biological field station, marine lab, and LTER sites. Next, descriptions of ecology-arts-humanities programs at four LTER sites display the wide variety of approaches that have been employed to share outcomes of collaboration—public performances, scholarly and literary books authored by individuals and groups, art exhibits, creative writing, and education projects. Reflection on these collaborations reveals the durability, expanding scope, and future prospects of these programs.

CONFLUENCE OF ECOLOGY, THE ARTS, AND HUMANITIES IN SPECIAL PLACES

An brief overview of field-based, arts-humanities programs at collections of sites administrated from the top down (NPS and NSF-Antarctic) and from the bottom up (biological field stations, marine labs, and LTER sites) provides contrasting examples of program objectives; roles of place; strengths of interactions among ecology, the arts, and humanities; opportunities for the public to visit the sites; and the resulting outreach efforts. By tracing a few steps in the history of confluence of art, ecology, and the public in special places, we witness a trajectory of increasing numbers of programs and connection with ecology.

Stunning US landscapes attracted renowned, 19th century artists whose paintings were instrumental in establishing national parks, attracting visitors, and paving the way for formal artists-in-residence programs to be instituted much later (Winfrey 2011). Now more than 50 NPS properties—parks, monuments, preserves—offer artist-in-residence programs with the overarching objective to “engage people to make enduring connections to America’s Special Places” (*public*

communications, <http://www.nps.gov/subjects/arts/index.htm>). Many NSP places host several artists in residence per year and ask them to donate a work and conduct a public event. Past development of these properties for public visitation provides the infrastructure that accommodates resident artists. An on-line gallery shares examples of the wealth of visual, literary, and sonic art by professionals and art works by non-professional visitors (*public communications*, <http://www.nps.gov/subjects/arts/index.htm>), and a single web portal leads to links to the individual site programs, which are managed locally by agency and private foundation staff (*public communications*, <http://www.nps.gov/getinvolved/artist-in-residence.htm>, <http://www.nationalparksartsfoundation.org/>). A great deal of art and humanities work and sharing occurs outside the residency programs, as exemplified by the exhibit and book of art celebrating the centennial of Zion National Park (Zion Natural History Association 2008). Although ecological features are icons of many park land ecosystems and the artists’ works and statements display keen attention to natural history, the intensity of ecological research varies greatly from place to place, and there is little evidence of close links among artists, writers, and ecologists, except in special cases.

With early roots dating from the 1950s, the NSF’s Antarctic Artists & Writers Program has produced a wealth of impressive works with wide public exposure, although very few people have the opportunity to directly experience that stunning, exceedingly remote landscape (*public communications*, <http://www.nsf.gov/geo/plr/aawr.jsp>). The program’s purpose is “to enable serious writings and the arts that increase understanding of the Antarctic and help document America’s Antarctic heritage.” That heritage began as exploration, but has been strongly focused on science since the mid-20th century. Several artists per year encounter Antarctica through NSF’s three year-round stations, several ships, and numerous austral-summer field camps. The resulting body of works includes many forms of visual and installation art, fiction and non-fiction writing, and studies of the history of human presence. Ecology has been an important part of the Antarctic science program, especially in studies over the past

several decades concerning topics such as large, near-shore marine animals and the cryptic biology of terrestrial and freshwater environments. Artists and writers have tended to emphasize the stark physical landscape, and ecological themes make limited appearance in their works.

Biological field stations and marine laboratories (FSMLs) are “centers of scientific research embedded in the environment” to provide access to model ecosystems, logistical support, and a community of scholars (Billick et al. 2013). The earliest FSMLs were established in the late 19th century (Lannoo 2012), and by 2014 member sites of the Organization of Biological Field Stations (OBFS) numbered 255 and the National Association of Marine Laboratories had 144 member sites (F. Felix, *personal communication*). Staff at these sites and their home institutions, mainly colleges and universities, conduct research and/or education programs in field locations that are generally not destinations for public visitors. The strong natural history heritage and field settings serve as a foundation that prompted leaders of many individual FSMLs to initiate arts and humanities programs at an accelerating pace over the past decade. A survey in 2014 suggests that at least 40 FSMLs have some form of arts and humanities engagement (F. Felix, *personal communication*). Motivations for undertaking these programs include diversifying the intellectual environment of the participants, strengthening education programs by adding to student and class numbers, and promoting community outreach through artist and writer residencies that include a component of interaction with the local public. The long-standing artist residency program at Huyck Preserve and Biological Research Station, for example, aspires to “contribute to the community by enhancing environmental awareness through the aesthetics of art” (*public communication*, <https://www.huyckpreserve.org/comenart-program.html>). The resulting programs have been extremely varied in intensity of effort, artistic and literary media, and ways of connecting with local communities, as described on the FSML Art at Field Stations and Marine Labs blog (see November 16, 2014, posting, *public communication*, <http://fsml-art.blogspot.com/>). Some art and written works remain in the confines of classrooms at

field stations and marine labs, while others reach wide audiences, such as in the form of installation pieces in the field, galleries, and museums.

When the National Science Foundation (NSF) created the LTER program in 1980 without mention of arts and humanities, it unknowingly set the stage for strong development of such programs three decades later. Substantial, sustained funding for LTER has supported development of infrastructure for long-term research, including field facilities, long-term field experiments, information management systems, and interdisciplinary communities of scholars. All these factors contribute to engaging arts and humanities. The locations of LTER sites are very diverse, ranging from remote locations in Antarctica and the North Slope of Alaska to urban ecosystems of Baltimore and Phoenix. Other LTER lands are a mix of properties with histories of past natural resource extraction and in some cases interspersed with native ecosystems, such as found in experimental forests of the US Forest Service, five of which are also LTER sites. Some LTER sites are strongly allied with federal land management agencies, which increases the motivation and avenues for outreach to the land managers and the public. Research topics at most LTER sites mesh with conservation and natural resource management issues of their home bioregions, tightly linking site science programs with society and feeding the desire to involve arts and humanities in communications programs (Driscoll et al. 2012). A majority of the two dozen LTER sites has independently started arts and humanities programs with intensities ranging from a single artist in residence per year to major public performances, art exhibits in galleries, and residency programs for half a dozen artists and writers per year (Goralnik et al. 2015).

Many other sites and institutions have arts and humanities residency programs in natural environments; and in some cases connection with ecologists and the public is possible and even expected. Hundreds of individual artist- and writer-in-residence programs with much deeper roots in the arts and humanities than science are based in beautiful settings across the country. These are generally highly independent, privately-funded programs with a primary objective of supporting the arts. At least a few have expressed intention to connect with ecology, such

as the Sitka Center for Art and Ecology on the Oregon coast embedded within a U.S. Forest Service's Cascade Head Experimental Forest, where quite a bit of ecological research takes place. Large research centers, such as the Cary Institute of Ecosystem Studies in Millbrook, NY, bring arts, ecology, and sense of the local landscape together in programs for public outreach. A different model is used at Mount St. Helens in southwest Washington where the US Forest Service has convened writers and scientists in campouts on 5-year increments of the eruption anniversary (2005, 2010, 2015), and writings from these shared experiences have been documented in a book (Goodrich et al. 2008) and an on-line journal (terrain.org 2013).

ARTS AND HUMANITIES AT FOUR LTER SITES

Examination of four LTER sites with particularly vibrant arts and humanities programs displays the level of effort, accomplishment, and diversity of approaches now being pursued. In many cases the arts and humanities activities align significantly with ecological science objectives of the LTER programs. Some funding for ecology-arts-humanities collaboration in these programs has come from NSF, but most has been from other sources, including the home universities, private arts/humanities institutions, and the US Forest Service.

Harvard Forest LTER Site (Harvard University, Petersham, MA)

The central theme of Harvard Forest LTER program has long been environmental history—and more recently the future of the New England landscape as shaped by both human and wild forces, such as sprawl and other development, hurricanes, pests and pathogens of tree species, and vegetation succession (Foster and Aber 2004). Harvard Forest investigators chart trajectories of land change by drawing on detailed archival, observational, archaeological, and paleoecological scientific sources; the technical and evocative literary depictions of the mid-19th century landscape by Henry David Thoreau; and artistic representations of land use legacies and ecological change (Figs. 1 and 2). Depictions of these trajectories are presented in simulation models, artistic works, narrative exploration, and

formulation and promotion of the Wildlands and Woodlands regional forest conservation strategy (Foster et al. 2014).

The arts and humanities have been part of the Harvard Forest program since its origins in 1907 under the direction of writer, artist, and forester Richard Fisher. The expression of artistry expanded in 1930s when intricately crafted scale models (dioramas) representing stages of land use and forest succession in the local landscape went on public display in the Fisher Museum at the Forest, and were highlighted in director Hugh Raup's essay *The View from John Sanderson's Farm* (Raup 1966). Several books published in the past two decades further represent the important roles of literature and visual arts in the Harvard Forest program. David Foster's (1999) book *Thoreau's Country: Journey through a Transformed Landscape* containing a selection of Thoreau's journal entries and Foster's own context-providing and at times autobiographical text paint a literary portrait of the sights, sounds, fragrance, and human presence of the mid-19th century New England landscape (Fig. 3). The book is richly illustrated with artist Abby Rorer's paintings of the nineteenth century landscape. The Thoreau connection combines authentic documentation of land and human conditions, keen insights to ecological processes, high literary quality, a sense of land ethic, and the opportunity to readily reach the many Thoreau aficionados throughout the region and beyond.

Foster and colleagues followed 15 years later with the book *Hemlock: A Forest Giant on the Edge* that masterfully blends a literary non-fiction Foreword essay by the writer Robert Sullivan, fine photography, quotations from luminary poets and other writers of the region, and the scientists' descriptions of not only science and conservation implications, but also how they feel about the loss of the iconic hemlock from their forested landscape (Fig. 4) (Foster 2014). The intent is to convey past and future dynamism of the land through waxing and waning of this tree species—a key component of the ecological and social landscape.

Overall, the Harvard Forest arts and humanities messages are about understanding, acknowledging, and respecting both the human and natural processes influences in the dynamic New England landscape—past, present, and



Fig. 1. Land use legacies in the New England landscape of Harvard Forest appear in the soil, vegetation patterns, and stone structures dating from the 18th- and early 19th-century agricultural period. Artist Debby Kaspari depicts many forms of stone structures, including this Poor Farm barn foundation in Petersham, MA. Graphite and pastels on paper.

future. Half a dozen artist residencies at the Forest, both short-term (1 week) and long-term (1–3 years), have resulted in large bodies of artwork (photography, writing, painting, installations, and film) displayed at public exhibits in regional art galleries, at the Harvard Forest Fisher Museum, and at national science conferences. Forthcoming books from these residencies include a collection of photographs and literary essays depicting Harvard Forest long-term ecological research themes and a book of literary journalism that explores environmental change from the perspective of a single, much-studied tree in the Harvard Forest. Increasingly, art, writing, and visual communication workshops—taught by former or current artists-in-residence—have become a fundamental part of

the Forest’s interdisciplinary course offerings for undergraduate students.

Bonanza Creek Experimental Forest and LTER Site (University of Alaska and US Forest Service, Fairbanks, AK)

For more than half a century interdisciplinary teams of scientists based in Fairbanks have been investigating how climate and wildfire influence forest succession and ecosystem processes in Interior Alaskan boreal landscapes (Chapin et al. 2006). Recent changes in climate and disturbances regimes are affecting forest composition and function, and influencing the nature of ecosystem services provided to rural and subsistence, including Alaskan Native, communities (Chapin et al. 2010). Patterns of and consequenc-



Fig. 2. Debby Kaspari created this image titled “Hemlock Grove with Chestnut Skeletons” with the fallen chestnut bole caught in an upright eastern hemlock. The chestnut succumbed to an introduced pathogen early in the 20th century and eastern hemlock is being lost to the introduced hemlock woolly adelgid. Graphite and pastels on paper.

es for social-ecological interactions and change are integral to research in the Bonanza Creek LTER program, which prompted engagement of the arts and humanities.

A 2007 gathering of artists and scientists at the

site of an unprecedented 2004 forest fire initiated a collaboration involving many creative people and science and arts institutions within the Fairbanks community. This led to a series of programs under the overarching theme “In a

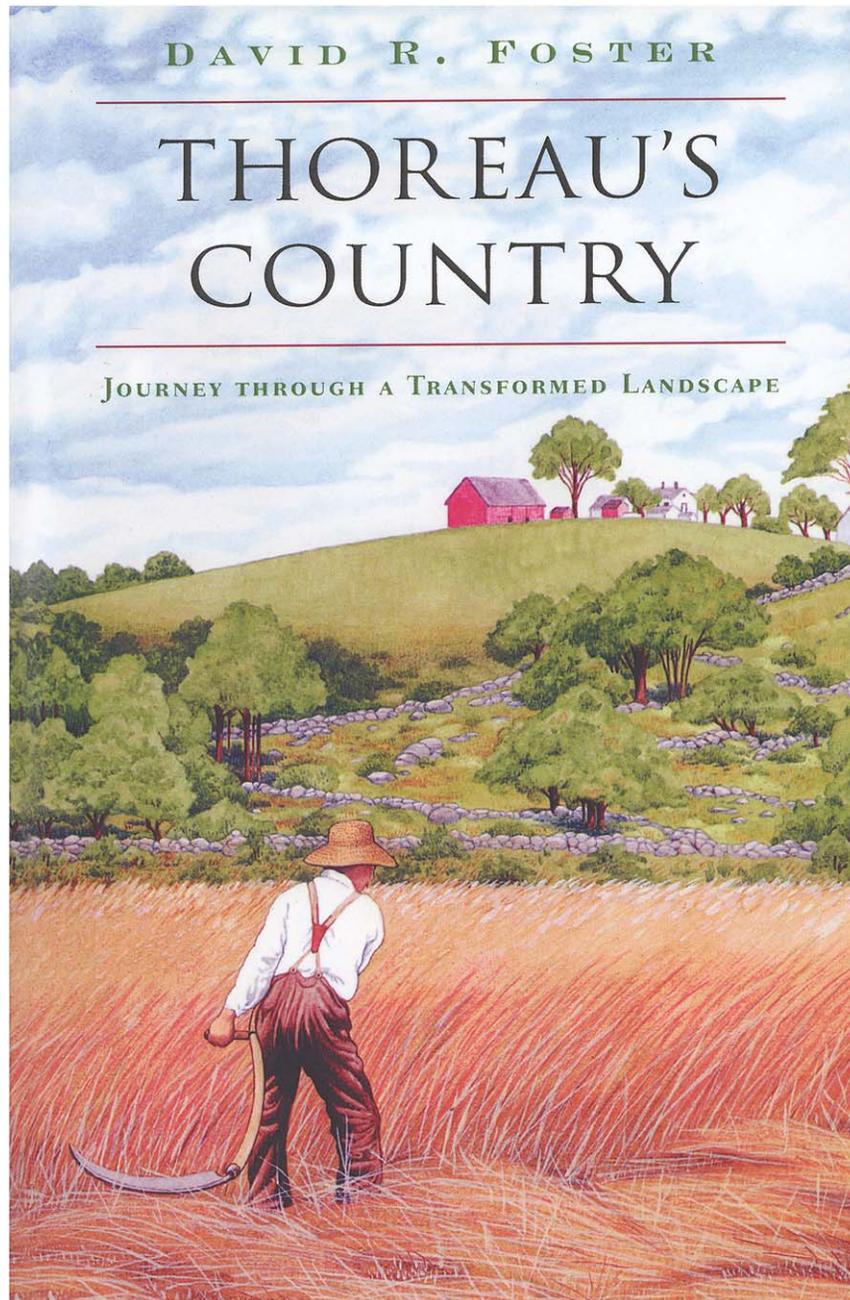


Fig. 3. Cover image of *Thoreau's Country: Journey through a Transformed Landscape* by David R. Foster (1999) appears courtesy of Harvard University Press, copyright 1999 by the President and Fellows of Harvard College. The watercolor illustration by Abigail Rorer depicts the New England landscape during the agricultural era Thoreau vividly describes. Design by Annamarie Why.

Time of Change” with specific thematic foci for a sequence of programs: “A performance by writers, artists and scientists” (2008), “Envisioning the Future” (2010, Fig. 5), “The Art of Fire”

(2012), and “Trophic Cascades” (2013). Planning for the “Envisioning the Future” program began with field trips including scientists and competitively selected artists to share perspectives

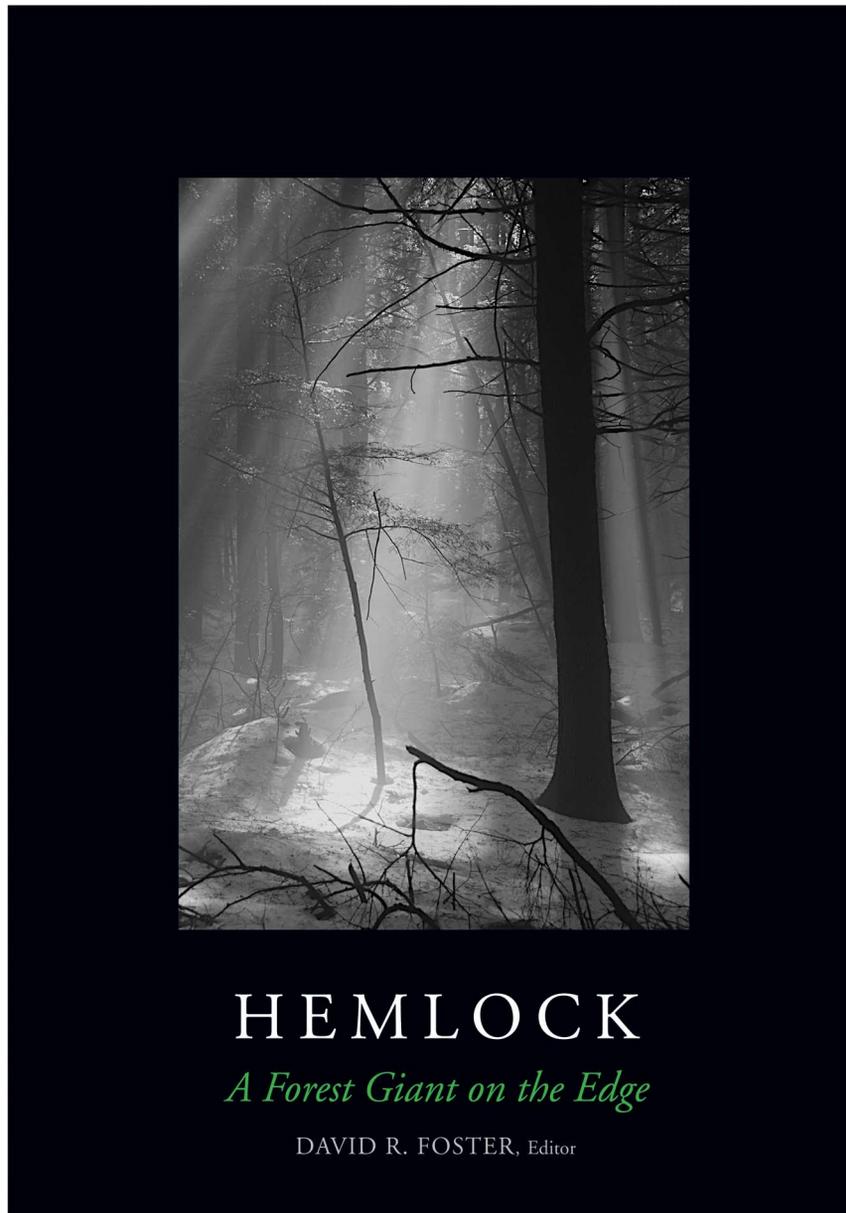


Fig. 4. Cover of Foster (2014) which reports on the science of hemlock decline to the introduced woolly adelgid as told through the lens of environmental arts and humanities. Cover photo: “Mist rising from the snow in a hemlock woods on the Harvard Forest.” David Foster.

across science-arts and native-western world-views. This preparation led to public performances and exhibits featuring original visual arts, creative writing, music, modern dance, Alaska Native traditional dance, and theatre, exploring consequences of environmental change imposed by climate warming, removal of keystone species, and other forms of ecological

change. In addition to professional artists, writers, and dancers/choreographers, performers were also drawn from the cadre of scientists and the larger community. The “Envisioning the Future” program included scientists playing varied roles: a senior scientist described how he feels about changes occurring on the land, a microbial ecologist and colleagues choreo-

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Fig. 5. The poster for the 2010 “In a Time of Change: Envisioning the Future” program advertises both the public performance and the exhibit of visual art at the Bear Gallery in Fairbanks. Fred Freer’s acrylic painting in Fairbanks, representing effects of warming on high-latitude marine ecosystems, serves as the backdrop.



Fig. 6. The Bonanza Creek LTER 2010 program “In a Time of Change: Envisioning the Future” featured: A. a senior scientist publically testifying to his concern for the wellbeing of Interior Alaska ecosystems and the planet, B. scientists and actors performing a skit about the intersection of their disciplines, and C. the Deliquescent Designs troupe dancing post-fire vegetation succession. Photo credit: James Barker.

graphed and danced a piece based on post-fire forest succession data, and scientists joined non-scientist actors to perform scenes exploring the nature of artistic and scientific pursuit (Fig. 6).

The success of the first two programs led to federal Joint Fire Sciences Program funding of the 2012 “The Art of Fire” program to explore the value of arts and humanities in communicating with the public and fire managers about issues relating to wildland fire. Preparation began with artists, fire managers, and ecologists sharing their worldviews and experiences in the field. Artists observed smokejumper training and prescribed fires, collected forest succession data with plant ecologists, visited Bonanza Creek LTER site, and then expressed their perceptions in new works, which were displayed and discussed through a

lecture series featuring artists and scientists (Fig. 7). A concurrent community art exhibit about fire science featured visual art by fire scientists, land managers, and fire fighters.

These public events stimulated Denali National Park and Preserve staff to enlist the Bonanza Creek group to create a “Trophic Cascades” event on “the premise . . . that art and science bring different, yet synergistic, perspectives and approaches to the natural world. Collaborations of art and science can engage people at the intellectual, intuitive and emotional levels, and more effectively strengthen society’s sense of place in the environment” (*public communication*, <https://sites.google.com/a/alaska.edu/itoc-trophic-cascades/home>). Scientists and artists joined for two field trips—one to Denali National



Fig. 7. Spruce Smoke. Fiberart of an Interior Alaska forest in flames, the immediate aftermath, and the soil refuge belowground by the widely acclaimed Alaska artist Ree Nancarrow. She says that the temporal viewpoint of landscape change held by Bonanza Creek LTER ecologists has inspired her to introduce the dimension of time into her work. Photo credit: Eric Nancarrow.

Park and Preserve and one to Bonanza Creek LTER site—to exchange views of the changing Interior Alaskan landscape in the face of shifting animal populations, wildfire regime, and climate change. A gallery exhibit in Fairbanks shared the works with the community (Fig. 8).

Over three thousand Fairbanks community members have attended the performances and gallery exhibits held in recent years. Extensive coverage in local media added to the reach of the programs into the community. Touring exhibits and components of the performance reached audiences in Anchorage, AK, Washington, DC, Portland, OR, and New York, NY. Arts and humanities continue to be an important part of the Bonanza Creek LTER program and are expressed in many forms designed to reach

diverse audiences. A new project focuses on the many roles of microorganisms in environmental health with funding from an individual Principal Investigator's NSF research grant, Bonanza Creek LTER, and other sources. The project will generate arts and humanities productions on the scale of past events, while adding new components like an artist-in-residence, a classic horror film series exploring the science of science fiction, hands-on microbial art activities for K-12 classrooms and public events, and integrative art and environmental science activities that integrate native knowledge for rural Alaska Native schoolchildren.



Fig. 8. “Red Fox with Prey” by Todd Sherman showing part of the complex trophic cascade within Interior Alaska ecosystems was part of the Bonanza Creek LTER Trophic Cascades program. Sherman comments “works reflect my ideas of animals and landscapes idealized and simplified from the complexities of the natural world.” Here he uses a cut-out technique to give a “just barely” three-dimensional sense.

*North Temperate Lakes LTER Site
(University of Wisconsin, Trout Lake, WI)*

Since the 1920s the focus of the Trout Lake Station in the Northern Highlands of Wisconsin has been to understand the composition and function of lakes at broad time and space scales. This ecological work ramped up with designation as an LTER site in 1981, and with the LTER program also came motivation and resources to investigate the deep connections between human communities and lakes, which center their lives (Magnuson et al. 2006). Invasive species, residential development of lake shores, and climate change, manifest in part by declining duration of lake ice cover, are accelerating change. New and more effective forms of interaction with regional residents are needed.

An exhibit titled “Paradise Lost? Climate

Change in the North Woods” (*public communication*, <https://lter.limnology.wisc.edu/ltearts/paradise-lost>) was the inaugural involvement of arts and humanities with the North Temperate Lakes LTER program. In 2006, 20 artists and 13 scientists and educators visited habitats and ecosystems in Wisconsin’s northwoods and shared knowledge about climate change and other impacts on lake and forest ecosystems of the upper Midwest. The artists’ media included visual arts, poetry, prose, and music. To encourage a deeper collaboration, the artists learned about science while the scientists were challenged to express concepts in art form and learn about the methods and philosophies of professional artists. Following this exploration, the group developed a travelling exhibition of art works complemented with relevant science text



Fig. 9. This watercolor titled “Vanishing Act” by artist Melinda Schnell represents effects of an invasive species. Schnell explains, “The school of walleyes in this painting is fading away as the rainbow smelt increase in numbers. Over a period of time the rainbow smelt could seriously deplete the game fish we prize in our northwoods lakes.” The progression of species interactions over time is shown in two panels from left to right with the loss of walleyes.

displayed together in 15 venues in three upper Midwest states over three years. The exhibit included a paludarium containing a living bog microcosm, a film with music, and a variety of interpretive panels and props to make the show interactive. The work of the project was published as a catalog for the exhibit (*public communication*, http://www.biology.wisc.edu/documents/paradise_lost.pdf). More than 100,000 people viewed the exhibit. Joint artist-scientist presentations at the openings of most exhibits and local media coverage spread the word about environmental change and the nature of environmental science even more broadly. During the course of the exhibit, over 2,500 school students participated through a

series of climate change and art lessons, leading the students to produce art works for the exhibits and attracting a broader audience to the shows.

The success of “Paradise Lost?” inspired the North Temperate Lakes LTER group to create a second art-science collaboration in 2011. Six scientists, five artists, and a poet worked together to develop the “Drawing Water: Artists and Scientists Explore Northern Lakes” traveling exhibit. That exploration focused on understanding how the ever-changing character of the landscape imposed by climate variability, human development activities, and changes in plant and animal distributions has affected lakes and the larger landscape. These works were displayed at the annual conference of the Wisconsin Associ-



Fig. 10. Of her watercolor “C Note” Ann Singaas comments, “We tend to think of water flowing through a landscape as only the pure substance, H₂O, but a body of water carries with it many other constituents, most of which are carbon based. The structure of the hundred-dollar bill is used as a framework to illustrate all that is involved in determining the role of lakes in carbon flux and the value of this research as we strive to understand and communicate the role of carbon in climate change.”

ation of Lakes and at four public venues in the northern Wisconsin lakes region. Some works delivered ecological messages, including effects of invasive species on native fish communities and whole lake ecosystems (Fig. 9), carbon dynamics of lake ecosystems (Fig. 10), and visual commentary on the diversity of bog lake ecosystems (Fig. 11). Each piece was accompanied by a concise explanation of the science relevant to the art, as well as stand-alone interpretive science panels with text and figures presenting information to community members. Large signs with distillations of these messages were also posted at selected, busy boat landings. An overarching objective in displaying these works to both the public and especially leaders of lake associations was to raise awareness of how lakes function as ecosystems so that local residents can devise and implement appropriate management approaches.

An artist-in-residence program piloted at North Temperate Lakes LTER in 2013 aims to engage an artist at the research station each year who collaborates with research staff, participates in an education open house for the public, and donates an art piece to the program. One of the early fruits of this program was the 2014 artist’s portrayal of some of the interesting tools of

science (Fig. 12).

*H.J. Andrews Experimental Forest LTER Site
(Oregon State University and US Forest Service,
Blue River, OR)*

The focus of ecosystem research at the H.J. Andrews Experimental Forest since its establishment in 1948 has been to understand structure, function, and dynamics of native forests and rivers of the Pacific Northwest and the effects of land use and environmental change in the mountain landscape. For several decades the Andrews Forest LTER program has worked on a central question: how do land use, climate variability, and natural disturbances affect key ecosystem properties, including hydrology, biogeochemistry, and biodiversity? Such basic science has frequently become socially relevant as contentious environmental issues have played out over years. Fundamental work on old-growth during the 1970s collided with evolving public sentiment in the 1980s to set the stage for a major shift in federal land forestry from timber production to biodiversity and old growth conservation in the 1990s (Spies and Duncan 2009). Adapting stories from science, photographers and writers helped drive that transition and well-crafted non-fiction writing advanced



Fig. 11. In her pastel “The Secret Life of Crystal Bog” artist and field biologist Terry Daulton depicts a few of the great variety of species occupying bog lakes of northern Wisconsin, where they are at the southern edge of their range and beginning to show signs of vulnerability to climate warming. Her attention to their beauty encourages viewers to consider the impacts of climate change to these iconic ecosystems.

public understanding of the science (Luoma 2006). While scientific understanding of old-growth forests and northern spotted owls, a species listed as threatened under the Endangered Species Act, played a big role in the policy shift, the battle over the future of federal public forest lands was fundamentally a matter of competing values—forest resource consumption vs. conservation of species and ecosystems.

This experience of conflict at the science-public interface helped motivate the Andrews Forest group to team up with philosophers and creative writers to establish a Long-Term Ecological Reflections program patterned on LTER research in the early 2000s. The intent of the Reflections program is to gather a long-term record of creative reflection on the natural world and our

relationship with it (Swanson et al. 2008). The Andrews Forest Reflections program has at its core two writer residency programs (one by invitation and one by application) and periodic gatherings of about 20 folks with diverse views on diverse topics, such as the meaning of watershed health and the exploration of new metaphors for restoration of forests and watersheds. As with LTER science, the Reflections program intends to be place-based, including incorporating sense of place in the works; take the long view (200 years is the stated horizon); collect, archive, and actively share the works; incorporate arts and humanities in education programs; and periodically step back and assess the works from the home site and at the scale of multiple sites/programs.



Fig. 12. Northern Temperate Lakes LTER 2014 artist-in-residence Helen Klebesadel painted this watercolor, titled “Tools of the Trade,” of floats that support equipment used to ‘mix’ Crystal Lake as part of whole-lake experiments.

While this work has yielded individual insights, its most important gift has been the great breadth of engagement with the land—an exploration and celebration of long-term ecological inquiry. Since the program began in 2002, more than 50 writers in residence have produced an extensive body of work inspired by the forest and streams, science findings, and approaches to long-term science. The writings have appeared in high-profile journals, such as *Orion* and *The Atlantic*, and they have been presented before live audiences totaling several thousand. The writers express their belief in the value of writer-scientist collaborations, as Alison Deming (2006) states,

“The song of a thrush flutters through the quiet, the auditory equivalent to seeing an orchid in the forest. Beauty is what I came here for, a beauty

enhanced not diminished by science. What a record we might have of the world’s hidden beauty, if field scientists and poets routinely spent time in one another’s company.”

And botany professor-writer Robin Kimmerer (2004) echoes this sense of importance in bringing the intellect and spirit together in the forest,

“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. The data may change our minds, but we need poetry to change our hearts.”

Philosophy professor-writer Kathleen Dean Moore tells her scientist friends, “You feed our



Fig. 13. In this image titled “Stump 2014.19” Bob Keefer shows western hemlock saplings growing on the stump of an old-growth Douglas-fir cut 50 years earlier. Land use legacies in Pacific Northwest forests are etched in big, old stumps and cull logs with cut ends, in contrast with the land use legacies of New England etched in stone (Fig. 1). Hand-colored, black-and-white photograph.

astonishment.” Writers see the research work itself, such as long-term field experiments, in emotive terms the scientists themselves seldom use, such as the faith, empathy, and love. In the context of ecologist Mark Harmon’s 200-year log decomposition experiment, Robert Michael Pyle (2004) reflects,

“To peer much further down the line requires not only empathy for those who follow, but also faith in the future, even if you won’t be there to see it for yourself. . . . Maybe looking to the future is a way of hoping there will still be something to see when we get there. Maybe it’s the only way to make sure of it.”

And the writers sense our close relations with the place and its creatures, as Deming (2006)

expresses after her hour-long stare-down with a northern spotted owl,

“We exchange the long, slow interspecies stare—no fear, no threat—only the confusing mystery of the other.”

A book of these, other writers’ works, and descriptions of the science context marks the first decade of the Andrews Forest Reflections program (Brodie et al. 2016).

Over the past few years arts and humanities have permeated many parts of the Andrews Forest program. Artists are recent arrivals, including Bob Keefer, whose medium is hand-colored, black-and-white photographs (Fig. 13), and painter Leah Wilson (Fig. 14), who has made a career-long commitment to creating artwork at



Fig. 14. Abstract artist Leah Wilson drew inspiration from engravings by bark beetles on the freshly-fallen bole of a massive old-growth tree in this work titled “Beetle Drawing I.” Gouache on paper.

the Andrews Forest. Art and humanities have been integral to field courses for middle school and university students. Perhaps the most telling embrace of humanities by the Andrews Forest program has been designation of an environmental philosopher as LTER Principal Investigator and incorporation in environmental ethics in the research program.

ACCOMPLISHMENTS AND CHALLENGES FOR ECOLOGY-ARTS-HUMANITIES PROGRAMS

This quick survey of place-based programs with ecology-arts-humanities interaction suggests that on the order of 100 sites in the US have some form of arts/humanities programs with commitments to environmental research and education, counting about 20 of the 25 LTER sites, at least 40 biological field stations and

marine labs, some of the approximately 50 NPS sites with artist/writer residencies, and a sampling of NSF’s Antarctic research stations. The roles of place are strong in all cases, but incredibly varied across the great range of sites from the South Pole to large urban centers in the cases of several LTER sites. The degree of connection between artists/writers and ecologists varies greatly among the institutional settings and other circumstances of individual sites. Fruitful one-on-one partnerships can be exceptionally rewarding in a variety of situations, but major confluences are probably more common in large, place-based communities dedicated to ecological study, such as LTERs. Motivations for undertaking this work vary among programs within and among these diverse institutional settings, but a common denominator has been outreach to the public. The types of arts and

humanities expression also vary widely among programs, as evident in the four LTER site examples, including books blending art and literature; public, multi-media performances; display of collections of visual art; creative writing of many genres; and connections with philosophers.

Intensive ecology-arts-humanities interaction has accomplished a great deal. It has communicated science-inspired stories to diverse audiences. Artists and writers have enabled scientists to see ecosystems and their own work in new ways. The work reveals scientists' passion and the emotional motivations—hope, faith, love—for doing science and for the ecosystems they study. It has enhanced the cultural and scientific value of places of sustained inquiry. Field experiments have transformed into installation art, triggering conversations far beyond the scope of the scientists' intentions. Multi-talented people find opportunities to express themselves—the photographer, dancer, novelist, and poet disguised as working scientists. Some work has contributed to near-term outcomes of science outreach, such as public understanding and action on issues like climate change and invasive species. Other work can be viewed as “basic” arts and humanities in the sense that its impacts won't be known for a long time.

The four case studies at LTER sites display outcomes ranging from the particular to the general. Art featuring stone structures at Harvard Forest and massive stumps at Andrews Forest, both enshrouded in forest, prompt reflection on land use legacies that are central features of these landscapes (Figs. 1 and 13). Public events in the forms of performances at Bonanza Creek and traveling art exhibits from the North Temperate Lakes program show how these media bring artists, writers, and scientists together and how they can reach broad audiences, even in rural areas. But, in the long run the common, overarching impact of this work is likely to be its exploration and celebration of long-term ecological inquiry from many points of view.

Intensive ecology-arts-humanities collaborations face several immediate challenges. Three important features of these programs lag well behind expectations for the science programs with which they are commonly associated. Long-

term science funded by NSF, for example, places high priority on information management that includes secure archiving, high standards for quality control, clear cataloging and documentation, and public access. No analogous system for archiving and access exists for arts and humanities works, which can be considered forms of “cultural data” that form a growing record of artistic, contemplative, and scholarly reflections documenting society's engagement with the natural world. Second, organized networking has become an important part of the US LTER, field station, and marine lab communities for the purposes of mutual support, and the LTER network has matured to the point of being able to conduct multi-site experiments and science synthesis (Robertson et al. 2012), but work in the arts and humanities has not yet achieved a comparable intensity of network communication and collaboration. Some progress in communication among ecology-arts-humanities programs is underway through workshops at periodic FSML and LTER meetings, blog postings (*public communications*, <http://fsml-art.blogspot.com/>), and a website with profiles for only a fraction of relevant sites (*public communications*, <http://www.ecologicalreflections.com/>); but much work remains. Multi-site art exhibits by the LTER network in the halls of NSF and at Ecological Society of America (ESA) and LTER All-Scientists meetings reveal the potential for study of works across many sites. Finally, little formal assessment has been done of these programs. Funding has been piece-meal and small scale, so formal assessment processes characteristic of large grants and granting institutions have not been required. A recent survey of LTER Principal Investigators (PIs) reveals that a majority (19 of 24) agree or strongly agree that arts and humanities potentially have important places in their programs (Goralnik et al. 2015). The PIs consider this work to be worthy of investment in its own right and to be integral to outreach and public involvement. Fundamentally, they perceive engagement of arts and humanities as inspiring creative thinking among both scientists and humanists and as a way to address environmental ethics issues prevalent in research and conservation topics at many sites. In practical terms, the number and diversity of programs undertaking the work and their lon-

gevity attest to the perceived value of the work.

LOOKING FORWARD

What does the future hold for ecology-arts-humanities work at sites of long-term ecological inquiry? The persistence of NPS and NSF-Antarctica programs for many decades and of field station, marine lab, and LTER programs for years argues that this work will continue. The recent, rapid development of such programs at field stations, marine labs, and LTER sites indicates that these collaborations are poised to grow in the coming decades, fueled in part by the growing recognition of the work and its accomplishments. These developments also suggest that there exists untapped potential for new programs to get underway.

A further reason to expect advancement of ecology-arts-humanities collaboration is the ecological science community's recent sense of urgency for understanding the coupled social-ecological system in terms of sustainability, ecosystem stewardship, ecosystem services, depiction and assessment of alternative future scenarios, and formulation of bioregional conservation strategies. All of these perspectives reflect a drive to prompt, lead, and participate in reframing our relation with the natural world. Efforts to invigorate appreciation of traditional ecological knowledge and natural history are also part of reconnecting humans with nature. The arts and humanities can be, and in some cases have been, integral in these initiatives.

Further steps in the ecology-arts-humanities intersection will include extension of past efforts, such as those described for the four LTER sites, and also taking on new challenges. As existing programs mature, they may cultivate the next generation of boundary-spanning luminaries, nurture new relationships of science with society, and expand the body of information about how science and society perceive ecosystems. New efforts at this inter-disciplinary interface may take several forms. In the parlance of NSF proposal evaluation criteria, much of the work to date has been "outreach" to students and the public, but the time is ripe to address the "intellectual merit" of tackling complex problems posed by dynamic ecosystems in new ways using more inter-disciplinary approaches than in the

past. An additional, in some cases complementary, area of work is inclusion of environmental ethics in future collaborations. Although, many topics of ecological research at these sites involve issues with an environmental ethical dimension, such as those related to resource extraction, conservation of species, and environmental justice, very few offer that training and senior staff may be ill prepared to deal with the ethical aspects of issues. Advancing the effectiveness of ecology-arts-humanities collaborations will require continued change in all the communities involved.

The benefits from melding of ecology, the arts, and humanities in places of sustained inquiry will surprise us. Expeditions for natural history exploration were an important venue for collaboration ripe with unexpected outcomes, especially in the 19th century, as multi-disciplinary teams ventured across unexplored geography. Many 19th century naturalist explorations were well staffed with illustrators and artists, such as Thomas Moran with Hayden's Yellowstone Expedition of 1871 and the Powell expedition down the Colorado River, and the Harriman Alaska expedition of 1899. Much of geographic exploration of the earth is complete, but the need is now great for intensively observant, deeply thoughtful, highly interdisciplinary, place-based expeditions through time in a changing global environment. Sites of long-term, ecological inquiry involving science, arts, humanities, and many other perspectives, including traditional ecological knowledge and cultural views, are essential to assess, portray, value, and achieve desirable futures. I hope this will be a central feature of the next century of ESA.

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