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Edited by Hannah Star Rogers, Megan K. Halpern, Dehlia Hannah, and Kathryn de Ridder-Vignone

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Hemlock Hospice

Landscape ecology, art, and design as science communication

Aaron M. Ellison and David Buckley Borden

Hemlock Hospice: overview and rationale

Hemlock Hospice was a series of eighteen site-specific sculptural installations that we co-designed and situated along a 1,500-meter-long (≈1 mile) interpretive trail at the Harvard Forest in Petersham, Massachusetts.[1] It presented a visual and interactive narrative about the

Figure 29.1 Wayfinding Barrier No. 1 and X-Trail Closure (2017)

Installations at Harvard Forest. Wayfinding Barrier No. 1: 1.5 × 3.75 × 4 feet; wood, acrylic paint, vinyl, assorted hardware, aluminum tape, and recycled field equipment (heat lamp and ant-nest boxes); X-Trail Closure: 10 × 10 × 3 feet; wood, acrylic paint, vinyl, and assorted hardware; Collaborators: David Buckley Borden, Jack Byers, Aaron M. Ellison, and Salua Rivero.Photograph: David Buckley Borden.

As the first installation on the Hemlock Hospice trail, the Wayfinding Barrier and X-Trail Closure not only rerouted visitors but also prompted visitors and scientists alike to reflect on how slow and subtle environmental changes alter our daily lives by changing familiar paths to unfamiliar ones. The "yellow" natural history trail was one of Harvard Forest's oldest natural history trails; for more than three decades, it was used daily by dozens of visitors and onsite staff. In 2014, as eastern hemlocks within this old-growth hemlock stand began to disintegrate as the trees succumbed to the depredations of the hemlock woolly adelgid, the yellow trail was closed because of safety concerns for visitors who use it regularly for recreation and occasional hunting.

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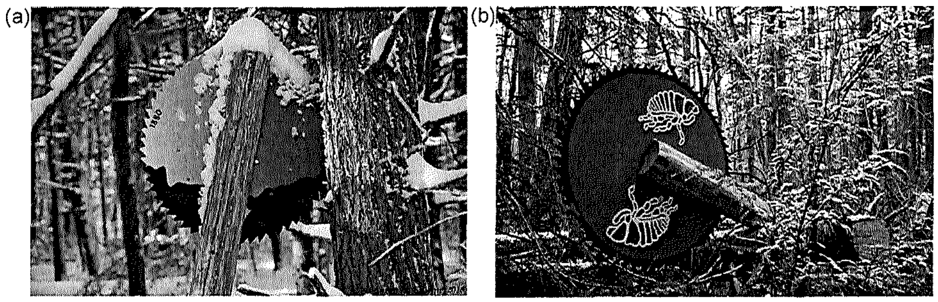

Figure 29.2 Double Assault (2017)

Installation at Harvard Forest. Variable dimensions; acrylic paint, wood, vintage sawmill saw blades, and assorted hardware; Collaborators: David Buckley Borden, Jack Byers, Aaron M. Ellison, and Salua Rivero; Photographs: David Buckley Borden and Aaron M. Ellison.

Interactions between climatic warming and the insect have led to a "double assault" on the trees. In the last century, average annual temperatures in New England have increased by nearly 1.5°C (>2.5°F) in parallel with the industrialization of the economy and the unsustainable burning of fossil fuels. Eastern hemlock favors cooler climates, and it is stressed by warmer temperatures. At the same time, winter minimum temperatures of −25°C (−13°F) or lower kill at least 50% of the adelgids (Costa et al., 2008). Because winters generally are colder further north where hemlock is more common, winter low temperatures historically have prevented the adelgid from spreading quickly (Fitzpatrick et al., 2012). Winter low temperatures colder than −25°C used to be the norm in southern New England, but now, they are very unusual. For example, the last time it was that cold in Groton, Connecticut was in 1983; the adelgid established there in 1985. For Harvard Forest, it was last that cold in 2004 and the adelgid was well established at Harvard Forest by 2009 (Ellison, 2014). There was a brief dip to −29°C in early 2018 at Harvard Forest (Boose, 2018), but by then, the rapidly reproducing adelgid had evolved substantially with greater tolerance to extreme cold (Butin et al., 2005). Whereas its populations used to take several years to recover from a cold winter, now, they bounce back within only a few months.

introduction of a nonnative insect (the hemlock woolly adelgid), the associated decline of a dominant forest tree (eastern hemlock), and a glimpse of New England forests of the near future. *Hemlock Hospice* was also designed intentionally to encourage people to reflect on how to interact empathetically with trees, insects, and forests (Figure 29.1). Finally, *Hemlock Hospice* was contextualized locally, regionally, and globally. Research scientists and support staff who work at the Harvard Forest daily witness the inexorable decline of this particular forest stand. Visitors from New England see in the decline of hemlock at Harvard Forest other ongoing forest declines caused by insects and pathogens throughout this region (Lovett et al., 2016). And forest declines around the world are accelerating because of human-caused climate change (Perie and de Blois, 2016; Figure 29.2).

Hemlock forests, hemlock decline, and the hemlock woolly adelgid

Eastern hemlock (*Tsuga canadensis*) is an evergreen tree related to pines, cedars, larches, firs, and spruces. For the last eight millennia, eastern hemlock has been a "foundation species" in eastern North American forests: it exerts disproportionate control on biodiversity, energy flow, and nutrient fluxes in the forest (Ellison, 2014). The dense canopy, shaded understory, and quiet soft soil built up from centuries of shed needles of eastern hemlock forests also has inspired some of America's great poets (e.g. *I think the Hemlock likes to stand* [F400 (1862) in Dickinson, 1998] and *Dust of Snow* [Frost, 1923]).

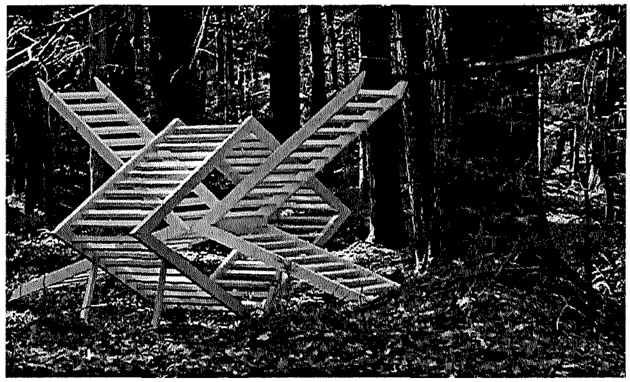

Figure 29.3 Insect Landing (2017)

Installation at Harvard Forest. 4 × 6 × 6 feet; recycled wood, acrylic paint, and hardware; Collaborators: David Buckley Borden, Jack Byers, Aaron M. Ellison, Salvador Jiménez-Flores, C. C. McGregor, Patrick Moore, Salua Rivero, and Lisa Ward; Photograph: Aaron M. Ellison.

The hemlock woolly adelgid was first documented in eastern North America in 1951, imported inadvertently by a plant nursery in Richmond, Virginia on Japanese hemlock trees from Osaka, Japan (Havill et al., 2006). It had been reported previously in the 1920s in British Columbia, where it feeds on western hemlock (*Tsuga heterophylla*) and mountain hemlock (*Tsuga mertensiana*) (Havill et al., 2016) with little ill effects. Once established in the eastern United States, the adelgid spread northeast into Pennsylvania (again, most likely via the horticultural trade) and southern New England (Fitzpatrick et al., 2012). It subsequently moved southwest into the Shenandoah and Great Smoky Mountains, then crossed the Appalachian Mountains and continued its spread west and north. As of 2018, the adelgid occurred in ≈90% of the range of eastern hemlock and in all populations of the much more narrowly distributed Carolina hemlock, *Tsuga caroliniana* (Canadian Food Inspection Agency, 2017; USDA Forest Service, 2017).

The colonization of North America by the adelgid, like that of other nonnative species, is strongly linked to transboundary shipping and the global economy (Bradley et al., 2012; Lovett et al., 2016). Its regional spread is linked as much to economic activities and transportation networks as it is to the prevalence of a suitable host plant and a hospitable climate. Local actions to manage ecological systems must account for regional, national, and international activities. The clarion call of the first Earth Day (1970) to "think globally, act locally" still applies today, nearly fifty years later.

In the early 1950s, a tiny mealy bug-like insect native to northeast Asia, the hemlock woolly adelgid (*Adelges tsugae*), was detected in Virginia (Havill et al., 2006; Figure 29.3). Spread by wind, birds, and people, it feeds on and kills eastern hemlocks of all ages and sizes. Although adelgid infestations on one or a few trees are controllable with regular applications of insecticides, these are infeasible for treating large numbers of trees in dense forest stands. Biological control measures for the adelgid are being investigated but have not yet proven effective in controlling it at landscape scales (Sumpter et al., 2018; USDA Forest Service, 2017).

Responses to hemlock decline range widely. Ecologists study how the adelgid, climate change, and patterns of land use affect rates of hemlock decline and the different trees and forests that may replace it (Ellison, 2014; Foster, 2014). Entomologists are developing methods to control the adelgid (Sumpter et al., 2018). Foresters suggest "preemptively" salvaging hemlock trees so landowners can realize economic value from them (Foster and Orwig, 2006; Figure 29.4). Geneticists are identifying eastern hemlocks resistant to the adelgid and cross-breeding them with non-resistant individuals to develop resistant trees (Ingwell and Preisser, 2011; Oten et al., 2014). Conservation biologists are planting orchards of eastern hemlocks in North Carolina, Chile, and Brazil to preserve genetically diverse stock so that

Figure 29.4 Bio-Resource Plug (2017)

Installation at Harvard Forest; 1.5 × 1.5 × 3.5 feet (plug); wood, steel, and plastic tubing; Collaborators: David Buckley Borden and Brian Hall; Photograph: Neal Pederson.

Throughout New England, as many hemlocks have been lost to pre-emptive harvesting to extract as much economic value as possible out of hemlock stands before they are killed by the adelgid as has been lost to the adelgid itself (Foster and Orwig, 2006). Hemlock is not an especially valuable timber tree; it checks and twists, and few hemlock logs can be used for post-and-beam construction (Meier, 2015). Most harvested hemlock are chipped for biofuel or bioenergy feedstock or pulped for toilet paper and paper towels.

If we think of and refer to nonhuman organisms as "natural resources," then it is easier to exploit them and harder to empathize with them. Yet, eastern hemlock also is a part of New England history and culture, and its loss represents more than simply the loss of a natural resource for which a synthetic substitute eventually can be found. Recall the words of *Dust of Snow* by the New England poet, Robert Frost (1923):

The way a crow
Shook down on me
The dust of snow
From a hemlock tree
Has given my heart
A change of mood
And saved some part
Of a day I had rued.

hemlock forests can be replanted if and when the adelgid has been controlled or eradicated (Jetton et al., 2013). Despite these efforts, we are witnessing the inevitable passing of these trees from our forests.

Hemlock Hospice integrated and communicated these diverse responses through site-specific art and design. For people, hospice and palliative treatment provide physical and spiritual care for terminally ill individuals, their families, and loved ones (Kane et al., 1985; Teno et al., 2004). Hospice care not only comforts individuals who are dying, often painfully, but also helps family and friends cope with impending loss and ultimately come to terms with it. By extension, *Hemlock Hospice* provided an expression of care for dying trees in a declining forest and opened a space for thoughtful and constructive conversations about our relationships with nonhuman organisms such as trees and insects (Figure 29.4). Visitors should have left *Hemlock Hospice* with newfound empathy for trees and species like the adelgid that interact with them and an acceptance of ongoing, dynamic changes in forests and other ecological systems (Ellison, 2013).

Designing *Hemlock Hospice* and democratizing art/science collaborations

In contrast to the typical practice diagram representing the relationship between art, design, and science (Figure 29.5) that places art at the apex as the cultural edge to engage broad audiences, the conceptualization, design, fabrication, and installation of *Hemlock Hospice* was intentionally collaborative and democratic. All eighteen pieces in *Hemlock Hospice* and the overall installation itself were informed by design-thinking, which made explicit the overall creative framework and goals of the project. In *Hemlock Hospice*, as in many other installations that interpret and communicate scientific information, both art and design are built on a foundation of scientific research (Ellison et al., 2018). This view of the relationship between art, design, and science not only seems to us to be inappropriately hierarchical but also omits other crucial and practical aspects of projects such as *Hemlock Hospice* that aim to integrate and communicate a variety of disciplinary perspectives. These aspects include community engagement, educational programming, promotion, and ultimately direct action (Figure 29.5), all of which are integrated empathetically at multiple stages throughout project conception, design, development, and implementation.

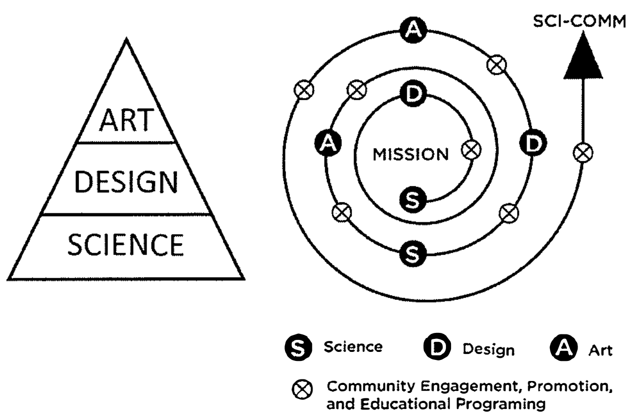

Figure 29.5 Interdisciplinary Feedback between Science, Art, Design, and Supporting Disciplines

Many art/science projects reflect unidirectional and hierarchical relationships (left) in which data generated from scientific observations or experiments provide the conceptual foundation for creativity. Design-thinking provides the overall framework and goals, accounting for the project mission, resources, and constraints for the artwork. The artistic creation acts as the cultural edge for transmitting an engaging message to broader (and generally non-scientific) audiences. In this view (common to "broader impact" statements in research grants), scientists hand off their data to a designer and artist, who then independently develop a way to communicate the results more broadly.

In contrast, we view art- and design-based science communication projects less hierarchically and more inclusively in terms of both participants and content (right). In this creative process, collaboration is built around a shared mission, builds on the inherent strengths of each discipline, and provides a framework for productive feedback. Community, education, and outreach modulate the ever-expanding potential by amplifying the desired science-communication goals.

Community engagement in the design of Hemlock Hospice

Communities inspire collaborations. *Hemlock Hospice* was situated at the Harvard Forest, whose communities motivated and drove its narrative. Onsite researchers (students, research staff, faculty) and support staff (facilities and administration) work together to realize the educational, research, and outreach mission of the Harvard Forest. Researchers come from all over the world to contribute to, and take advantage of, long-term site-based field and archival ecological research. Students visit Harvard Forest to learn about its research. Hikers, horseback riders, hunters, day visitors, and many others use Harvard Forest trails and lands for recreation and contemplation. *Hemlock Hospice* engaged and expanded these Harvard Forest communities by involving them variously in conceptualizing and fabricating individual pieces, determining access and location for installations, and providing thoughtful feedback, critique, and validation of the work as it progressed from design through installation and opening.

The artful design of *Hemlock Hospice* reflected not only individual inspiration but also curation and editing of content provided by the Harvard Forest onsite community. This community collectively both set the tone of the narrative—much of the background data on eastern hemlock, the adelgid, and current hemlock decline has been collected by Harvard Forest researchers (summarized in Foster, 2014)—and contributed many nuanced cultural details to the individual pieces and the landscape context of *Hemlock Hospice*. For example, the caricature of New Englanders as thrifty Yankees and the sustainability ethos of the Harvard Forest community were apparent in the recycling or repurposing of ≈90% of the materials used to construct the *Hemlock Hospice* sculptures. These included lumber and wood fragments left over from onsite processing of locally sourced wood used to heat Harvard Forest's office, laboratory, and residential spaces (e.g. the tree stumps in *Bio-Resource Plug* [Figure 29.4] or the sawmill saw blades in *Double Assault* [Figure 29.3]), and "eco-debris" from decommissioned experiments (e.g. the heat lamp and ant-nest boxes in *Wayfinding Barrier No. 1* [Figure 29.1]).

Design-thinking and beta-testing Hemlock Hospice

Design-thinking also was a central element of the creation and realization of *Hemlock Hospice*. We applied a key element of design-thinking—"beta-testing," the iterative solicitation of critical and constructive feedback from a range of communities and stakeholders during design development—to the creative development of this first art-based interpretive trail at Harvard Forest that substantially improved its final design. Three months prior to the official opening of *Hemlock Hospice*, we brought Harvard Forest researchers and administrative staff on tours to identify any public safety issues and to ensure that the sculptures did not conflict with co-located research projects. We worked consistently with the leadership team at Harvard Forest (including the Director, Director of Administration, and Site Coordinator) to identify appropriate sites for individual installations to create maximum aesthetic impact while minimizing effects on ongoing research projects and the ecological integrity of the forest stand itself. At the same time, concerns about limbs of disintegrating trees falling on visitors inspired additional decisions regarding design direction, project branding, wayfinding, and the overall route of the trail through the forest.

We then beta-tested the trail with undergraduate participants in Harvard Forest's Summer Research Program (McDevitt et al., 2016) and first-year graduate students in the MLA program at the Rhode Island School of Design; the latter group had a particular interest in using both ecology and applied creative strategies to create intentional user experiences in outdoor environments. Additional *ad hoc* beta-tests were done with other groups of visitors from the surrounding community. The value of all these beta-tests was that each group brought a unique perspective and background that we synthesized into the design and siting of the artwork that makes up *Hemlock Hospice* and its supporting elements (e.g. wayfinding signage and a self-guided trail map).

Through this ongoing beta-testing and our responsive and iterative creative approach, we were able to focus on human-centric solutions that focused viewers' experiences on interpreting sculptural pieces presenting a complex narrative of environmental and cultural forces. This design-thinking approach led us to a more nuanced and empathetic understanding of design features and functions ranging from the layout of the trail in the forest to the graphic design of the trail maps. Specifically, beta-tests and empathetic attitudes allowed us to set aside our own assumptions about the narrative and functionality of the interpretive trail. The design impact of the trail was our driving concern; it was not a matter of our collective creative egos. Beta-testing ensured a constant reframing of the educational experience of the trail in terms of the visitors and viewers, which ultimately resulted in a stronger art-based science communication project.

Beta-testing is one example in which we applied design-thinking in the creative development of *Hemlock Hospice*. This regular back-and-forth between the artist/designer and the community differed from the more traditional vision of science (data) → design → art envisioned in the standard practice diagram (Figure 29.5). However, the use of design-thinking tactics, including beta-testing, prototypes, and scaled study models emerged naturally from Borden's background as a landscape architect. The approach is also remarkably similar to Ellison's (and other scientists') practice of iteratively developing and testing hypotheses and confronting them with data, leading to their rejection or refinement (Hilborn and Mangel, 1997).

Community engagement in the production of Hemlock Hospice

Realizing designs of individual sculptures and the overall installation engaged other communities. At a very practical level, production costs money, and resources for art are practically nonexistent in departments such as Harvard Forest that are focused on scientific research or at field stations run and used by scientists (but see the AS.IF Center for a useful counterexample[2]). For example, salaried scientific researchers can fold art/science collaborations into their day-to-day work, but freelance artists/designers who normally are paid only when projects are completed should be compensated for their work throughout the process so that they can similarly focus their full energies on the collaborative project. Ellison—the lead scientist for *Hemlock Hospice*—not only contributed and helped to interpret data but also worked as a behind-the-scenes "executive producer," identifying, with the help of the supportive administrative team at Harvard Forest, unrestricted and unencumbered funds that could be reallocated to those items needed to successfully complete this science communication project.

Borden—the lead artist/designer of *Hemlock Hospice*—was supported with a year-long fellowship from the Harvard Forest. Materials, supplies, and fabrication also cost money, and we had a great deal of help from a community of visiting fabricators who refined the designs and constructed the sculptures themselves (Hass, 2018). We drew on the expertise and craft of more than a dozen painters, woodworkers, printmakers, and fabric artists, each of whom brought crucial ideas and skills to *Hemlock Hospice*. Each also designed a hard hat used by visitors to the installation (Figure 29.6), and their contributions were explicitly recognized in the associated trail guide and publicity efforts. We do not think that the meaning

Figure 29.6 Hospice Visitor Check-in and Safety Helmet Station (2017)

Installation at Harvard Forest. Variable dimensions; acrylic paint and vinyl on hard hats; Collaborators: David Buckley Borden, Jack Byers, Benjamin Carlson, Aaron M. Ellison, Salvador Jiménez-Flores, and Salua Rivero; Photograph: Aaron M. Ellison.

We advised all visitors to Hemlock Hospice to put on hard hats—each designed by one of our visiting fabricators—because falling limbs and disintegrating trees are a safety hazard in declining hemlock stands. Wearing hard hats was a ritual of immersion that embedded visitors more deeply in the installation—they became participants and caregivers rather than simple observers. The act of putting on hard hats prompted visitors to look up and observe the gray, thinning canopy of dying trees while engaging them in the research context of the forest, where scientists working in adelgid-infested stands routinely wear hard hats and other personal protective equipment.

of the individual pieces and the overall installation was changed by our explicit assertion that *Hemlock Hospice* was the result of a broad-based and inclusive collaboration. However, we do think that this assertion emphasized the interpretation of the causes and consequences of hemlock decline as reflecting scientific and cultural consensus rather than that of a single individual.

Encouraging empathy in a community of care-givers

Empathy is the ability to understand and share the feelings of another (or "an other"). The installations of *Hemlock Hospice* engaged different visitors in myriad ways and sparked different degrees of understanding and empathy. A casual visitor might have viewed *Wayfinding Barrier No. 1* (Figure 29.1) as a simple detour sign; a regular hiker might have been taken aback by the large object preventing them from walking in their normal route; a member of the Harvard Forest Woods Crew might have remembered cutting the wood used to support or frame the sculpture; and an ant researcher might have hoped that ants would still be able to take up residence in the now-airborne nest boxes. When conversations occurred among these diverse groups, each brought their own interpretations and unique perspectives to subsequent discussions about the changing forest. An art/science project like *Hemlock Hospice* can provide a vehicle for the expression of community values and can give visual voice to the people that work in and around the installation site (here, the forest). All who experienced *Hemlock Hospice* attained a greater empathetic understanding of the forest, too.

Hemlock Hospice had its origin in the observations that eastern hemlock forests are inexorably declining as adelgids spread, feed on, and ultimately kill their host trees. Although many groups and stakeholders continue to focus on chemical and biological control efforts or *ex situ* conservation plantings, these measures to date have been ineffective at slowing the spread of the adelgid or the demise of hemlock forests at the landscape scale. With *Hemlock Hospice*, we wanted to spark a conversation about making the transition from "curative" to hospice care for hemlock forests, a conversation that seems to us to be especially relevant as people and their activities are rapidly transforming the world and extinguishing its biodiversity (Figure 29.7).

Figure 29.7 Sixth Extinction Flag (2017)

Installation at Harvard Forest. 5 × 5 feet; Canvas, thread, nylon rope, and grommets; Collaborators: Jackie Barry, David Buckley Borden, Mike Demaggio, and Aaron M. Ellison; Photograph: Aaron M. Ellison.

Eastern hemlock is but one of many species being lost around the world as part of the ongoing sixth "mass extinction" in Earth's history (Harris, 2000; Leakey and Lewin, 1996). The loss of hemlock, the gain of the adelgid, the deliberate and unintentional movement of species, and the conversion of "natural" areas to human-dominated ones are global-scale phenomena; the rapid changes in forest structure occurring at Harvard Forest are a local example. Keeping the global picture in mind while foregrounding attention and study on local changes and the actions responsible for them will allow us to focus our energies where they can do the most good.

In clinical practice, the patient in hospice care and the family are considered together to be the unit of care (Wittenberg-Lyles et al., 2012). By analogy, eastern hemlock and the broader Harvard Forest communities are partners in hospice care for eastern hemlock forests. Interdisciplinary teams and nurturing empathetic relationships between family caregivers and patients are just as crucial in our stewardship of our changing environment (Berenguer, 2007) as in human-centered hospice care (Wittenberg-Lyles et al., 2012). Empathy is not always natural in caregiver–patient relationships (Larson and Yao, 2005) and needs even more encouragement when the patient, like eastern hemlock, is not human (Balding and Williams, 2016; Berenguer, 2007).

Good artistic design "helps people deal with change… [and changes] our understanding of how the world evolves" (Antonelli, quoted in Luebkeman, 2015). In *Hemlock Hospice*, we encouraged our communities to think about what it means to be a tree—living, dying, or dead—or an immigrant insect such as the adelgid (Figure 29.8). We also encouraged thinking of trees and forests not just as inanimate resources (Figure 29.4) for our use, but rather as cohabitants with us of the forest, this region, or the Earth (Geisel, 1971).

Successes, challenges, and lessons learned

The successful design and execution of *Hemlock Hospice* was possible in large measure because the artist/designer was supported to work full time for a year as part of the Harvard Forest community. The substantial accomplishments of *Hemlock Hospice* were realized because of the nonhierarchical nature of the collaboration (Figure 29.5): the lead and collaborating artists, designers, and fabricators were embedded in an active scientific research site; and scientists simultaneously were full partners in the design and creation process. Bringing together artists, designers, and scientists on a common project also has its challenges, including different modes of communication among participants, different measures of scientific and artistic success, and different expectations for direct action.

The utility of study models

Artists and scientists communicate ideas in different ways. Scientific ideas often are framed as hypotheses and data are analyzed quantitatively or modeled mathematically. Artistic ideas often are more conceptual, qualitative, or sensorial. We found a common language through another element of design-thinking—constructed physical study models (Figures 29.8 and 29.9) with which artistic ideas could be made sufficiently concrete so that evidence-based scientists could respond to them both intuitively and intellectually.

Fast Forward Futures (Figure 29.9, left) exemplifies our effective use of study models. Our own discussions and critiques raised in beta-testing emphasized the importance of illustrating the forest of the future, after eastern hemlock succumbed to the adelgid. We identified several locations where fallen hemlocks had created large canopy gaps and black birch (*Betula lenta*) thickets had initiated the succession to the next forest type (Case et al., 2017). Our first attempt at highlighting this otherwise unremarkable successional stage was building a colorful zig-zag fence around the birch (Figure 29.9, right). Although this "framing" seemed sound in the abstract, the actual installation was unsuccessful because the fence was visually swallowed by the dense birch. In response, we made tenth-scale models of the wooden members used to create the fence (Figure 29.9, right). We then used these to create four dozen small study models over the course of a couple of hours, a process that eventually led us to the final design.

Figure 29.8 HWA Tent (2017) and Study Model for HWA Tent

Installation at Harvard Forest. 2.5 × 2.5 × 6 feet; wood, acrylic paint, canvas, thread, and nylon rope; Collaborators: Jackie Barry, Johnny Buck, David Buckley Borden, Aaron M. Ellison, and Salua Rivero; Photographs: David Buckley Borden and Aaron M. Ellison.

By referring to an organism like the hemlock woolly adelgid (HWA) as an "invasive species," we usually mean that it is an organism living where we don't want it and behaving counter to our desires. We also implicitly ascribe agency to it, as if the invasive species planned its illegal entry through our borders (Larson, 2005). But there is, in fact, no evidence that invasive species plan their actions. Rather, these organisms, like those we hold in higher esteem, simply are acting according to normal evolutionary drives: survive and reproduce. The adelgid did not deliberately emigrate to Richmond; it was carried there as an unrecorded stowaway on plants we humans imported for enjoyment and financial gain. And once on these shores, the adelgid behaved like any other immigrant. It sought a place to live, food to eat, and an opportunity to produce offspring to perpetuate its lineage. Our extensive hemlock forests with hundreds of millions of trees are ideal food and housing for the adelgid; given adequate food and shelter, it successfully reproduces and evolves. No agency required.

The study model (inset) is one example of a common visual language shared by artists, designers, and scientists. Just like a series of scientific experiments allows us to test a series of alternative scientific hypotheses (Chamberlin, 1890; Hilborn and Mangel, 1997), a study model allows us to iteratively test artistic ideas through the design process. The study model for the HWA Tent was a scaled-down, simplified version of a concept about invasive species, colonization, and habitat. It lacked many of the details of the final design but also sparked new ideas about how to communicate important scientific details such as the range of the adelgid (through the state "patches") and unique identifiers of hemlock (two white stripes under the needles), while also highlighting that hemlock is a temporary home for each new adelgid generation.

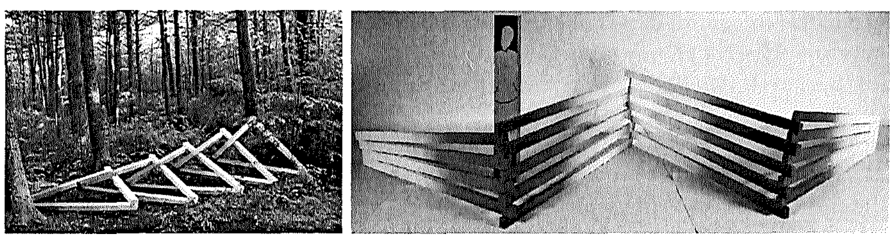

Figure 29.9 Fast Forward Futures (2017)

Installation at Harvard Forest. 4 × 8 × 26 feet; wood, acrylic paint, and assorted hardware; Collaborators: David Buckley Borden, Jack Byers, Aaron M. Ellison, Salvador Jiménez-Flores, and Salua Rivero. Photographs: David Buckley Borden.

Situated adjacent to and pointing toward a gap created by a dead and fallen eastern hemlock and now filled with black birch saplings, Fast Forward Futures (left) is an abstraction of the "fast forward" icon of a media player. It is created from five interlocking delta symbols representing change and painted in a global-warming-inspired heat gradient (see also Figure 29.2). The initial idea for this piece was a colorful take on a split-rail fence (right). This unsuccessful design was reworked and refined using tenth-scale timbers assembled and reassembled in nearly fifty study models.

Measures of success

Scientists and artists may have different measures of success. Salaried scientists usually are paid for the process ("doing science"), whereas artists and other creative content producers usually are paid only when they sell their "work." In the case of *Hemlock Hospice*, we were on the same level: we were both salaried. Scientists are rewarded for writing technical papers and books, whereas artists are rewarded by selling paintings, sculptures, videos, etc. In the case of *Hemlock Hospice*, we and our collaborators had scoped the project together and were united in the overall mission of the project. There were only a few times when we questioned what we were doing, and if we did disagree on a particular direction or piece, we immediately stepped back and asked whether we were moving the agenda forward.

One example was the development of the interpretive trail guide for self-guiding visitors. The artist/designer emphasized imagery while the scientist emphasized textual explanation. But together, we made hundreds of small decisions about the final trail guide using a common, mission-driven editorial filter: did the graphics, information, writing, and editing clearly communicate the science in a culturally engaging way? Similarly, neither the science nor the sculptural installations were the ends in and of themselves for either of us. Rather, the primary measure of success was whether this collaborative art/science project created opportunities for understanding, outreach, and further community-building and engagement.

Education and outreach also was central to our mission of science communication; it was intentionally planned from the outset, not as an afterthought. We were fortunate in having the help and support of a full-time outreach director at Harvard Forest (Clarisse Hart, who also directs its well-respected Fisher Museum), additional outreach and event planning by a contracted public-relations consultant, and time "borrowed" from devoted Harvard Forest staff. Each of us contributed print and online media contacts to promote the project and encouraged individuals to visit an installation at a relatively remote site. We added indoor exhibition content to the Fisher Museum, which itself draws thousands of visitors annually to view its historical dioramas (Foster and O'Keefe, 2000), leveraging it as a springboard for the *Hemlock Hospice* trail.

One of the most salient critiques of *Hemlock Hospice* and other art/science collaborations was that it did not include an explicit direct-action component. Many people viewing *Hemlock Hospice*, especially those learning about the adelgid for the first time, wanted to do something tangible to control it, save the trees, or take broader actions to prevent environmental degradation. *Hemlock Hospice* was successful because it led people to consider a sustainable future. But, even though we cannot save the hemlocks, we still missed an opportunity to provide concrete steps forward. Expanding our communities even further to include educators and activists, educational institutions and NGOs, and policy- and decision-makers could have suggested immediate actions inspired by this art/science collaboration. Although we did not do that explicitly with *Hemlock Hospice*, we took that route with our follow-up installation, *Warming Warning*, which was emplaced on Harvard's main campus from October to December 2018.[3]

Conclusions

Traditional art/science projects reflect unidirectional and hierarchical relationships: scientists intentionally or unintentionally provide data to designers and artists who interpret it for broader audiences (Ellison et al., 2018). Notable examples range from Ellie Irons' work in a variety of media, focused on revealing interconnections between humans, nonhumans, and nonliving earth systems[4] to the pieces by more than a dozen contemporary artists in the 2018 *Indicators: Artists on Climate Change* exhibition at the Storm King Art Center.[5] The resulting artistic creations communicate messages—scientific or otherwise—that most often are independent of the intent of the scientists who generated the data.

Our experience with *Hemlock Hospice* suggests that art/design/science collaborations can communicate scientific information more effectively *and accurately* if both participants and content are neither hierarchical nor exclusive. More broadly, the most successful art/science projects will engage diverse communities in their programming, publicity, and outreach at multiple points throughout their conception, design development, fabrication, and promotion.

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Notes

1 https://harvardforest.fas.harvard.edu/
2 https://asif.center/
3 https://harvardforest.fas.harvard.edu/warming-warning/
4 https://ellieirons.com/
5 https://stormking.org/indicators/

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