The Way Forward for Biological Field Stations

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Change needed to ensure survival and scientific relevance

Biological field stations are at risk unless they modernize and better communicate their mission to policymakers, funders, the public—even their own universities. In a range of key areas—funding, public communication, leadership, cyberinfrastructure, and networking—many of the world's field stations lag, leaving themselves vulnerable to cuts or even elimination, according to a 2014 report from the National Research Council (NRC). At the same time, there are real opportunities for enhancing field stations' contributions to research on many pressing issues.

"They are increasingly vulnerable at a time when financial resources are limited," says Jerry Schubel, president and chief executive officer of the Aquarium of the Pacific in Long Beach, California, who chaired the NRC committee that wrote *Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century*. "We could lose an important part of the nation's research infrastructure at a time when it's even more important than it was in the past because of the ways [humans] are changing the environment."

Field stations contribute significantly to solving today's biggest biological problems, from climate change and biodiversity loss, to invasive species and pollinator decline. "Field stations and marine labs provide a network of points across the globe where we can take the pulse of Earth's ecosystems,"

Naturalist Gary Griffith examines the structure of a wintergreen blossom at the Sagehen Creek Field Station, part of the University of California's 39-site Natural Reserve System, the world's largest university-administered reserve system. Photograph: Faerthen Felix, University of California Regents.

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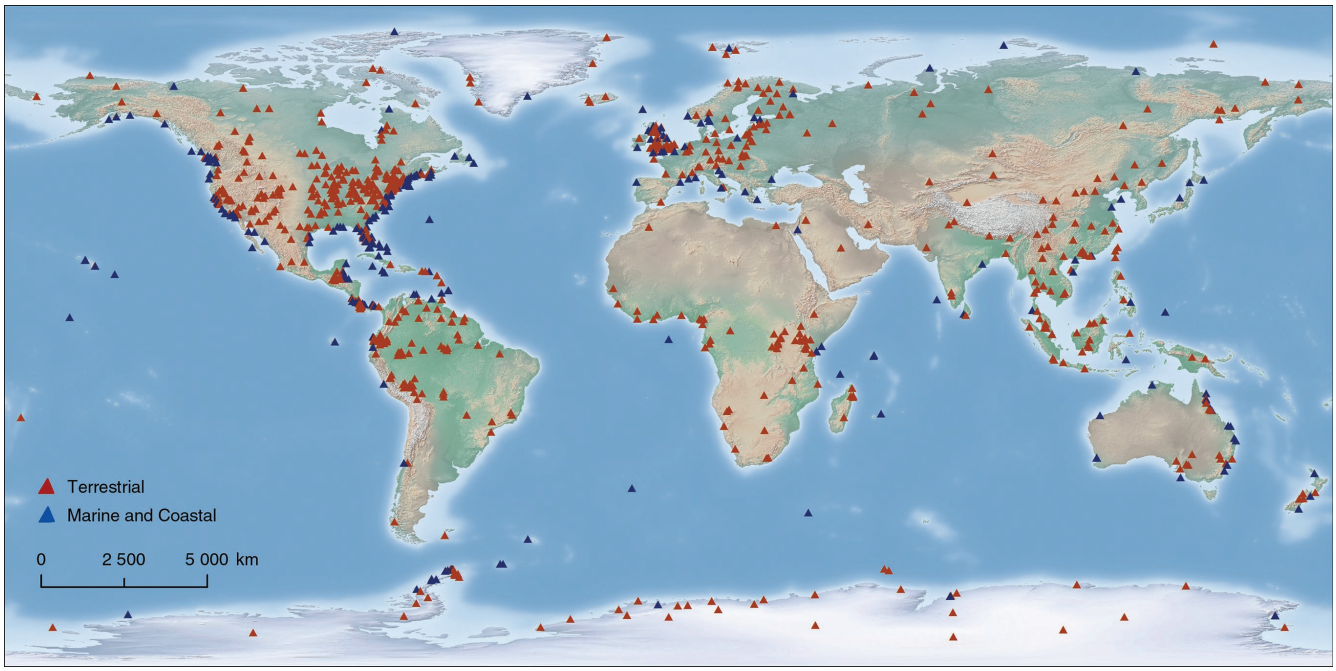


The National Research Council identified more than 900 field stations, marine labs, and nature reserves around the globe. Abbreviation: km, kilometers. Image: National Research Council.

reflects Diane Debinski, who served on the NRC committee and is a professor of ecology, evolution, and organismal biology at Iowa State University. "Many of the field stations are located in pristine areas where these vital signs provide a baseline set of data. These baseline data can be used to calibrate ecological changes when compared to more human-modified regions."

For more than a century, field stations have provided scientists with protected places to conduct long-term research and to collaborate with others across disciplines. "Convergence" is hot today, notes Schubel, but to field stations, it is old hat; they have long been sites for cross-disciplinary research. "You go to a field station, you live and work and eat together, and you can exchange ideas. All of these become opportunities to do even more." As living laboratories, they also play a special role in giving K–12 students, members of the public and media, and elected officials direct access to research being conducted in the natural world and to opportunities for citizen science.

Despite their societal value, they are too often under the radar not only of the public but of the universities that own them. "A lot of field stations are doing a great job with citizen science and giving information to the public," says Sarah Oktay, president of the 300-member Organization of Biological Field Stations (OBFS). "We need to do a better job of describing who we are, why we're here, and why we matter." Three-quarters of field stations are affiliated with universities that are under "intense financial pressure," says Schubel. "If you're in a remote place, you're easier to cut than a department that exists on campus." Many universities are asking field stations to justify their existence, whether in terms of research dollars coming in or numbers of students recruited to the university. Several field stations have been closed in recent years, among them the San Blas Field Station in Panama; the National Wildlife Research Center in Kingsville, Texas; and the Meanook Biological Research Station in Manitoba, Canada, and others survived only after a concerted effort by supporters.

Globally, there are more than 900 field stations, with more than one-third of them in the United States. A precise count is difficult, explains Oktay. "Some are closing, some are opening, some are combining," she says. Others may not be counted, because they do not identify as a field station, but they perform the same role.

A 2012 survey by OBFS and the National Association of Marine Laboratories (NAML) showed a great diversity among field stations. Many are remote wilderness outposts with the director as the sole employee, whereas others are huge marine labs, such as Woods Hole Oceanographic Institute, with sophisticated marine research vessels and a staff of 1000. Sixty percent had 10 or fewer employees, whereas 2 percent had between 250 and 500.

Mapping the world's field stations turned out to be a challenge, says NRC committee member Robert Plowes—one that had not been undertaken before. "Every time we cast the net, we came up with a whole lot more," says Plowes of their attempt to count the total. "For a while, [we could find] few field stations in Africa—I'm from Africa myself, so I knew there were more field stations there."

The report, which included not only terrestrial field stations but marine labs and nature reserves, grew out of a 2013 vision paper, published by OBFS and

NAML. "OBFS and NAML have been working for a long time to see how our entities fit together," says NAML president Nancy Rabalais. "We have many of the same issues and opportunities." NAML has 144 member marine labs, roughly 70 percent of the total, set up in regional associations.

It is not only university belt tightening that threatens field stations. As director of the Louisiana Universities Marine Consortium, a lab in coastal Cocodrie, Rabalais has faced significant state budget cuts. "Everybody is trying to get money in different ways," she says. Her lab used to receive 43 percent of its funds from the state—that figure is now 34 percent. "So we're having to make more and more in research grants," she says. "That's happening all over the United States."

She and other leaders find the NRC recommendations useful as field stations navigate shifting terrain. "It's a plan," she says. "It definitely builds on the strengths of what these individual facilities have to offer."

Although NRC lays out big challenges for moving forward, Jeff Brown, director of University of California, Berkeley's, Central Sierra Field Research Stations, says the recommendations are doable. "We have this network, this support group, that we can bounce ideas off of," he says. "The challenge for us is how we package and communicate this to the people we need to be partnering with. That's our biggest hurdle—how do we communicate this effectively. We preach to the same choir all the time—we have to create a new choir."

Every field station won't be able to build an expensive data-monitoring system, but there are "bite-size chunks," says Oktay, which give even the tiniest sites ways to move forward. For example, the report places a high priority on field stations networking among themselves. This prompted Oktay to involve the University of Massachusetts Boston Nantucket Field Station—where she is the only full-time employee and manages a $200,000 budget—more actively with the Gulf of Maine regional network.

Field stations provide an invaluable opportunity for K–12 students to get hands-on experience in the natural world. Here, junior rangers explore the Nantucket Field Station, part of the University of Massachusetts Boston system. Photograph: Len Germinara.

"Even at a podunk field station like ours I get a lot done," says Oktay, noting that Nantucket annually receives 1000 visits from K–12 students and 10,000 from members of the public, with classes, workshops, and seminars for 400 college students.

Entrepreneurship over scholarship

No matter the size, every field station needs visionary leadership, the report stressed. The days of choosing field station directors solely on the basis of their scholarship are over—or should be. "When we select the leaders of these institutions, there should be as much emphasis on their entrepreneurial and business skills and leadership and management as on their scholarly skills," says Schubel.

"You need someone charismatic who understands science really well," he continues. Directors don't have to be experts in cost–benefit analysis, but they need to work with someone who is. "In academia, we promote people who are good at what they do in terms of science, but they end up in administrative roles where they don't have the leadership skills they need." Field station directors must develop a business plan; raise funds; network with other field stations and community partners; schmooze with the public, policymakers, and the media; and help create and sustain a vision; among other skills. Or, as Oktay puts it, "We also have to fix toilets and talk to congressmen and do a lot of things that most scientists don't do."

"Some field stations have gotten the message loud and clear; others are just coming to grips with what needs to be done, and that's part of the value of the NRC report," says Ian Billick, director of the Rocky Mountain Biological Lab, who led the team that wrote the 2013 OBFS–NAML vision paper. "Field station directors need to be entrepreneurial [given] the funding reality. . . . Those institutions out in front articulating and documenting their value are going to be funded in the future. They're very vulnerable if they don't get that."

Tooting their horn

To be valued by policymakers, universities, philanthropists, and the public,

field stations need to do a much better job proving their worth. However, few have developed basic metrics to measure their impact. "The few metrics that are available are haphazardly collected, fragmented, and infrequently shared," the NRC report noted.

Field stations are often unable to even track whether they are identified as research sites in articles published in peer-reviewed journals. "You'd be amazed at the number of research papers that say 'this was done in northern California,'" says NRC committee member Mark Stromberg, retired director of the University of California Natural Reserve System. "Come on, why can't you put the name [of the field station] in there!" Stromberg says that even when their facilities are named in publications, field station directors are often unaware of it. They may need to search bibliographic databases to discover research papers based on work done at their field station. Often, scientists work years at a field station, then move across the country and forget to send back copies of published papers that used data that they collected there.

To solve this problem, Stromberg is working with Carly Strasser and others at the California Digital Library to create a system of assigning a digital object identifier (DOI) to a description of each field station, perhaps a three-page summary. "Any field station or marine lab can write up not only a general description but a one-page description of a feature like a lake within a field station with its own DOI," he explains. Every time the field station is mentioned in a publication, the DOI can be referenced. Stromberg anticipates that the system will be implemented this year.

Other metrics might include the number of students conducting research; user days by researchers, students, and the public; media stories; and laws or policies influenced by work done at field stations.

"Are field stations providing feedback to societal-level problems, such as invasive species and climate change?" asks Plowes, research

Red imported fire ants* (Solenopsis invicta) *arrived in the United States in the 1930s and reached the Brackenridge Field Station around 1980. This led to long-term research at the field station into the ecology, impacts, and potential biological control of fire ants. Photograph: Robert Plowes.

Further reading.

Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century. Committee on Value and Sustainability of Biological Field Stations, Marine Laboratories, and Nature Reserves in 21st Century Science, Education, and Public Outreach. Board on Life Sciences, Division on Earth and Life Studies, National Research Council, 2014.

Field Stations and Marine Laboratories of the Future: A Strategic Vision. National Association of Marine Laboratories and the Organization of Biological Field Stations, 2013.

Topics in *BioScience*: Biological Field Stations. A collection of articles that appeared in *BioScience*, primarily in 2009, available as a PDF through *www.aibs.org*.

scientist at University of Texas, Austin's Brackenridge Field Station. "You can measure that, you can show how policies have been shifted as the result of research at field stations. That's a challenge for smaller field stations that don't have a lot of visibility."

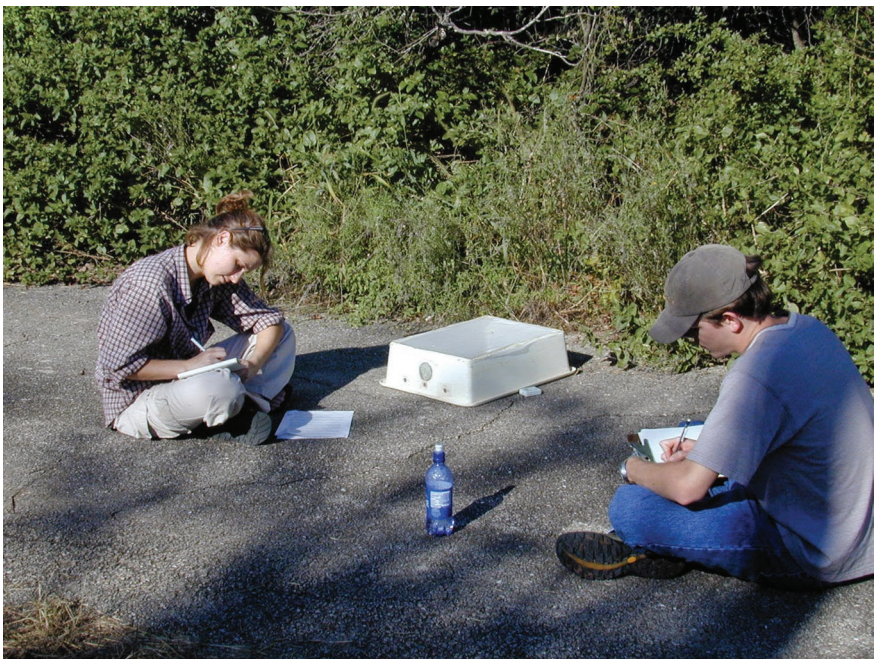
With clear measures of success in hand, field stations would be much better positioned to demonstrate their value to universities, nonprofit funders, and elected officials. "The idea of metrics and documenting success is a really critical one," says Billick. "The challenging part is relating the science done to why society cares. That's very difficult. We need to develop metrics and stories that capture the research being done."

In addition to establishing metrics, forging strong relationships is important. "We try to keep our potential funders and relevant environmental organizations and government agencies apprised of what we're doing and the importance of the work," says Rabalais.

The University of Wyoming–National Park Service Research Station in the Grand Tetons has a weekly cookout for the public, including the local community and visitors, says Debinski, who has conducted research there since 1992. People pay $5 for dinner and the chance to hear a scientist discuss research being conducted there. "A lot of field stations are located in beautiful places where people have a strong attachment to the ecological community they're living in," says Debinski. "That culture of communication about science is really a valuable model, and it seems to be becoming more popular."

Plowes learned the importance of having strong relationships when his own field station was eyed for closure by University of Texas budget cutters. "It's twice been all the way to the regents level, where there have been reviews done of whether this is the most appropriate use of the land," he says, "and in each of those reviews, one in the late '80s and the other in 2008–2009, the regents agreed it was in the best interest of the university to maintain the field station for student learning and research. That was done on the back of the testimony and outcomes of many students who have been through there."

A researcher samples phorid flies that were introduced for biological control of fire ants. Basic studies on this host–parasite interaction are conducted at Brackenridge Field Station in Austin. Photograph: Robert Plowes.



The campus of University of Texas at Austin is just minutes from Brackenridge Field Station. Here, two students study how fire ant foraging declines in the presence of parasitoid phorid flies. Photograph: Robert Plowes.

Networking critical to scientific relevance

For field stations to contribute significantly to solving pressing problems, they must link their research to other field stations at all levels—regionally, nationally, even globally, according to the report. The National Science Foundation has invested millions in establishing the National Ecological Observatory Network and the Long

Term Ecological Research Network, in which some field stations participate. Field stations can greatly complement these efforts by organizing around a common research interest. "Often, the networks that are most effective are self-organized," says Stromberg.

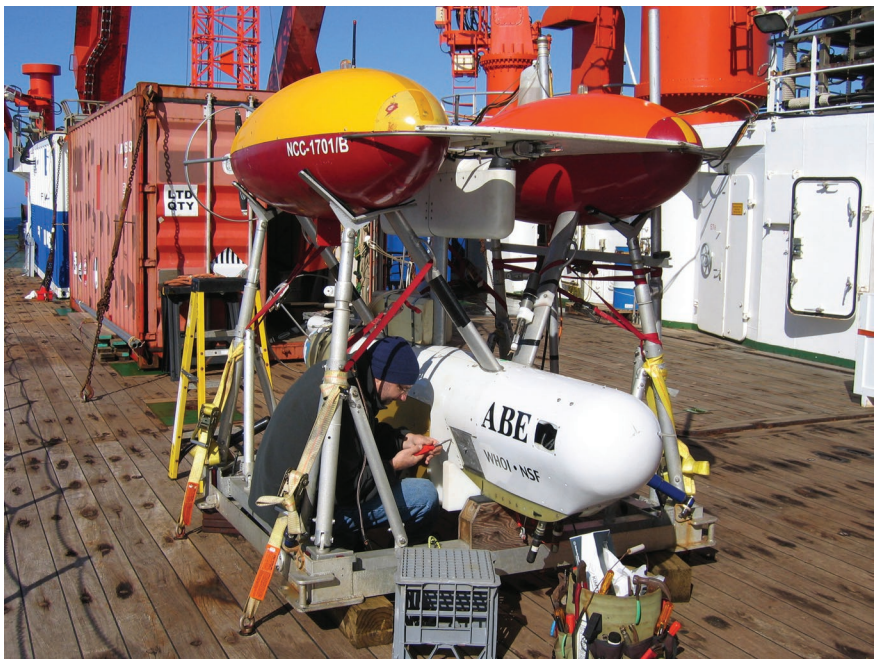
"We want to get better integrated and create regional synergies," says Oktay. Her field station now works with 25 others in the Gulf of Maine, perched between Nantucket and Canada. "We didn't know much about each other," she says. "When we get together, we can ask regional questions.… Because of climate change and fisheries pressures and resource pressures and large-scale land questions, we're all more clued in on how much more we have to network." For example, Nantucket and other field stations in the region are measuring anthropogenic contaminants, such as pharmaceuticals, nutrients, and herbicides, and sharing data. "Seeing how someone else collects and saves data is really helpful," she says. "It seems so simple, but it's one of the biggest needs."

With greater networking, field stations could also calibrate their equipment to better share data and coordinate collections, she adds. Or, "if one of us wants to buy a $100,000 piece of equipment, let's see if we can use it too, and then the other gets a different piece."

The 2013 OBFS–NAML report recommended that field stations create a network center to enhance and expand their research. "The challenge is to create a very rich data environment," says Billick. "There's no reason why each field station should create its own data infrastructure. It's inefficient. By creating a standard platform, it would be much easier to integrate those data streams from multiple field stations. Some kind of network center would provide huge bang for the buck."

Connecting for the twenty-first century

The 2012 survey of field stations showed a troubling lack of financial support for infrastructure, from



Field stations range in size from tiny outposts with no full-time staff to sophisticated marine labs such as Woods Hole Oceanographic Institute. Shown here: Andy Billings, an engineering assistant at Woods Hole, making final checks on ABE (the autonomous benthic explorer), leading up to its first dive at Brothers Volcano. Photograph: New Zealand American Submarine Ring of Fire 2007 Exploration, National Oceanic and Atmospheric Administration (NOAA) Vents Program; NOAA Office of Oceanic and Atmospheric Research and Office of Exploration and Research.

Hands-on research opportunities often influence students far more than in-school classwork, say field station directors and education experts. Here, University of Massachusetts Boston students explore the saltwater marsh at Nantucket Field Station. Photograph: Len Germinara.

buildings to Internet connectivity. Basic tools of a researcher's trade—online catalogs of species lists, maps, weather data, and land-use history—are often not available, a particular problem for visiting scientists.

"Cyberinfrastructure is a critical component so people can be connected with campuses and so data sharing can happen," says Debinski. "That's getting easier over time—cell phone connectivity is getting better. But some of the less glamorous things, like fixing old buildings, [have] to be made a priority."

Adding to the infrastructure challenge is the remote location of many field stations and the extreme weather conditions that many face. The Louisiana Universities lab is buffeted by the elements, but with limited funding, basic maintenance is deferred, says Rabalais. That may be the norm. The OBFS–NAML survey showed that only 14 percent of respondents said their financial planning included depreciation of buildings and equipment. Oktay has similar difficulties in Nantucket. "We get 100-mile-an-hour winds here in winter," she says. "My first thought when the power goes out is, what's in the freezer—how many carcasses do I have, how do I need to protect them so I don't lose tissue samples?"

Like other labs and museums, many field stations also struggle to find the resources to digitize their collections and field notes—the so-called dark data. "All it takes is one flood, one storm," says Oktay, who sees capturing the lab's dark data as a high priority. Over a 3- to 4-year period, her lab has digitized perhaps 60 percent of its backlog, thanks to the help of citizen volunteers. Still, she says, "I don't know what I'm missing. I've been here 11 years, but our field station has been here 50 years, and our prior director died."

The University of California's Sagehen Creek Field Station has digitized most of its dark data, thanks to the efforts of an aspiring grad student and the Berkeley Ecoinformatics Engine, which was cited as a model by the NRC. The program allows scientists across disciplines and work sites, including labs, natural history museums, and field stations, to integrate their data. Researchers can now freely access Central Sierra's data. "That's going to help them do more transformative science," says Brown.

Field stations provide researchers with the opportunity to study the natural world in remote areas, over long periods of time, alongside scientists from other disciplines. Shown here is a mature western white pine, growing on a high ridge in the Sagehen Basin. Photograph: Faerthen Felix, University of California Regents.

On another front, Brown has partnered with others to greatly enhance the field station's connectivity. "I have 1.5 megabytes of bandwidth, which these days is nothing," he says. "To stream a webcam with a decent resolution you need 20 megs. And when I've got 40 to 50 people here online, it just bogs down." But thanks to a federal program to improve connectivity to rural school districts, Sagehen has found an affordable solution. The school district's new fiber optic system gives it 1 gigabit of bandwidth. "They'll only use 100 megs of that, so we put together a partnership to get us 100 megs for free and some hardware," says Brown. In turn, the field station provides learning opportunities for students. Other partners include the University of Nevada, Reno; other labs; and the US Forest Service, which will be able to operate a webcam at its fire lookout post.

On all fronts, field stations need to band together and to look outward to ensure not only their survival but to make a more significant contribution to solving the world's toughest environmental problems. "None of us has the resources to do what we need to do," says Brown. "We have to get way out of our comfort zones to create the kind of partnerships we need to move into the future."

Beth Baker is a freelance writer and the Features editor of BioScience (bbaker@aibs.org). Her latest book is With a Little Help from Our Friends—Creating Community as We Grow Older (2014, Vanderbilt University Press).