44 Trade-offs of Participation in the Long-Term Ecological Research Program

Immediate and Long-Term Consequences

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INTRODUCTION

For those who may have skipped to this chapter and not read the 3 introductory chapters, the 36 essays, or the 4 evaluative chapters of this book, the answer to the burning question "Does participation in the Long-Term Ecological Research (LTER) program change scientists?" is an unequivocal "Yes!" As Boyer and Brown (Chapter 41) point out, however, those changes are mostly in the realms of knowledge acquisition and behavior adoptions in the practice of science. Participation in the program did not appear to have a substantial effect on the development of attitudes. Could such changes have occurred outside of the LTER program? Schlesinger (Chapter 40) thinks so. He suggests that the LTER program provides "some structure and modest standardization to a set of common measurements" but that it has not substantially broadened or deepened the ecological sciences. Yet the effect of the LTER program on science, while a fascinating and often-addressed question, is not the focus of this book (see Willig and Walker, Chapter 1). Of course, to address how scientists change also involves understanding how they approach and conduct science. In addition, personal change occurs in a broad societal context. For example, the LTER program has coincided with and helped promote a transition in ecology from research done by one or a few investigators on a particular organism or process in a particular habitat to investigations involving multidisciplinary teams working together to test models about how ecosystem dynamics unfold across large spatial and temporal scales. However, going to "big programs" and "big data sets" does not mean losing a sense of place or being divorced from the natural history of particular organisms. Even as spatial and temporal scales increase, ecological research is ideally still "place aware" (Bestelmeyer, Chapter 19).

Using the essays of this book as a rich source of information to address fundamental questions about the nature of scientists, we provide some final thoughts on how the LTER program has affected its participants, particularly on how they view time and space,

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collaboration, and communication. We end with reflections on the future of ecology and society, based on the views expressed in this book and on our own participation in the LTER program.

TIME AND SPACE

The strongest common theme in the essays is the effect of conducting long-term research on the scientists themselves (Flint, Chapter 42). Participants in the LTER program have internalized three lessons. First, it is humbling to realize that conclusions about the properties of an ecosystem based on a short (e.g., 2- to 4-year) study make poor predictors of decadal or longer temporal patterns (Magnuson's Invisible Present; Magnuson 1990). Second, it is similarly humbling to discover that no matter how deeply one examines a particular location, data from a variety of locations are needed for general understanding (Swanson's Invisible Place; Swanson and Sparks 1990). Third, we are humbled when we try to understand what is happening at a particular moment and realize that we need data from many sources and disciplines (Porter's Invisible Moment; Porter, Chapter 39). Once these lessons are internalized, scientists working on long-term research might well become more patient with long-term data collection, explore more comparative aspects of ecosystem dynamics, or become more interdisciplinary in their research. The rewards of such changes include expanded perceptions of interactions across space or through time (Bestelmeyer, Chapter 19); an integrated coupling of short- and long-term phenomena, such as the potential for the reversibility of coral–algal shifts (Schmitt, Chapter 28); and a better understanding of the complex responses to global change, such as grassland responses to altered fire regimes (Blair, Chapter 21).

COLLABORATION

A second strong theme underlying the essays was that participation in the LTER program requires at least some collaboration: among fellow ecologists, other environmental scientists, or social scientists within one's site and across the LTER network. Collaboration is most commonly found in disciplines studying complex systems (e.g., oceanography, ecosystems) and can involve sharing equipment, skills, or ideas. One example that exemplifies all three types of sharing is when information managers in the LTER program collaborate on software development (O'Brien, Chapter 34). Collaboration can make one into an amalgam of unlikely parts or skills, much like a platypus (Grove, Chapter 10), and is best suited to those who prefer to play in an ensemble, rather than to those who prefer duets or solos (Grove, Chapter 10). Advantages to collaboration include the ability to disentangle interactions within complex ecosystems (Tilman, Chapter 13), conduct meta-analyses (Borer, Chapter 12), share syntheses (Gaiser, Chapter 17), and build more comprehensive stories (Silver, Chapter 26). Disadvantages include uneven contributions from members of a research team (Troxler, Chapter 18) and overcoming the challenge of data collection protocols that are so site-specific that they rarely match across sites. This latter hurdle likely arose because the LTER program originated and evolved primarily as a site-based rather than network-based model (Waide [Chapter 2]; Gholz, Marinelli, and Taylor [Chapter 3]), with very few sites in similar ecosystems types (e.g., only one site in a tropical rainforest). The effort to collaborate within, but especially across, disciplines is huge, requiring time, mutual respect, and a willingness to learn about other's areas of expertise. The LTER program does not offer formal training in how to collaborate (Silver, Chapter 26), but the essayists were mostly positive about the benefits of doing so over the course of a career. More organized cross-site visits of some duration (e.g., sabbaticals) were suggested as a programmatic

catalyst to promote network connectivity. Encouragement and support for coordinated, long-term research efforts that are designed to enhance cross-site comparison, synthesis, and theory are needed to provide the intellectual stimulus to advance ecological understanding, especially within the core areas of the LTER program. Such coordination can also provide an effective mechanism to engender a multidisciplinary culture of collaboration among scientists with interests in complex spatiotemporal system dynamics, whether or not they are senior personnel on an LTER project.

COMMUNICATION

A third theme addressed how science is communicated, within circles associated with the LTER program, with the broader scientific community, and with the public. A related topic was whether research in the LTER program is perceived as being either basic or applied. For some (Gragson, Silver; Chapters 16, 26, respectively), the LTER program is focused on basic research; for others (Gaiser, Chapter 17), applied research is a substantive part of the core mission of the LTER program. A third viewpoint is that the LTER program helps integrate basic and applied research (Giblin, Chapter 32) into an amalgam that represents actionable and predictive science and that by its nature, informs policy by providing long-term understanding.

Communication within LTER circles is strengthened by the degree of collaboration and a sense of a shared mission. However, this shared bond among scientists in the LTER program can lead to a degree of insularity (Boyer and Brown, Chapter 41) and can be seen as excluding others not in "the club." Entry into such tightly knit research groups with a long history of collaboration may be perceived as intimidating. Gragson (Chapter 16) is an anthropologist and notes how LTER scientists could be considered as a distinctive "ethnic group" within a particular tribal organization! Flint (Chapter 42) observes that many of the essayists are aware of this "clubbiness," and Hamlin (Chapter 43) detects a certain degree of defensiveness about the topic. Aside from entry into the system as a graduate student, suggestions on how to reduce this (perceived or real) insularity include increased efforts to invite researchers to participate and attempts to make databases more accessible. This was somewhat surprising, given the extent to which the LTER program has pioneered the development of metadata standards and the publication of resulting information on publicly accessible electronic media (Stafford, Porter; Chapters 5, 39, respectively). Indeed, each LTER site is evaluated at least twice per funding cycle on the extent to which data and metadata are incorporated into long-term repositories and are available to the scientific community and public via the Web. Nonetheless, the insularity issue will remain to some extent as long as (1) scientists in the LTER program bond among themselves through work and friendship and (2) those outside of the program remain uninformed of its data and metadata management activities.

Communicating science to the public is a much-valued but challenging part of the LTER program. Many LTER projects now have social scientists on their research team and recognition grows among ecologists that all ecosystems are influenced by human activities. The essayists (e.g., Lugo, Collins; Chapters 25, 35, respectively) describe several outreach programs, notably the Schoolyard Project, but also such approaches as webcams linking Antarctica to classrooms around the United States (Ducklow, Chapter 31). The degree to which outreach is integrated into a particular LTER site's activities varies, in part based on the degree of physical isolation between a site and the public. Some sites, such as H. J. Andrews Experimental Forest, have strongly emphasized the socio-ecological aspects of their site and have invited musicians and poets to interact with scientists at the site. Some LTER scientists receive training (e.g., from programs such as

the Leopold Leadership Program and the Google Science Communication Program) on how to communicate to the public with minimal scientific jargon (Silver, Chapter 26). Yet, such integration is not happening fast enough for some (Lugo, Chapter 25). Pickett (Chapter 11) notes the need to abandon outreach and the delivery model of science in "favor of continual dialogue and mutual learning and listening." Flint (Chapter 42) terms this approach the "coproduction of knowledge."

THE FUTURE OF THE LTER PROGRAM, ECOLOGY, AND SOCIETY

Scientists in the LTER program are clearly having fun. They have access to valuable, long-term data sets, facilities and support staff, mentors, and friends, as well as to opportunities to travel and explore other ecosystems and cultures. All of this occurs in a minimally hierarchical organization based on mutual trust and informality. There are, however, a few caveats. Scientists in the LTER program must raise supplemental resources for most of their research. Although budgets for each LTER project are large compared to those in other programs in NSF's Division of Environmental Biology, where one or several investigators collaborate, per-collaborator funding in budgets at LTER sites is limited by the costs of maintaining infrastructure, core measurements, and support staff. Scientists in the LTER program also must figure out how to get the site refunded every 6 years. Long-term research plots must sometimes be sacrificed in proposals in favor of initiating new experiments that address cutting-edge questions. Stable, visionary leadership must be found and new recruits trained to replenish aging scientists within each site. Despite these caveats, the benefits are clearly substantial. But so what? Do the achievements of this contented (and very accomplished) group matter for ecology, science, or society? Will all of the collaboration and long-term focus lead to the development of new fields such as fish acoustics (Magnuson, Chapter 30), support ongoing developments in eco-geosciences (Swanson, Chapter 6) or ecoinformatics (Porter, Chapter 39), elucidate the relationship between ecology and time (Walker and Wardle 2014, Wolkovich et al. 2014), or enable the development of a general (Scheiner and Willig 2011) or efficient (Marquet et al. 2014) theory of ecology?

Lugo (Chapter 25) argues that the LTER program must embrace socioecology and all its inherent messiness to remain relevant and to become more integrated with society. Hamlin (Chapter 43) notes that science is developing down two divergent paths, the traditional individualistic approach and a more recent communal approach. The former, originally characterized by the single-investigator style of studying a particular site or suite of organisms and only sharing data in publications, is currently exemplified by the trend to obtain patents on biological discoveries. The latter is represented by research in the LTER program, where communal approaches dominate, data and metadata are rapidly and widely shared, and interdisciplinary and (temporal and spatial) scalar divisions become obsolete. Hamlin (Chapter 43) finds the fact that scientists in the LTER program embrace "big, messy problems over discrete disciplinary problems" to be remarkable, representing a sea change from "the paradigm-based model of science articulated by Thomas Kuhn." In contrast, Schlesinger (Chapter 40) argues that such changes (e.g., the deepening and broadening of scientific pursuits) are not likely to be affected by the existence of the LTER program. Whatever the larger societal effects, the essayists contributing to this volume are generally enjoying the challenges that "big, messy problems" present!

We undertook this book project because we thought that the effect of participation in the LTER program on LTER scientists had not been evaluated adequately. We do not have a non-LTER control group and know little about conducting sociological research.

Nevertheless, the essayists (and accompanying evaluators who have the requisite historical and social science credentials) provide a rich source of personal reflections and assessments based on substantive participation in the LTER program. Some scientists found it difficult to talk about their attitudes. Others, perhaps embedded in the LTER tribe for their entire professional lives, found it difficult to evaluate the effect of LTER on those attitudes. Nonetheless, most essays demonstrate a remarkably strong imprint of the "LTER experience" on each scientist. We therefore conclude that experience in the LTER program leads to multiple changes in how scientists think about time and space, collaborate, and communicate. Nonetheless, documentation and assessment of the extent to which participation by scientists in the "cultural experiment" embodied in LTER program remains a challenge for the future. We suggest that there are also broader societal implications of the LTER program, as many scientists adopt its multiscalar, multidisciplinary, and networked approach. Critical among these implications is the ability of ecology to adapt to a rapidly changing world. Will the LTER-style collaborative approach, for example, become an effective tool to address our many environmental challenges? As science continually adapts to societal conditions, its relevance and acceptance by society at large may well depend on how well it can integrate the pursuit of intellectual curiosity and the solution of practical concerns. The extent to which the LTER program has and will contribute substantially to such integration remains to be determined. Indeed, such integration represents a challenge for all those who manage and administer programs dedicated to the advancement of fundamental and mission-specific scientific programs.

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