2-21-2017

The International Long Term Ecological Research Network: a platform for collaboration

Kristin Vanderbilt
Southeast Environmental Research Center, Florida International University, krvander@fiu.edu

Evelyn E. Gaiser
Southeast Environmental Research Center, Florida International University, gaisere@fiu.edu

This material is based upon work supported by the National Science Foundation through the Florida Coastal Everglades Long-Term Ecological Research program under Cooperative Agreements #DBI-0620409 and #DEB-9910514. Any opinions, findings, conclusions, or recommendations expressed in the material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

esa

ECOSPHERE

SPECIAL FEATURE: INTERNATIONAL LTER

The International Long Term Ecological Research Network: a platform for collaboration

KRISTIN VANDERBILT† AND EVELYN GAISER

Southeast Environmental Research Center, Florida International University, OE-148, 11200 SW 8th Street, Miami, Florida 33199 USA

Citation: Vanderbilt, K., and E. Gaiser. 2017. The International Long Term Ecological Research Network: a platform for collaboration. Ecosphere 8(2):e01697. 10.1002/ecs2.1697

Abstract. Many scientists around the world became interested in the U.S. Long Term Ecological Research (U.S. LTER) Network's research model during the 1990s and began to develop LTER and Long Term Socio-ecological Research networks in their own countries. These local networks, including the U.S. LTER Network, were loosely federated in 1993 to form the International Long Term Ecological Research (ILTER) Network, a "network of networks." Although the first 10 yr of ILTER Network activities were largely supported by funds from the U.S. National Science Foundation, the ILTER Network had transformed into a robust, self-sustaining entity by 2006 following a two-year strategic planning process. The goal of the ILTER Network is to improve understanding of how pressures such as climate change and land use affect global ecosystems in order to inform solutions to current and future environmental problems. To fulfill this mission, the ILTER Network fosters collaborations among member scientists to extend the scope of their research across disciplinary boundaries and across more of the ILTER's 600+ research sites. The ILTER Network also has many long-term data sets that are freely available for use by students, scientists, and policymakers all over the world. In this collection of papers, we consider how the ILTER Network has been, and will be, leveraged by U.S. researchers to advance understanding of ecological and socio-ecological systems around the globe.

Key words: collaboration; Everglades; information management; international; International Long Term Ecological Research; Long Term Ecological Research; Long Term Socio-Ecological Research; National Science Foundation; network; Special Feature: International LTER.

Received 6 October 2016; revised 13 December 2016; accepted 13 December 2016. Corresponding Editor: Debra P. C. Peters.

† **E-mail:** krvander@fiu.edu

INTRODUCTION TO THE SPECIAL INTERNATIONAL LONG TERM ECOLOGICAL RESEARCH NETWORK ISSUE

The U.S. Long Term Ecological Research Network: a model for research

Long-term ecological research provides valuable data to test hypotheses about the drivers of ecosystem transformation. In 1980, the U.S. National Science Foundation (NSF) responded to the need for more long-term studies by creating the U.S. Long Term Ecological Research (U.S. LTER) Network (Callahan 1984). Today, the U.S. LTER Network has grown to encompass 25 sites in ecosystems that include forest, grassland, desert, agricultural, freshwater, arctic, coastal, marine, and urban environments. Each site gathers long-term data on five core processes: primary

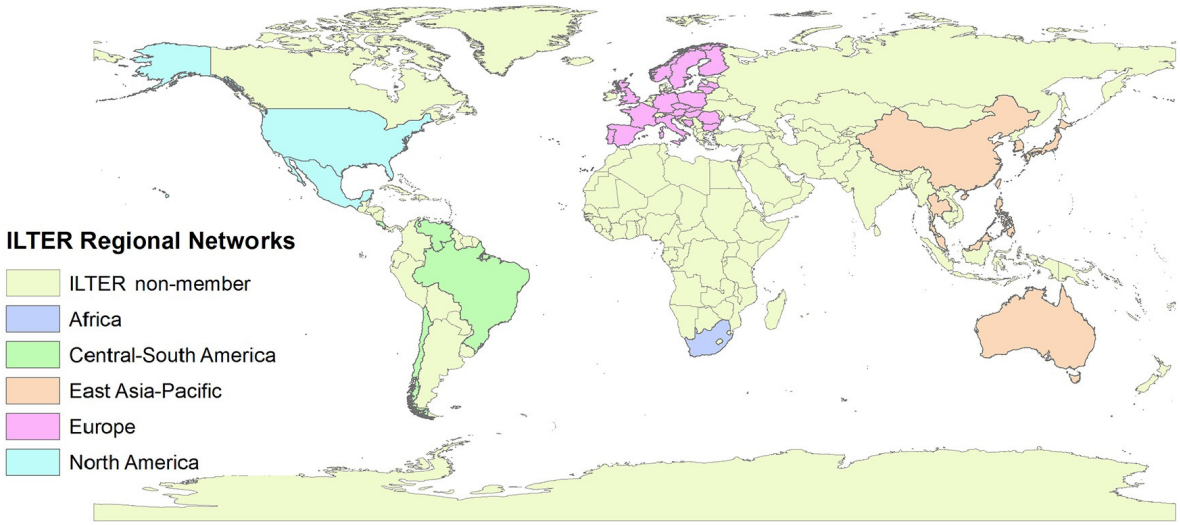

Fig. 1. Forty countries are organized into five regional International Long Term Ecological Research (ILTER) Networks.

production; cycling of organic matter; spatial and temporal distributions of populations; inorganic nutrient cycling; and patterns of disturbances. U.S. LTER sites are networked to facilitate the synthesis of these thematically similar data sets across sites in order to detect generalizable ecological theory (Hobbie et al. 2003). The value of long-term data has continued to grow as time series reveal how climate change and other anthropogenic pressures drive and interact with ecosystem change, and particularly as the need to mitigate these changes becomes more urgent through impacts on ecosystem services.

The need for long-term research is not limited to the United States, and NSF also facilitated the development of long-term research programs around the world. The International Long Term Ecological Research (ILTER) Network was formally created in 1993 at an International Summit, hosted by the U.S. LTER Network, which was attended by representatives of 16 countries (Nottrott et al. 1994). Many participating researchers already had long-term data collection efforts underway at multiple sites (Risser 1991), and these scientists embraced the idea of linking sites at the country level and international level to form a "network of networks." By 1998, several local LTER Networks were forming (e.g., in Mexico, Ceballos et al. 1998; Taiwan, King 1998; and Poland, Prus and Perzanowski 1998). Regional ILTER networks have also been organized (e.g., LTER Europe, Mirtl 2010; East Asia-Pacific, Kim 2012; Africa; North America; and Central-South America; Fig. 1).

Many early ILTER Network activities were driven by the U.S. LTER through supplement grants from NSF. For 3 yr, NSF assigned a program officer to the LTER Network Office (the centralized office in charge of U.S. LTER outreach) to help catalyze ILTER activities (French 1998*a*). Delegations of U.S. scientists visited emerging networks (Sprott 1996*a*), and reciprocal visits by international scientists to U.S. LTER sites were also made (Sprott 1996*b*). U.S. researchers attended regional ILTER meetings (Sprott 1995, French 1998*b*). Several information management workshops were organized in the United States and abroad by U.S. information managers to share basic U.S. LTER information management strategies (Acevado 1998, Brunt 1998, Michener 2002). Publication of ILTER research was supported by U.S. LTER resources (e.g., Lajtha and Vanderbilt 2000) to strengthen nascent ILTER networks. NSF supported travel by U.S. LTER students to Asian LTER sites (French 1998*c*, Sherrod 1999), and for students from Taiwan and Japan to travel to sites in the U.S. LTER (Vanderbilt 1998). The LTER Network Office published a catalog of ILTER Networks in 2000 (Gosz et al. 2000).

The role of the U.S. LTER Network in the ILTER Network changed as the ILTER Network

matured. The first non-U.S. ILTER chairperson was elected in 2002. Beginning in 2003, NSF funded a two-year strategic planning effort so that the ILTER Network could establish a more sustainable structure less reliant on U.S. funds. A new system of ILTER governance was put in place when the ILTER Network adopted a new strategic plan in 2006 (Hamburg and Bourgeron 2006). Standing committees (Executive, Coordinating, Science and Programming, Information Management, Public Policy, and Fundraising and Marketing) were created and the ILTER Network became a legal entity, facilitating dues payment by member networks (Kaufman and Anderson 2006). The ILTER Network thus transitioned from a satellite of the U.S. LTER to an autonomous, self-sufficient international organization with increased capacity to contribute to global research. U.S. scientists and students are presently participating in ILTER-sponsored research initiatives led by domain experts from around the world (e.g., Shibata et al. 2014).

The ILTER Network: a platform for collaboration

Having grown from a loose federation of independent national networks into a body that is engaged in coordinated international research, the ILTER Network now offers its members expanded research opportunities. The ILTER Network differs from many other global networks in that members engage in *long-term, site-based* ecological research. ILTER researchers can extend the scope of their research to sites that are located in many more ecosystems than are represented in one country's LTER Network alone. ILTER sites provide a rich suite of long-term, co-located interdisciplinary data sets on climatic, hydrological, biogeochemical, and other environmental variables that provide context for new studies (Haase et al. 2016). To help researchers find sites with the characteristics they need for their research, the ILTER Network has developed a new database that describes the ecosystem, infrastructure, and available data sets from sites within the ILTER Network (Peterseil 2016; https://data.lter-europe.net/deims/site/search).

International Long Term Ecological Research scientists can benefit from working with colleagues from around the world who have different research perspectives, social cultures, and knowledge bases. Many ILTER sites, for instance, have an extensive history of human habitation, and socio-economic and ecological site dimensions have been integrated into the Long Term Socio-Ecological Research (LTSER) concept (Singh et al. 2010). Several ILTER networks have established LTSER platforms (Mirtl 2010, Arnas et al. 2016) which are different than traditional LTER sites, such as those in the United States, which often consist of a relatively homogeneous habitat type with limited human disturbance. LTSER platforms, in contrast, may be thousands of square kilometers in size with a substantial human population and wide range of ecosystems and land-use patterns. The long-term nature of LTSER platforms allows for the establishment of trust relationships between scientists and local stakeholders that support transdisciplinary research (Maass et al. 2016). LTSER researchers cooperate across institutional and disciplinary divides, synthesizing long-term monitoring, historical research, forecasting, and scenario building activities to provide knowledge that supports ecosystem sustainability (e.g., delivery of ecosystem services; Dick et al. 2016, Forsius et al. 2016) and informs policy (e.g., critical loads of nitrogen in Europe; Dirnböck et al. 2014). Scientists from LTSER platforms and LTER sites build diverse, synergistic international research teams with members who have a wide range of research expertise on many ecosystems and social systems.

The ILTER Network's bottom-up governance style encourages scientist engagement. The ILTER Network provides a framework for connecting researchers and would-be collaborators. Teams of ILTER scientists can self-organize and deploy research projects as they wish. The First ILTER Open Science Meeting, held October 9–14, 2016, in Skukuza, Kruger National Park, South Africa, brought together LTER and LTSER scientists from throughout the world to share their ideas and find new research partners. The ILTER's "Nitrogen Initiative" (Shibata et al. 2014) is an example of a research project that arose from a groundswell of interest by participants in annual ILTER science meetings.

ILTER member networks are committed to free and open data sharing (Vanderbilt et al. 2010) to support science at all levels. For data to be shared, it must be discoverable, and the ILTER information management community grappled with how to develop an ILTER data repository. Limited ILTER funds made it desirable to use existing

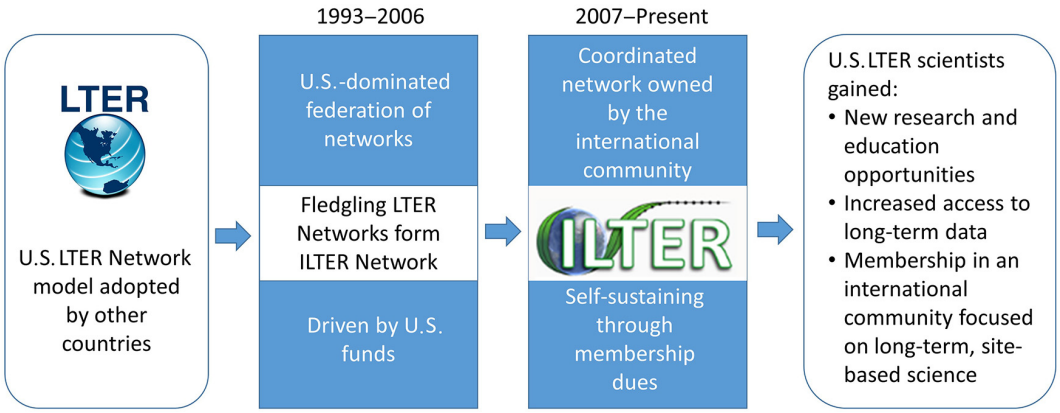

Fig. 2. U.S. scientists today can capitalize on the National Science Foundation's investment in the establishment and early growth of the International Long Term Ecological Research (ILTER) Network.

infrastructure, and the ILTER information management community identified DataONE, a distributed network of data centers (Michener et al. 2011), as the mechanism to expose ILTER data. In order for ILTER metadata and data to be ingested by DataONE, the metadata must conform to a structural and content standard known as the Ecological Metadata Language (EML; Fegraus et al. 2005). Workshops have been held throughout the ILTER Network to train scientists to document their data using EML (Porter et al. 2007, FRIM CCU 2012). Once documented in EML and entered into an international repository such as the Knowledge Network for Biodiversity (https://knb.ecoinformatics.org/), ILTER data and metadata are harvested into DataONE where they can be queried by location, taxon, creator, DOI, and data attribute, among other characteristics. The DataONE portal offers a wealth of ILTER data for anyone to use.

The U.S. LTER as a member of the ILTER Network

The US National Science Foundation invested significant resources between 1993 and 2006 in the establishment of the ILTER Network. Since 2006, many U.S. LTER scientists have also received supplements to their LTER grants for ILTER-related activities. In this special issue, we consider the return on NSF's investment in the ILTER Network by exploring how past, present, and anticipated future interactions of U.S. scientists with other ILTER members enrich research perspectives and opportunities (Fig. 2).

Since the inception of the ILTER Network, U.S. scientists and students have capitalized on the existence of the ILTER Network by connecting with researchers working in similar ecosystems in other countries to evaluate how ecosystem processes compare across locations (e.g., Vanderbilt 2002, Holub et al. 2005, Lin et al. 2006, Bowman et al. 2008). The first paper in this issue presents a case study examining how the comparison of the iconic ecosystem of the Florida Coastal Everglades LTER with similar coastal wetlands elsewhere in the world has informed general ecosystem paradigms. Results of long-term studies from the Caribbean and Australia have shed light on puzzling Everglades phenomena such as the "upside-down estuary" and "productivity paradox" (Gaiser et al. 2015).

U.S. LTER information managers have formed very productive partnerships with other ILTER information managers. They have synergized with scientists and each other to promote data sharing, the use of common information management tools throughout the ILTER, and development of a multilingual data catalog. The second paper in this issue focuses on ILTER information management collaborations, where information managers have responded to ILTER Network needs through bottom-up, self-organized, and collectively funded trainings and workshops (Vanderbilt et al. 2015). This grass-roots approach to developing tools for use in an international context may be a model for other groups in an era of dwindling resources.

Looking into the future, many possibilities for U.S. scientists to leverage the ILTER Network

can be envisioned. In the third paper, by focusing on the role that the ILTER Network can play in global phenology research, the authors provide another example of how ILTER research, when coordinated across many different ecosystems and locations, can shift disciplinary theoretical paradigms. The authors review what is known about controls on plant phenology, discuss new technological developments in the field, and assert that the ILTER Network is an ideal platform for implementing these technological advances to yield comparable data across many ecosystems (Tang et al. 2016).

Together, the three papers in this special issue demonstrate that, through investment in the ILTER Network, NSF helped create a valuable framework for producing generalizable science, replicable models for information sharing, and addressing critical questions about environmental change across the globe. U.S. LTER scientists have leveraged, and will continue to benefit from, research opportunities made possible by membership in the ILTER Network.

Acknowledgments

This paper was stimulated by conversations at the 2013 meeting of the International Long Term Ecological Research Network in Seoul, Korea. Some support for synthesis was provided by international supplements to the Florida Coastal Everglades Long Term Ecological Research Program through U.S. National Science Foundation grants (DEB-9910514, DBI-0620409, and DEB-1237517). Some support for U.S. scientists' travel came from international supplements to the Sevilleta Long Term Ecological Research Program through U.S. National Science Foundation grants (DEB-9411976, DEB-0080529, DEB-0620482). The authors declare no conflict of interest.

Literature Cited

Acevado, M. F. 1998. Information management: a strong beginning in the Latin American LTER. LTER Network News. http://news.lternet.edu/Article1094.html

Arnas, C., J. R. Gutierrez, D. A. Kelt, and P. L. Meserve. 2016. Twenty-five years of research in the north-central Chilean semiarid zone: the Fray Jorge Long-Term Socio-Ecological Research (LTSER) site and Norte Chico. Journal of Arid Environments 126:1–6.

Bowman, W. D., C. C. Cleveland, L. Halada, J. Hresko, and J. S. Baron. 2008. Negative impact of nitrogen deposition on soil buffering capacity. Nature Geoscience 1:767–770.

Brunt, J. 1998. Using the World Wide Web to Advance Data Management in LTER. LTER Network News. http://news.lternet.edu/Article1141.html

Callahan, J. T. 1984. Long-Term Ecological Research. BioScience 34:363–367.

Ceballos, G., M. Maass, R. Medellin, M. Equihua, R. Dirzo, A. Garcia, M. Lazcano, L. Hernandez, and F. Noguera. 1998. The Mexican Long Term Ecological Research Network. Pages 52–57 *in* R. Waide, C. French, P. Sprott, and L. Williams, editors. The Long Term Ecological Research Network 1998. LTER Network Office, University of New Mexico, Albuquerque, New Mexico, USA.

Dick, J., et al. 2016. Analysis of temporal change in delivery of ecosystem services over 20 years at long term monitoring sites of the UK Environmental Change Network. Ecological Indicators 68: 115–125.

Dirnböck, T., et al. 2014. Forest floor vegetation response to nitrogen deposition in Europe. Global Change Biology 20:429–440.

Fegraus, E., S. Andelman, M. Jones, and M. Schildhauer. 2005. Maximizing the value of ecological data with structured metadata: an introduction to Ecological Metadata Language (EML) and principles for metadata creation. Bulletin of the Ecological Society of America 86:158–168.

Forsius, M., A. Akujarvi, T. Mattsson, M. Holmberg, P. Punttila, M. Posch, J. Liski, R. Virkkala, and P. Vihervaara. 2016. Modelling impacts of forest bioenergy use on ecosystem sustainability: Lammi LTER region, southern Finland. Ecological Indicators 65:66–75.

French, C. 1998*a*. International Networks Gaining Momentum. LTER Network News. http://news.lternet.edu/Article1145.html

French, C. 1998*b*. Central European LTER Network: development continues. LTER Network News. http://news.lternet.edu/Article1095.html

French, C. 1998*c*. Science exchange: US students visit Asian LTER sites. LTER Network News. http://news.lternet.edu/Article1096.html

FRIM CCU [Forest Research Institute Malaysia]. 2012. FRIM helps Kasetsart University set up ecological database system. https://www.frim.gov.my/en/frim-helps-kasetsart-university-set-up-ecological-database-system/

Gaiser, E. E., et al. 2015. New perspectives on an iconic landscape from comparative international long-term ecological research. Ecosphere 6:181.

Gosz, J. R., C. French, P. Sprott, and M. White. 2000. The Long Term Ecological Research Network 2000. Academy Printers, Albuquerque, New Mexico, USA.

Haase, P., M. Frenzel, S. Klotz, M. Musche, and S. Stoll. 2016. The long-term ecological research (LTER) network: relevance, current status, future perspective and examples from marine, freshwater and terrestrial long-term observation. Ecological Indicators 65:1–3.

Hamburg, S., and P. Bourgeron. 2006. On the move: International LTER Coordinating Committee Meeting in Namibia develops strategic plan. LTER Network News. http://news.lternet.edu/Article119.html

Hobbie, J. E., S. R. Carpenter, N. B. Grimm, J. R. Gosz, and T. R. Seastedt. 2003. The US Long Term Ecological Research Program. BioScience 53:21–32.

Holub, S. M., K. Lajtha, J. D. H. Spears, J. A. Tóth, S. E. Crow, B. A. Caldwell, M. Papp, and P. T. Nagy. 2005. Organic matter manipulations have little effect on gross and net nitrogen transformations in two temperate forest mineral soils in the U.S.A and central Europe. Forest Ecology and Management 214:320–330.

Kaufman, H., and M. Anderson. 2006. International Long Term Ecological Research Network final draft strategic plan. https://www.ilternet.edu/sites/default/files/FINAL_DRAFT_STRATEGIC_PLAN_Aug2006.pdf

Kim, E.-S. 2012. International Long-Term Ecological Research Network activities in the East Asia-Pacific Region and biodiversity monitoring. Pages 111–132 *in* S. Nakano, T. Yahara, and T. Nakashizuka, editors. The Biodiversity Observation Network in the Asia-Pacific Region. Springer, Tokyo, Japan.

King, H.-B. 1998. The Taiwan Ecological Research Network. Pages 22–27 *in* R. Waide, C. French, P. Sprott, and L. Williams, editors. The Long Term Ecological Research Network 1998. LTER Network Office, University of New Mexico, Albuquerque, New Mexico, USA.

Lajtha, K., and K. Vanderbilt, editors. 2000. Cooperation in Long Term Ecological Research in Central and Eastern Europe: proceedings of the ILTER Regional Workshop, June 22–25, 1999, Budapest, Hungary. Oregon State University, Corvallis, Oregon, USA.

Lin, C.-C., J. H. Porter, and S.-S. Lu. 2006. A metadata-based framework for multilingual ecological information management. Taiwan Journal of Forest Science 21:1–6.

Maass, M., et al. 2016. Changes in biodiversity and trade-offs among ecosystem services, stakeholders, and components of well-being: the contribution of the International Long-Term Ecological Research Network (ILTER) to Programme on Ecosystem Change and Society (PECS). Ecology and Society 21:31.

Michener, W. 2002. Ecoinformatics Training in Maputo, Mozambique. LTER Network News. http://news.lternet.edu/Article746.html

Michener, W., D. Vieglais, T. Vision, J. Kunze, P. Cruse, and G. Janée. 2011. DataONE: data observation network for earth–preserving data and enabling innovation in the biological and environmental sciences. D-Lib Magazine 17:3.

Mirtl, M. 2010. Introducing the next generation of ecosystem research in Europe: LTER-Europe's multifunctional and multi-scale approach. Pages 75–93 *in* F. Muller, C. Baessler, H. Schubert, and S. Klotz, editors. Long-Term Ecological Research, between theory and application. Springer, Heidelberg, Germany.

Nottrott, R. W., J. R. Franklin, and J. R. Vande Castle, editors. 1994. International Networking in Long-Term Ecological Research, Proceedings of an International Summit, 23–24 September, 1993, Estes Park, Colorado. LTER Network Office, University of Washington, Seattle, Washington, USA.

Peterseil, J. 2016. Standardised description of long term observation sites using DEIMS and EnvThes. Page 45 *in* Proceedings of the International Long Term Ecological Research Network 1st Open Science Meeting, 10–13 October, 2016. Skukuza, Kruger National Park, Pretoria, South Africa.

Porter, J. H., C.-C. Lin, M. Jeng, and S.-S. Lu. 2007. Ecological Information Management Training in the East-Asia-Pacific Region. *In* Proceedings of the Urban Forestry and East-Asia Pacific Information Management Conference, 16–21 October, 2007. Kookmin University, Seoul, Korea.

Prus, T., and K. Perzanowski. 1998. Long Term Ecological Research in Poland. Pages 58–64 *in* R. Waide, C. French, P. Sprott, and L. Williams, editors. The Long Term Ecological Research Network 1998. LTER Network Office, University of New Mexico, Albuquerque, New Mexico, USA.

Risser, P., editor. 1991. Long-Term Ecological Research, an International Perspective, SCOPE47. John Wiley and Sons, New York, New York, USA.

Sherrod, S. 1999. Students Attend US-Japan ILTER Workshop 11–19 June, 1999 Otsu and Tomakomai, Japan. US LTER Network News. http://news.lternet.edu/Article993.html

Shibata, H., et al. 2014. Consequence of altered nitrogen cycles in the coupled human and ecological system under changing climate: the need for long-term and site-based research. Ambio 44:178–193.

Singh, S. J., H. Haberl, V. Gaube, C. M. Grünbühel, P. Lisievici, J. Lutz, R. Matthews, M. Mirtl, A. Vadineanu, and M. Wildenberg. 2010. Conceptualising long-term socio-ecological research (LTSER): integrating socioeconomic dimensions into long-term ecological research. Pages 377–398 *in* F. Muller,

C. Baessler, H. Schubert, and S. Klotz, editors. Long-Term Ecological Research, between theory and application. Springer, Heidelberg, Germany.

Sprott, P. 1995. ILTER Meeting in Hungary. LTER Network News. http://news.lternet.edu/Article1940.html

Sprott, P. 1996*a*. U.S. LTER and LMER scientists visit Iberian sites. LTER Network News. http://news.lternet.edu/Article1232.html

Sprott, P. 1996*b*. Central Europeans visit NSF and LTER sites. LTER Network News. http://news.lternet.edu/Article1233.html

Tang, J., C. Körner, H. Muraoka, S. Piao, M. Shen, S. J. Thackeray, and X. Yang. 2016. Emerging opportunities and challenges in phenology: a review. Ecosphere 7:e01436.

Vanderbilt, K. L. 1998. ILTER graduate students visit H. J. Andrews experimental forest. LTER Network News. http://news.lternet.edu/Article1134.html

Vanderbilt, K. 2002. DIRT: extending an LTER Project to the ILTER. LTER Network News. http://news.lternet.edu/Article750.html

Vanderbilt, K. L., D. Blankman, X. Guo, H. He, C.-C. Lin, S.-S. Lu, A. Ogawa, É. Ó. Tuama, H. Schentz, and W. Su. 2010. A multilingual metadata catalog for the ILTER: issues and approaches. Ecological Informatics 5:153–230.

Vanderbilt, K. L., C.-C. Lin, S.-S. Lu, A. R. Kassim, H. He, X. Guo, I. San Gil, D. Blankman, and J. H. Porter. 2015. Fostering ecological data sharing: collaborations in the International Long Term Ecological Research Network. Ecosphere 6:204.