

# THE WORLD WIDE WEB AS A TOOL FOR ECOLOGICAL RESEARCH PROGRAMS

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*Abstract.* The World Wide Web provides a new technology for the ecological research community to disseminate information and facilitate research programs. In this chapter, the history of the World Wide Web (WWW) and its implementation at Long-Term Ecological Research sites are reviewed. A summary of WWW use in the context of ecological research is presented along with selected examples.

## INTRODUCTION

The rapid expansion of the World Wide Web (WWW) has created a new level of accessibility for ecological data and information. A review of the use of the WWW by sites within the Long Term Ecological Research Program (LTER) provides an overview of multiple ways in which the WWW can facilitate ecological research programs.

## HISTORY OF THE WWW

Shiple and Fish (1996) observed that “the Web has exploded into an information revolution and a cultural phenomenon.” Prior to the WWW, finding specific data or information on the Internet could be difficult. In 1989, Tim Berners-Lee at CERN (European Laboratory for Particle Physics) proposed a hypertext system that would provide simple and consistent access to documents from any source. He invented communication protocols that incorporated existing information systems (such as Gopher and ftp) and browsing software capable of running on all platforms (Kennedy 1995). In 1993, the first graphical browser (Mosaic, NCSA) was released. The WWW has experienced dramatic growth since that time.

Table 1. Growth of the World Wide Web.

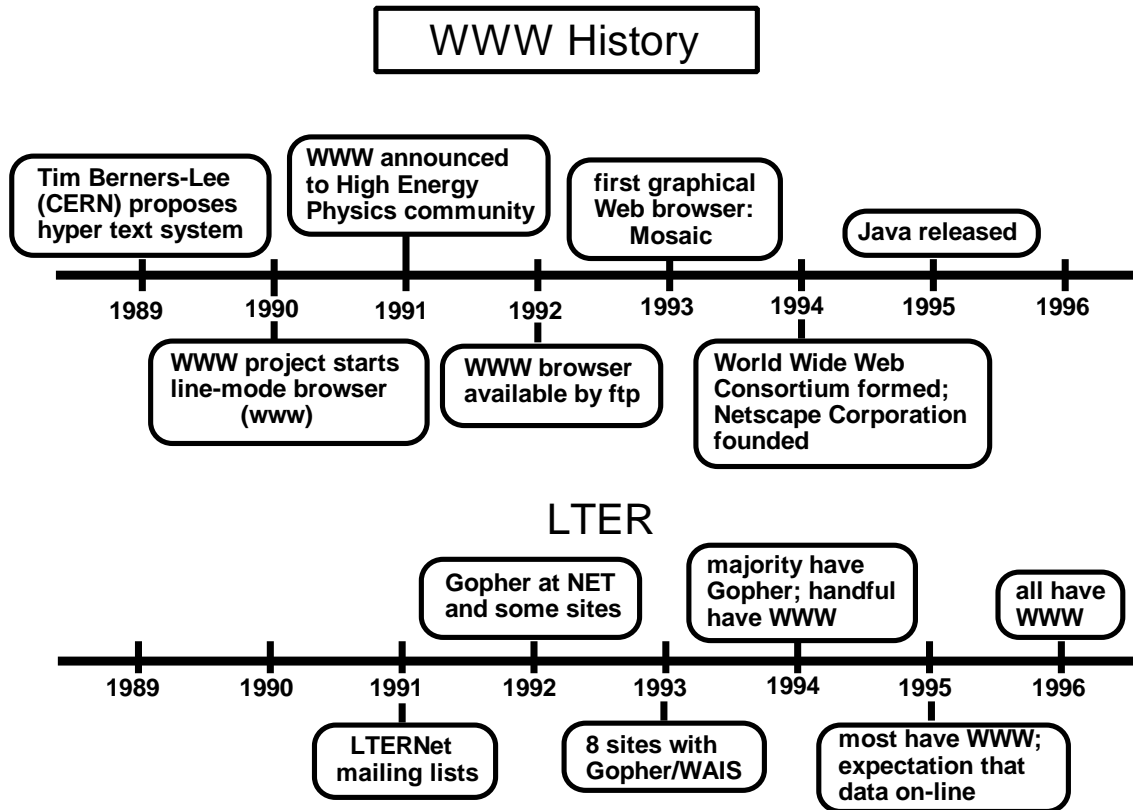
### WWW Statistics

(from Matthew Gray of the Massachusetts Institute of Technology,  
<http://www.mit.edu:8001/people/mkgray/net/index.html>)

Month	Number of Web Sites	Percent “.com” Sites
6/93	130	1.5
1/97	650,000 (est.)	62.6

With current WWW browsers, a vast network of information is available including multimedia documents with audio and video. These browsers also include email and conferencing functionality.

Figure 1. Highlights of the development of the World Wide Web (top) and its implementation at the LTER sites (bottom).



Data managers within the LTER research network quickly recognized the potential of the WWW (Ingersoll and Brunt 1995). By 1994, some of the eighteen LTER sites had home pages on the WWW, and by 1995 most sites had a presence on the WWW. At the same time, there was a growing expectation within and outside the LTER community that LTER data be accessible on the WWW.

#### USES OF THE WWW BY ECOLOGICAL RESEARCH PROGRAMS

From the perspective of an ecological research site, how can the WWW be used to enhance research programs? In presenting an overview of how sites within the LTER program are using the WWW, addresses (URL's) to specific locations on the WWW will be included as examples (Table 2). These examples provide only an introduction to what has been done. For a more thorough examination, all LTER site WWW servers can be accessed through the LTER Network home page (<http://lternet.edu>).

Research sites get many different types of inquiries for information, ranging from the K-12 student working on a class project, to prospective graduate students wanting to know more about the program, to colleagues looking for particular types of data for a research project, to members of the local research group looking for a copy of a document or the current calendar of events. A wide variety of information types can be provided on the site's home page to meet the needs of diverse users.

An LTER site home page can provide access to general information about the research site, including site characteristics (e.g., Coweeta LTER Basin map, North Temperate Lakes LTER map to field station, North Temperate Lakes LTER lake characteristics). The research program can be described detailing major objectives, approaches to questions, research results and future directions. A personnel directory can be provided including address, phone, email address, fax, a biographical sketch, and links to other information. The personnel directory can be searchable and set up to provide on-line updates. Important site documents can also be accessed through the WWW. These documents might include a site history, a bibliography of publications, recent research proposals, and electronic publications.

Table 2. Locations of example documents from selected LTER site home pages on the WWW.

<b>Research Site Information</b>	
Coweeta LTER Basin map	<a href="http://sparc.ecology.uga.edu/webdocs/gis/html/maparchive/cwtbase.html">http://sparc.ecology.uga.edu/webdocs/gis/html/maparchive/cwtbase.html</a>
North Temperate Lakes LTER map to field station	<a href="http://limnosun.limnology.wisc.edu/tls/map/map.html">http://limnosun.limnology.wisc.edu/tls/map/map.html</a>
North Temperate Lakes LTER lake characteristics	<a href="http://limnosun.limnology.wisc.edu/lter_lake.html">http://limnosun.limnology.wisc.edu/lter_lake.html</a>
Sevilleta LTER personnel directory and links to home pages of individuals	<a href="http://sevilleta.unm.edu/people">http://sevilleta.unm.edu/people</a>
Niwot Ridge LTER searchable bibliography	<a href="http://culter.colorado.edu:1030/Niwot/Niwot_Ridge_LTER_bibliography.html">http://culter.colorado.edu:1030/Niwot/Niwot_Ridge_LTER_bibliography.html</a>
<b>Data and Metadata</b>	
Bonanza Creek LTER data catalog	<a href="http://www.lter.alaska.edu/cgi-bin/w3-mysql/dfd/dfd.html">http://www.lter.alaska.edu/cgi-bin/w3-mysql/dfd/dfd.html</a>
Short Grass Steppe LTER dynamic queries of database	<a href="http://sgs.cnr.colostate.edu/data/data_cat/climateindex.html">http://sgs.cnr.colostate.edu/data/data_cat/climateindex.html</a>
Virginia Coastal Reserve LTER spatial data archive	<a href="http://www.vcrlter.Virginia.EDU/data/TMairAtlas.html">http://www.vcrlter.Virginia.EDU/data/TMairAtlas.html</a>
Biodiversity information: Cedar Creek LTER catalog of flora	<a href="http://www.lter.umn.edu/florfaun/flora/t1.html">http://www.lter.umn.edu/florfaun/flora/t1.html</a>
<b>Project Management</b>	
Niwot LTER data management policy	<a href="Gopher://culter.colorado.edu/00/.NWTPOLICY.TXT">Gopher://culter.colorado.edu/00/.NWTPOLICY.TXT</a>
Virginia Coastal Reserve LTER calendars	<a href="http://atlantic.evsc.virginia.edu/calendar.html">http://atlantic.evsc.virginia.edu/calendar.html</a>

There has been considerable development on the WWW to provide access to data and metadata. Sites have data catalogs that provide an overview of data set availability and data set descriptions. LTER data sets are supposed to be available on the WWW within two years after collection with a minimum of restrictions (S. Collins, e-mail communication). Many sites make their data available as text files; however, some sites whose data reside in relational databases have developed programs that provide dynamic queries of the database. Through dynamic queries, subsets of a database in which the user has specified variables and the time period of interest can

be provided. The results of such queries can be displayed graphically. Because databases are updated over time, it is desirable to maintain a log of database updates on the WWW so that users can determine whether the data which they downloaded at a given point in time is still consistent with the most current version of the data.

Spatial data such as GIS coverages, satellite images, and photo archives can also be provided through the WWW. Catalogs of spatial data may include thumbnail versions so that the user may have a look at the image without having to download a large file. Thumbnails may also provide information on satellite images that are not licensed to be distributed publicly.

Sites have published other types of data and products on the WWW including models and software developed at a site. Biodiversity information can be provided as species lists or more detailed descriptions of fauna and flora.

The WWW can be used to facilitate data management activities and to deal with issues related to data access. Researchers can provide the required metadata for submitted data sets through the use of forms for metadata entry. All sites provide a statement of their data access policy and some require those who download data to provide information through the use of forms. The collected information can then be passed to site researchers. Documents detailing data management policy and protocols have also been provided at most sites.

Project management can be facilitated through the WWW by communicating information of primary interest to the local research group. Publishing calendars and interactive forms for scheduling trips and equipment use has proved useful at some sites.

The amount of site information and data that are provided through the home page of an LTER site is extensive. At least one site is developing navigation tools (Andrews LTER; <http://www.fsl.orst.edu/lter/navigafr.htm>) to aid browsing through their large collection of linked documents.

The WWW page may also contain links to other sites. Some common links are weather information, professional societies (e.g., ESA), funding agencies (e.g., NSF), affiliated institutions, and sources of Internet information and help.

At a larger scale, the WWW can be used as a tool for an entire research network or even a network of networks. The home page of the LTER Network (<http://lternet.edu>) illustrates how the WWW can be used to create a unified point of entry to a distributed information system. Some network-level information products developed by the LTER data managers and network office data management staff include an all-site bibliography, personnel directory, and data catalog. Current projects include an integrated climate database across all sites and an expanded, updated data catalog.

In the future, the WWW will expand its contribution to ecological information systems. Development of documents for the WWW has become easier with the advent of HTML editors and the integration of HTML exporting capabilities in word processing software. The use of forms is allowing the flow of information to be two-way. Java <sup>TM</sup> (<http://java.sun.com>; Campione and Walrath 1996) scripts are being developed to automate documentation, quality control and data processing (see Jones, this volume). Research groups are exploring the WWW as an environment for collaboration.

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