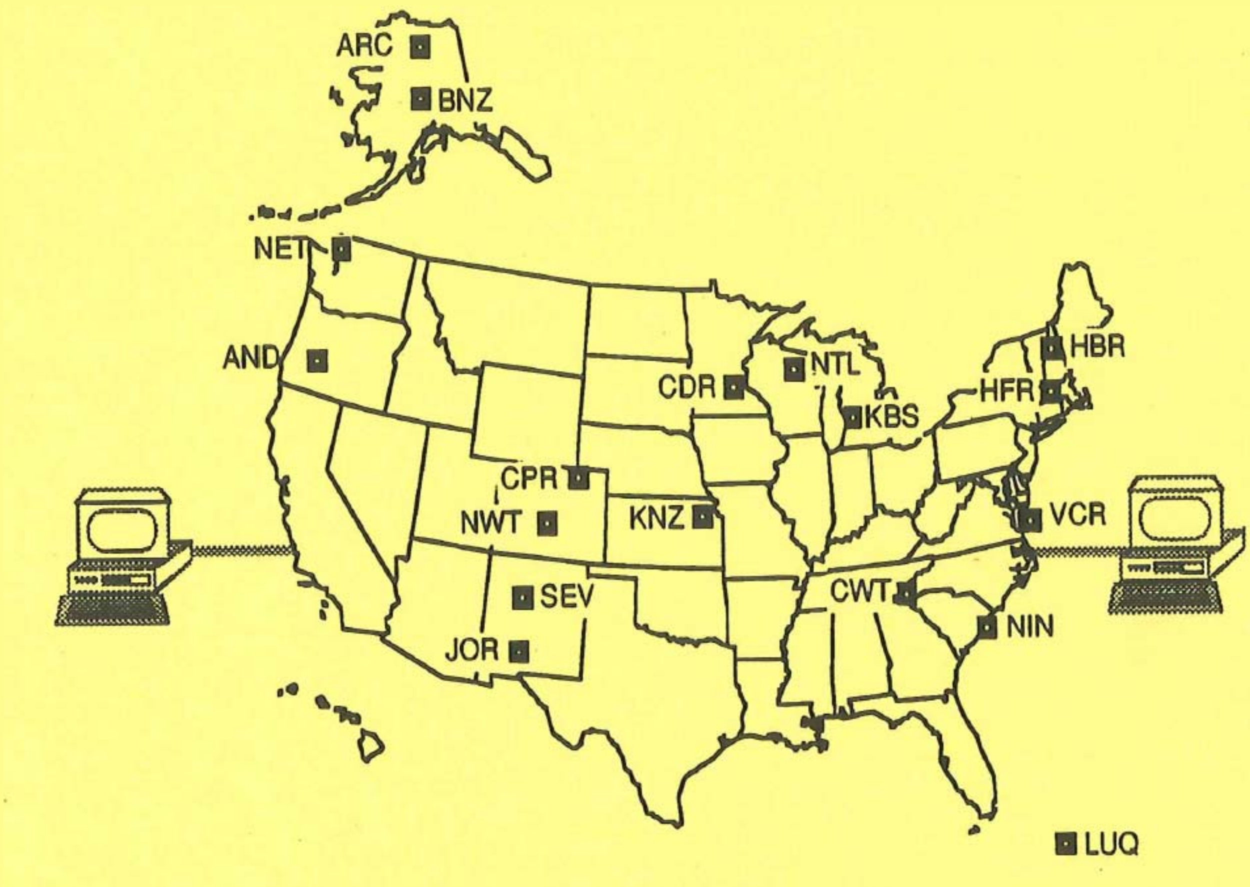
INTERNET CONNECTIVITY IN LTER

Assessment and Recommendations



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Executive Summary

Traditional forms of networking are no longer sufficient to support the expanding needs of the ecological community. Fortunately, computer networking technology is rapidly becoming available that can virtually eliminate the physical and temporal barriers to productive collaboration. Almost 90% of the institutions that administer LTER grants have existing or planned connections to the Internet (an association of high-speed, high- capacity, wide-area networks, including NSFNet, a network established and funded by the National Science Foundation). However, the majority of LTER computers, all of the field laboratories and many PI's remain isolated from Internet capabilities. In order to derive the maximum benefits from electronic networking, we recommend that the LTER network pursue complete connectivity. This includes Internet connections to all administrative headquarters and development of a minimal network infrastructure within each LTER site (cost: $648,500 for equipment and installation, $81,760 for personnel, communications lines and commercial network charges); enhancing local-area network capabilities to permit disk sharing, peripheral sharing, ”user friendly” electronic mail (cost: $833,000 to provide computers, software and personnel), and to provide direct electronic mail service to large field laboratories (cost: $100,000 for computers and $20,000 in communications line charges); and extending full NSFNet connections to all large field laboratories (cost: $250,000 to for equipment and installation, $67,000 in communications line charges). We estimate total costs between 1.4 and two million dollars.

In addition, we recommend that NSF and the LTER coordinating committee: 1) consider funding proposals that include support for technical personnel in networking and computer integration, 2) consider funding proposals to develop workshops that involve advanced uses of computer networks in ecological sciences, 3) consider funding proposals for a UNIX system and network administration workshop, and 4) consider a proposal to produce a networking manual to assist sites in developing their networks. If this type of funding were considered over a period of several years it would insure a well developed network of investigators and computers, capable of growth to meet new demands and able to serve as a model and catalyst for others in ecological and biological research.

During the preparation of this report, this committee formally visited five LTER sites (CWT, NIN, HFR, HBR and ARC) and informally visited four others (AND, CPR, SEV and VCR). Site visits were both informative and beneficial. The visits helped to facilitate interaction between principal investigators, data managers and campus networking and computer officials, and increased the sensitivity of campus administrators to LTER networking needs. PI's had diverse expectations, desires and concerns regarding networking. We would recommend that site visits such as these be completed and continued.

Introduction

The LTER Connectivity Committee was established in July 1989 by James Edwards, Acting Division Director, BSR, NSF and Jerry Franklin, Chair, LTER Coordinating Committee. The committee is composed of three Data Managers from within the LTER network [James Brunt, Chair (Sevilleta LTER), Rudolf Nottrott (LTER Network Office) and John Porter (Virginia Coast Reserve LTER)] and two advisors from NSF (Dan VanBelleghem, Associate Program Manager - NSFNet, NCRI, and Robert Robbins, Program Director, Special Projects, DIR). The committee was charged with:

- assessing the current connectivity of LTER sites to the NSF-sponsored national computer network.
- assessing the needs of the Principal Investigators for increased electronic communication and how that might better facilitate research at their site and between cooperating sites.
- developing cost estimates for achieving desired levels of connectivity.
- making recommendations to the Coordinating Committee and NSF along with a detailed plan for implementation.

Ecology and Networking

Ecologists use many forms of scientifically productive networking. Traditional forms include society meetings, workshops, journals, phone calls and mail. With the increasing use of computers in ecology, traditional forms of networking are rapidly becoming insufficient to support the expanding needs of the ecological community. Collaboration between scientists at different institutions is ill served when messages related to ongoing research and draft copies of manuscripts and proposals spend days, rather than hours or minutes, reaching their destination. Large ecological datasets, be they data recorded by automated sampling equipment, satellite images, GIS data layers, model outputs or data collected by time-honored means, are unwieldy to transfer in paper forms. Some advanced forms of networking, such as linking ecological simulation models, each running on a different computer, in a different state, are simply impossible using traditional networking methods.

Fortunately, computer networking technology is rapidly becoming available to ecologists that can virtually eliminate the physical and temporal barriers to productive networking. Ecologists with access to the Internet (regional wide-area networks connected by the NSFNet backbone collectively make up the Internet) can exchange data, draft manuscripts and memoranda in minutes, regardless of their physical locations. Supercomputers can be as easy to access as the campus mainframe. Similarly,

regional centers are in turn linked at various speeds (from T1 [1.5 MB/second] to 9600 baud) to individual institutions within their region. Information is transmitted over the Internet using TCP/IP (Transmission Control Protocol/Internet Protocol) protocols.

The campus or institutional network provides access to more localized computer resources, as well as serving as a link between local users and wide- area networks (Figure 2). In addition to the capabilities of the wide-area network such as electronic mail and access to mainframe computers (albeit, at a strictly local scale), the campus network permits the sharing of computer peripherals (printers, disk drives, tape drives) and can extend the benefits of local area networks between buildings. In its most common form, it is a wide-band cable or fiber optic link that runs between (but not necessarily within) buildings, and is linked to local area networks by computers called routers or bridges. Campus networks can support a wide array of transmission protocols, among them TCP/IP. The local area network (LAN) provides for sharing of computer peripherals (e.g., printers, disk drives and plotters), as well as serving as a link to more expansive networks (Figure 3). LAN’s are often integrated with campus networks that are, in turn, connected to the Internet. A LAN can take two forms. In its most basic form, it links individual computers. Using TELNET (a program which allows you to log onto computers across a network) and FTP (a program which allows you to rapidly and accurately transfer files between computers), the LAN can be used as the avenue for accessing other computers on the network or transferring files. However, in this form, the user interface of the LAN is not very different from using conventional communications programs (albeit, orders of magnitude faster). In its more advanced form, computers running networking software are added. This permits direct sharing of peripherals, programs and data in a way that is virtually transparent to the user. Most LAN programs support add-ons for electronic mail and automated backups. Sharing of disk drives across a LAN permits the sharing of data files (subject to security restrictions) and greatly facilitates keeping current backup copies of all data on the network. LAN's can take a variety of forms, but the most common consists of an ethernet (a hardware connection capable of 10 Mb/s data transfer rates) running one or more types of networking software (e.g., NFS, 3Comm, Appletalk, Novell, or TOPS). Network software for personal computers is usually designed so that a user (although not the network administrator) need know little to nothing about how a network operates. He or she simply operates as though they were on their own stand-alone computer, but with the benefits of larger disk capacities, better backups and a larger variety of peripherals. An additional advantage of PC LAN software is that it typically supports add-ons that make checking electronic mail as easy as turning on the computer. The networking software may (but often does not) use TCP/IP protocols. However, regardless of the type of networking software used, specific software products (such as the TELNET and FTP programs from the National Center for Supercomputing Applications) can be used to link to campus and wide-area networks using TCP/IP.

Access by personal computers to NSFNet can be accomplished in a variety of ways (Figure 4). Providing the fastest and most versatile link is a direct connection via a LAN connected to a campus network that is in turn connected to the Internet. This method has the advantages that file transfers may be made directly to and from the PC at rates comparable to reading data directly from a disk drive. It also allows the PC to derive benefits (access to disk space and peripherals) incumbent to computers on a LAN with networking software. Alternatively, access to NSFNet can be gained by logging onto a mainframe or mini-computer via a modem or high-speed asynchronous connection (provided that the mainframe is itself connected to a network with access to the Internet). Data files can be transferred to the mainframe over the Internet and then downloaded to the PC using Kermit or some other asynchronous file transfer protocol.

Assessment of Current Connectivity

Summary Description

Committee Activities

Data on LTER connectivity came from 1) questionnaires about type and connectivity of computers used at each LTER site, answered by each site's data manager, 2) a phone interview with the data manager of each LTER site regarding the locations where LTER activities take place and the status of connections to those places, 3) a phone interview with a computer or networking official associated with the institution or campus, and 4) visits to selected LTER sites which included interviews of PI's, campus administrators and data managers, as well as detailed on site inspections of computational and networking resources.

Summary Tables and Analyses

Tables 1-3 provide a summary overview of the connectivity of the various classes of LTER sites (see Appendix E for notes on individual sites). Locations where LTER activities take place were classified

Table 1: Summary of Main Site Connectivity

Status of Internet and LAN connections at "main" locations. "Main" locations are at the administrative headquarters of an LTER site. "Yes" indicates that one or more LTER computers are connected to a network. "Planned" indicates that funding and plans are in place to make a connection.

LTER Site	Location	Internet	Campus Networked	LTER on Campus net	LAN	Phone
AND	OSU	Yes	Yes	Yes	Yes	Yes
ARC	MBL	Yes	Yes	No	No	Yes
BNZ	Fairb	Yes	Planned	No	Yes	Yes
CDR	UMin	Yes	Yes	Yes	Yes	Yes
CPR	CSU	Yes	Yes	Yes	Yes	Yes
CWT	UGA	Yes	Yes	Yes	Yes	Yes
HBR	Cornell	Yes	Yes	Planned	Yes	Yes
HFR	Forest	No	No	No	No	Yes
JOR	NMSU	Yes	Yes	Yes	No	Yes
KBS	Field	No	Yes	Yes	Yes	Yes
KNZ	KSU	Yes	Yes	No	Yes	Yes
LUQ	U.PR	Yes	Yes	Yes	Yes	Yes
NET	U. Wash	Yes	Yes	Yes	Yes	Yes
NIN	U.SC	Planned	Yes	Planned	No	Yes
NTL	UWisc	Yes	Yes	Yes	Yes	Yes
NWT	UColo	Yes	Yes	Yes	Yes	Yes
SEV	U. NM	Yes	Yes	Yes	Yes	Yes
VCR	U. VA	Yes	Yes	Yes	Yes	Yes

Table 2: Summary of Field Site Connectivity

Internet and LAN connections at "field" locations (locations that are both field laboratories and administrative headquarters are listed under "main" locations). "Yes" indicates that one or more LTER computers are connected to a network. "Planned" indicates that funding and plans are in place.

LTER Site	Location	Internet	Phone
AND	Forest	No	Yes
ARC	TUL	No	No
BNZ	Field	No	
CDR	Field	No	Yes
CPR	Field	No	Yes
CWT	Field	No	Yes
HBR	Field	No	Yes
HFR	(see main)		
JOR	Field	No	
KBS	(see main)		
KNZ	Field	No	
LUQ	ElVerde	No	
NIN	NrthIn	No	Yes
NTL	Lake	No	Yes
NWT	Field		
SEV	Field	No	No
VCR	Oyster	No	Yes

Table 3: Summary of Associated Site Connectivity

Internet connections to "associated" locations. Associated locations have one or more LTER PI's associated with them. "Yes" indicates that the institution or campus has at least one computer connected to the Internet. "Planned" indicates that funding and plans are in place to establish a link to the Internet.

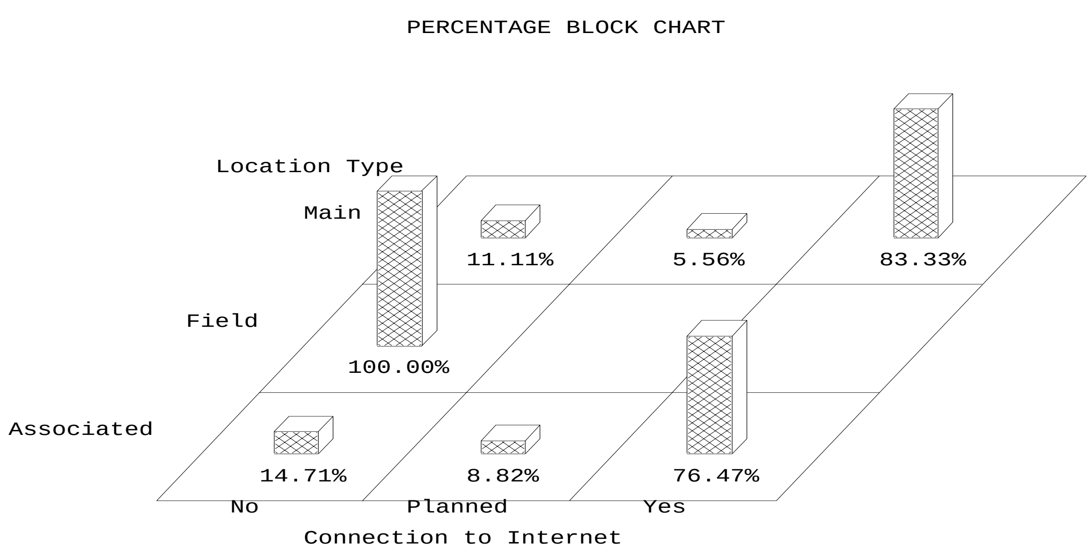
LTER Site	Location	Internet	LTER Site	Location	Internet	LTER Site	Location	Internet
ARC	Fairb	Yes	HFR	Clark	Yes		TXTech	Yes
	UCinn	No		Harvard	Yes		UGA	Yes
	UKan	Yes		MBL	Yes		UOK	Yes
	UMin	Yes		UMass	Yes		UTenn	
BNZ	BYU	Yes		UNH	Yes		Yale	Yes
	CMich		JOR	SDS	Yes	NIN	Aiken	No
CDR	StPaul	Yes	KBS	U.Mich	Yes		C.C.Col	Planned
HBR	Durham	Planned	LUQ	ColoSt	Yes		Winthr	No
	IES	No		Harvard	Yes	NWT	INSTAAR	Yes
	Penn	Yes		NASA	Yes			
	Syr	Yes		ORNL				
	UNH	Yes		ORSt	Yes			
	UWyom	Yes		Siena	No			
	Yale	Yes		SUNY	Yes			

into three categories for the purposes of analysis. "Main" locations are where the administrative headquarters of each LTER site is located.

Typically, these are at major universities, and can be quite distant from the field site. "Field" locations are situated at the site of data collection (field locations that were also main locations were classified as main locations). The facilities available at field sites and how they are used varies greatly. Some field locations have extensive laboratory, dormitory and computational facilities whereas others are equipped with only the minimal facilities and support no full-time personnel. "Associated" locations are institutions other than the "main" institution that have PI's working at them. For a few sites, the aggregate number of PI's at associated locations outnumbers the number of PI's at the main location.

The Internet (NSFNet) connectivity varies between the types of sites (Figure 5). Conspicuously, none of the field sites has an Internet connection, whereas nearly all main and associated locations (almost 90 percent) have an existing or planned Internet connection. Despite the high level of connectivity of the institutions that house LTER administrative headquarters, only 11 of 17 LTER main locations have working network connections within a building housing LTER computers. Of those 11 locations, ten have working local area networks.

Figure 5 Internet Connectivity

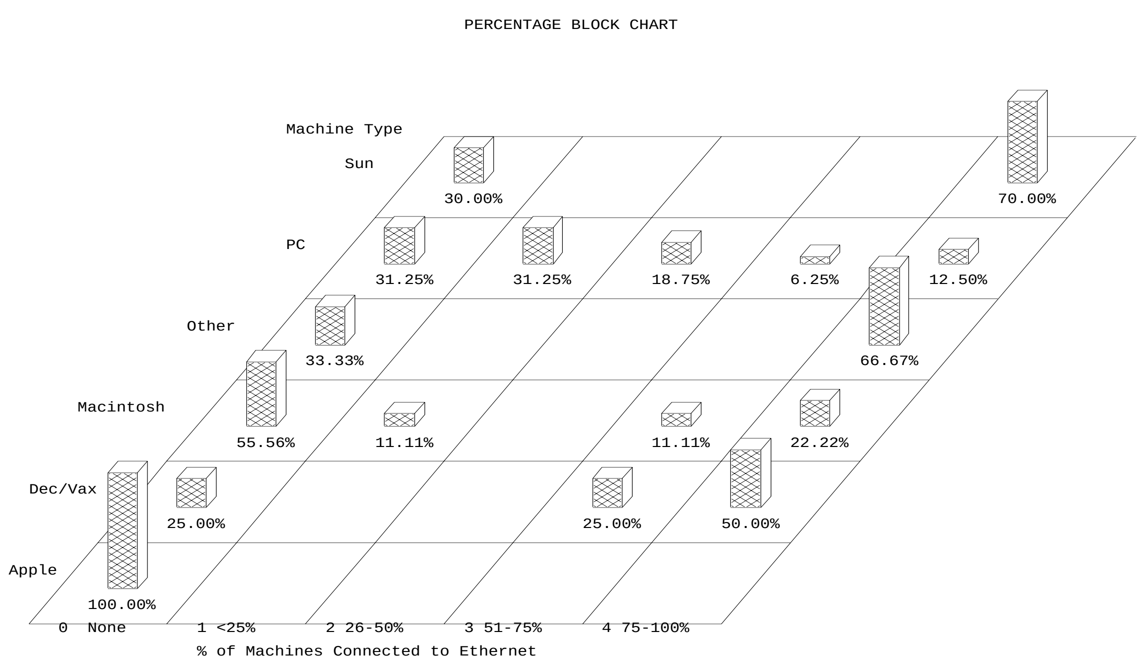


Despite the number of sites with established Internet, campus and LAN connections, connectivity of most types of LTER computers remains low. Figure 6 shows, for each machine type, a graph classifying the various sites by what percentage of their machines are connected to an ethernet.

Ideally, 100 percent of the sites having a particular machine type should be in class 4 (75-100% of the machines connected). For the most common type of computer, the IBM-PC, 81% of the sites had fewer than 50% of their machines attached to a LAN and 31% of the sites had no PC's connected (see Appendix D for more information on LTER computers). Although the situation was better for some other classes of computers (especially multiuser computers such as the SUN and DEC computers), there is a generally low level of network connectivity by LTER computers.

The limited connectivity of LTER computers is mirrored by the limited number of LTER researchers that can be contacted by electronic mail. Of the approximately 350 researchers associated with the LTER program, only 210 have electronic mail addresses (although this number has been increasing subsequent to the installation of the LTERNET mail forwarding system at the LTER network office). The use of electronic mail group lists (maintained at the LTER Network Office) eliminates the need to individually contact researchers with common interests. However, mail groups only work for

Figure 6 LAN Connectivity of LTER Sites



those researchers with electronic mail addresses. A common complaint of PI’s that do not participate in the electronic mail system is that existing, mainframe-based mail systems are too unwieldy to access or use. In some cases, PI’s encountered institutional barriers to obtaining mail accounts.

PI’s Expectations from Electronic Networking

Most principal investigators were enthusiastic about the possibility of improved network connectivity. In our discussions with principal investigators, two points were made repeatedly. First, that extended network connectivity must implemented in a form that facilitates scientific activities. Networking must provide services in a way that does not require extensive training or expertise with computers to master so as not to detract from the time available for purely scientific activities. Secondly, that networks must structured to provide rigorous data security. Specific requests with regard to desirable network functions included:

- easy to access, reliable and fast electronic mail
- rapid and reliable transfer of text and graphics (NSF proposal submission, intra and intersite proposal development, Manuscript development, etc.)
- rapid and reliable long-distance data transfer
- archiving over the network of data from remote locations
- better access to researchers at other institutions (e.g. the US Forest Service)
- remote computer access for modeling
- access to mainframe computers
- access to supercomputers
- access to files, programs, printers and similar resources on other networks
- access to national information and software repositories
- access to LTER Network Office Services (mailing lists, mail forwarding system, core dataset catalog (proposed))

Some of the more advanced functions envisioned by principal investigators, such as video teleconferencing, are presently in experimental stages, but will likely be available before the end of the century to LTER researchers connected to the Internet.

Special Cases

Field sites

Presently, none of the LTER field sites have an Internet connection. Field sites represent a special challenge in this regard, because most of them are in remote locations far from major lines of communication. The most extreme case is the Arctic Tundra LTER site, which does not even have a telephone connection. The main obstacle to the operation of Internet connections to field sites are the relatively high recurrent costs of a leased line.

Forest Service Sites

A number of LTER researchers are U.S. Forest Service (USFS) employees and five field sites are administered by USFS. The Forest Service has its own wide-area communications network spanning the entire US. This network includes approximately 200 satellite transceiver stations and connects to most of the LTER sites administered by the Forest Service.

The communications system and the Forest Service computing system are based on Data General hardware and software. The lack of TCP/IP access to the Data General system has made the exchange of mail and data between Forest Service researchers and researchers on other networks (Internet, Bitnet) all but impossible.

A mail bridge has been established between the LTERNET mail forwarding system and the Data General CEOMAIL facility. This has alleviated the communications problem, but a file transfer function between the Data General system and the Internet, as well as all other higher-level Internet functions, remain unavailable. Plans are under consideration at the Forest Service for a TCP/IP gateway, which would make these functions available, but the time frame for any such changes, or indeed whether such changes will ever materialize, is uncertain.

Distributed Sites

A ”distributed” LTER site is one where PI’s are located at a large number of different institutions. LTER sites that fall into this category are Hubbard Brook and Luquillo. Distributed sites pose special problems for achieving connectivity because of the sheer number of institutions and computer systems involved. However, the payoff derived from connectivity is that much greater because it can help to foster intra- as well as intersite collaboration.

Recommendations

General Remarks

Computer networking is on the minds of Long-Term Ecological Research Investigators. There is a consensus among them that effective cooperative research is requiring increased and reliable electronic communications between investigators. The National Science Foundation Network (NSFNet) and associated mid-level networks provide a common and stable thread with which LTER can be joined. Nearly 90% of universities administering LTER grants are connected to the Internet. The majority of investigators, however, do not have direct access to this network because there is a missing link somewhere between the computer on their desk and the Internet access point on their campus.

New levels of cooperation in cross-site modeling and intersite comparison can be achieved if computers are able to communicate and interoperate. The convenience and value of a common electronic mail system has already been demonstrated to those LTER researchers with access to Internet mail, but there is now a need for reliable transfer of documents between investigators, for the remote access of computers and for wide-ranging information services. A common network, adhering to at least some level of archival, interface, and access standards, will also allow for development of LTER tools to be shared among sites and for the testing and use of already developed tools, such as Andrew and PS-Expres.

We recommend that the LTER network pursue complete connectivity (cost estimates are listed in Appendix B) through the addition of equipment, personnel, and education directed at networking. Depending on local priorities and existing resources, particular sites may be able to achieve their connectivity goals by concentrating on different networking objectives therefore, no precise prioritization can be detailed here. However, it is our consensus that individual LTER sites should first develop a basic LAN infrastructure (with connections to the Internet) at the main location of each LTER site and provide at least minimal access to Internet services to all LTER researchers. Secondly, they should upgrade LAN facilities at main locations to provide complete Internet connectivity and provide direct electronic mail service to remote sites. Finally, full Internet connectivity and a LAN infrastructure should be established at large field sites. When possible, advanced applications of networking should be encouraged because they allow sites to act as prototypes.

There are several situations encountered by LTER sites that will require special attention. These are: sites where investigators are located at a site which is not a node on the Internet; those sites where the administrating institution does not support the contingency of the LTER investigators; and field research sites that are often isolated from universities but represent an important networking component.

LAN Infrastructure

Establishment of a basic LAN infrastructure at each site with connections to the Internet (Figure 7) provides at least a minimum set of capabilities. These are:

1. to provide electronic mail, file transfer, and remote login capabilities via the Internet to all LTER researchers,
2. to establish connections to the Internet by all LTER computers located at main[1] sites, and
3. to facilitate minimal connections to Internet for computers located at field[2] and associated[3] sites.

As needed, buildings should be connected to institutional networks (in a few cases where main sites are isolated from institutional networks, direct connections to the Internet will be required) by purchasing and installing cables and routers. LAN cables, transceivers, interface cards, and gateways to complete the network within buildings will also be needed.

In its role of support for cooperative research, we believe the network office can provide valuable services toward achieving this basic infrastructure. At the LTER Network Office, a multiuser computer with sufficient capacity to support user accounts for all LTER researchers should be obtained. It should be connected so as to be accessible via the Internet, modem, commercial networks (such as TYMNET and TELENET) and the U.S. Forest Service X.400 network. It can provide default computer accounts for all LTER researchers, regardless of their parent institutions. This computer account will be accessible over the Internet and it will provide a temporary repository for data and text to be exchanged between LTER sites[4]. The account can also provide an "default" electronic mailbox for researchers who want this capability and cannot obtain it locally.

To facilitate access to the Internet from remote sites using a modem, we recommend that commercial networks be used. An account on one or more commercial networks (TELENET or TYMNET) should be established to increase LTER researcher access to the Internet. Such access could

[1]"Main" locations are where the administrative headquarters of each LTER site is located.

[2]"Field" locations are situated at the site of data collection (field locations that were also main locations were classified as main locations).

[3]"Associated" locations are institutions other than the "main" institution that have PI's working at them.

[4]An LTER researcher at Site A can use FTP (File Transfer Protocol) to transfer data from his PC to a public directory on his account. A colleague at site B can then access that data or manuscript and download it (again with FTP) to her local computer.

be via a direct connection to the Internet (a service recently proposed by TYMNET) or indirectly through a computer at the LTER network office or other LTER site with existing commercial network access. Potentially, commercial networks could reduce connection charges for isolated researchers, and could facilitate access to mail and file exchange services by researchers attending scientific meetings. Participating researchers would need portable computers equipped with modems for use while traveling.

Enhanced LAN’s

Upgrading LAN facilities and providing direct electronic mail to large field sites (Figure 8) adds these additional capabilities:

1. increased Internet access,
2. transparent sharing of files and peripherals,
3. ”user friendly” tools such as LAN mail services that can be connected to Internet mail, and
4. inexpensive, reliable mail connections can be maintained to remote sites.

To achieve this level of functionality, each main site would need a computer and LAN software to provide file and mail service for computers on the LAN. Most main sites will benefit from acquiring a multiuser computer which can be connected to the Internet and be accessed via modem. Such a computer can act as a file and mail server and provide Internet access for local modem connections (this computer can also serve as UUCP host for remote site mail, below). Whenever possible a mail gateway between Internet mail and LAN mail should be implemented to provide "user friendly" access to Internet mail facilities.

Field Site Options

Field locations should be equipped with a modem supporting 2400 baud or higher in order to provide at least minimal access to electronic mail. Field sites requiring on-site electronic mail facilities should acquire a small UNIX system (either a PC running UNIX or a UNIX workstation) with a modem and equipped with communication software like UUCP[5]. Such a link would provide indirect access to mail

[5]1. UUCP software allows a computer to access other UNIX computers (USENET) and exchange messages unattended using modems at preselected hours of the day and night.

from the Internet with minimum phone charges.

Providing full Internet connections to large field sites (Figure 9) provides these additional capabilities:

1. full Internet file transfer and remote login capabilities at large field sites, and
2. file and peripheral sharing services within large field sites.

Large field sites with extensive labs, full-time personnel and multiple computers on site should be fully connected to networks. Those sites can be connected to the Internet via a router connected to leased line running to a router at the main site (or a closer Internet access point). LAN cables, transceivers and interface cards would be used to link computers at the field site to the router. Electronic mail would be obtained either by linking back to the mail server at the main site or on a multiuser computer at the field site. Because telecommunication line charges for a dedicated line can be substantial, alternative ways of linking sites, such as packet radio or satellite connections, should be explored.

Plan of Implementation

It is the finding of this committee that all LTER investigators should have direct access to the Internet services. We believe this can be achieved through continued technology supplements directed at networking and educational workshops and materials. The recommendations presented here do not represent a series of thresholds or intermediate goals to be met, but general directions to follow in pursuit of complete connectivity. It is not reasonable to attempt a strict prioritization of the recommendations because of the heterogeneity existing between sites. To alleviate this we recommend to the LTER/CC and NSF the following actions:

1. Consider technological supplemental funding aimed at the completion of the computer networking connections and functions, as detailed below. Continued consideration of this type of request over several years would assure a well developed network. The networking connections and functions considered here are:

   I Internet connection at the regional-mid-level network node level[6].

   II Development of connection to existing campus backbone networks.

   III Development of an Ethernet based local area network or backbone within buildings where LTER investigators are located.

   IV Upgrade Network Office computer system to support intra and intersite communication of mail, manuscripts and data.

   V Enhancement of local area networks to provide additional access, peripheral sharing, etc.

   VI Development of connections to field sites.

2. Consider requests that include support for technical personnel in networking and computer integration. A major concern of investigators is obtaining the increased technical knowledge required as advances in computer technology are incorporated into existing research programs. Although using a network is easy, establishing and administering a network can require considerable time and expertise. This is particularly true with regard to data security.

3. It is desirable that each LTER site have at least one multiuser UNIX (or variant) computer which can provide electronic mail and network services to investigators. Many investigators reported difficulty in receiving electronic mail and transferring documents. The existence of a computer

[6]Funding level I requires a significant amount of recurring costs and should possibly be considered with some degree of extended funding and cost sharing. All the levels should be developed in cooperation with local network contacts at individual institutions.

under local control would provide flexibility to the system and would give all the users at a site a place to login to utilize the Internet services. Furthermore, local control permits a site to establish accounts for collaborative researchers, facilitating intersite research.

4. We recommend that NSF and the LTER Coordinating Committee consider for funding proposals to develop workshops that involve advanced uses of computer networks in ecological sciences and technical instruction, for example, a UNIX system administration workshop. Most sites have or will have a UNIX computer for their on-site multiuser machine.

5. We also encourage consideration of a proposal to produce a networking manual to assist sites in developing their networks. It takes much time and effort to stay abreast of current technology in computers and networking. Continuing education is an important component of maintaining a stable functional network that will enhance scientific endeavors.

Acknowledgements

The members of the Connectivity Committee would like to extend their thanks to the Data Managers and campus Internet contacts for their help in obtaining information about computers and networks at each of the sites. We would particularly like to thank Bruce Haines, Bill Michener, Emory Boose and Jim Laundre for making our visits to their sites both pleasant and productive. Principal investigators throughout the LTER network were extremely generous with their time during our visits to their sites or during impromptu networking ”rap sessions” at conferences and workshops. This report would not have been possible without the aid and information provided by our NSF advisors, Bob Robbins and Dan VanBelleghem and periodic advice and encouragement from Caroline Bledsoe. Finally, we would like to acknowledge the role of NSFNet in making this report, which was written by individuals living in three different time zones, possible.

APPENDIX A

Glossary

Andrew: a multi-media a message exchange and bulletin-board system developed by Carnegie-Mellon University.

Asynchronous connection: a method of communicating between computers, typically using a modem or a direct connection between serial communication ports.

Bridge: a type of router that operates at the physical network level rather than at the protocol level.

Backbone: the central cable(s) of a network. Branch cables off the backbone connect to computers or other networks.

Broadband cable: a cable that carries many different channels of information simultaneously using cable television technology. Often one or more pairs of channels are used to exchange information between ethernets.

Ethernet: the most common type of network used to provide physical connections between computers.

File server: a computer with a high-capacity hard disk that is shared among computers hooked to a network. The networking software on the computer handles requests for data by the client computers.

FTP: File Transfer Protocol. The standard protocol for the transfer of files on a network using TCP/IP protocols. In addition to being a standard protocol, there are many specific programs named FTP that use the file transfer protocol.

Gateway: a device that passes information between two networks which use different protocols for transferring information.

Internet: the collection of networks (including NSFNet, ARPANET and MILNET) that use TCP/IP protocols and operate as a single cooperative wide-area computer network.

LTERNET: a computer at the LTER Network Office which implements a mail forwarding system for LTER researchers. The name is also used to refer to the network electronic links between LTER sites.

Mail server: a computer that sends and receives electronic mail and provides an interface for a user to read and send mail.

NIU: Network Interface Unit. A device that connects to a high-speed network (such as an ethernet or broad-band cable) and provides connections for computers using serial (RS-232) connections, typically at 9600 baud.

NSFNet: National Science Foundation NETwork. A high-speed, high-capacity, wide-area network using TCP/IP protocols, established and at least partially funded by NSF. It forms a major part of the Internet.

PS-Expres: a program that allows submission via NSFNet of proposals and reports in electronic form.

Repeater: a hardware device that copies signals from one ethernet to another.

Router: a device that transfers information between paths on a network.

SLIP: Serial Line Internet Protocol. A loosely standardized variant of TCP/IP that uses connections between the serial ports of computers to transfer information over short or long distances. However, it does not support all TCP/IP functions.

TCP/IP: Transmission Control Protocol/Internet Protocol. The suite of protocols used to transfer information across the Internet.

TELENET: a commercial network. It includes dial-up nodes in most major cities that permit registered users to make long-distance connections to computers for a fixed monthly fee, plus connect time.

TELNET: a protocol for logging onto and using a computer over a network. Like FTP, it is used both as the name of a protocol and as the name of numerous programs that implement the protocol.

Transceiver: a device that connects a computer to a LAN (ethernet) cable via a drop cable.

TYMNET: a commercial network. It includes dial-up nodes in most major cities that permit registered users to make long-distance connections to computers for a fixed monthly fee, plus connect time. In the near future (scheduled date is Feb. 28, 1990), connections to the Internet via TYMNET will be possible.

UUCP: Unix to Unix Copy Program. A program that allows exchange of file and mail messages between UNIX systems over dial-up phone lines.

USENET: A network of computers that use UUCP to communicate mail and news.

APPENDIX B

LTER Networking Cost Estimates

Rationale for Estimates

We have presented two types of cost estimates. The ”comprehensive” cost estimates are as realistic as we could make them but, where costs were uncertain, our general approach was to try to overestimate costs rather than to underestimate them. For example, in arriving at estimates for the numbers of multiuser computers and file servers required to enhance LAN capabilities, we assumed that all sites would need to acquire both. Clearly, some sites already possess multiuser computers or can combine functions by using that computer to provide both mail and file services. However, a detailed knowledge of existing and projected computer workloads (e.g., an existing multiuser computer running a GIS package probably has little excess CPU or disk capacity to use for providing electronic mail or network services) and the types of networking software to be used (some popular PC networks don’t support UNIX) would be required to precisely estimate the needs for each site. Thus, we made the conservative assumption that all sites would need to add both a multiuser computer and some other network server. Additionally, we included some costs that may be shared by non-LTER sources. Attaching a building to a campus network or establishing an Ethernet within a building extends network access to all researchers within the building, regardless of LTER affiliation. It would seem reasonable that some cost sharing would be possible, either through institutional matches or cost recovery (user fees for non-LTER researchers). Nonetheless, here we assumed that LTER sites would pay all of the costs. Finally, we also included some items that are not strictly required to provide network services (e.g., optical disks) but that significantly enhance the research support capabilities of network computers.

In the ”bare bones” estimates, we took a less conservative approach in estimating costs. For example, we assumed that sites would require either a multiuser computer, or a dedicated file server, but not both. Similarly, all but the most necessary equipment (with some loss of functionality) has been deleted. We also assumed that fewer buildings would need connections.

Both types of estimates do not include costs for ancillary (but recommended) activities and materials such as UNIX system administration workshops or networking manuals.

Specific assumptions

Personnel costs are listed separately in the estimates because they typically require different types of funding than equipment or line charges. We assumed a pay rate of $40,000 per year for a full-time individual specializing in network operation. However, a competent network administrator would only require a fraction (we estimate 1/3) of their time working on a LTER site’s network. Therefore, we included in the estimates 1/3 of a full- time networking specialist. Sharing a network specialist with other parts of an institution should be possible for most LTER sites. However, LTER sites isolated from large campuses, may find such sharing difficult.

In estimating costs for access to the Internet via a commercial network, we assumed that 20 LTER researchers would be using the network for one-half hour per day for 260 working days per year. Because individual ID’s are used to access the commercial networks, billing can be made to specific sites if use is too intensive by any particular site (this would create some administrative costs at the network office).

Areas of Uncertainty

Costs of connecting a site via a leased line and connecting a building to a campus network are difficult to estimate for the general case. The cost of leased lines is extremely variable and is not a simple function of the distance traversed. Estimates for a particular site will require detailed work with local telecommunications companies to establish costs and options. Our estimate of $13,500 per year for a leased line approximates the cost for a moderate-speed (19.2 to 56 KBS) leased line running to a site 70 miles away.

The cost of getting a network cable to a building is highly variable. In many cases, campuses provide the cable to the building at no charge. Cost sharing may also be possible with other potential network users in the building. Therefore, our estimate of $15,000 per building includes only the router and associated hardware needed to connect a building to an existing cable.

Comprehensive Cost Estimates

Development of a basic LAN infrastructure, connections of main sites to the Internet, and minimal electronic mail access for all LTER researchers.

			ONE-TIME	RECURR.	PERSONNEL	TOTAL
			648,500	68,560	13,200	730,260
MAIN LOCATION		SUBTOTAL	455,000	27,000	0	482,000
	ONE-TIME		455,000			
2.00	40000	80000	Connect site to Internet			
15.00	15000	225000	Connect building to campus net			
15.00	10000	150000	Establish LAN within buildings			
	RECURRING		27000			
2.00	13500	27000	Line and service for Internet connection[1]			
NETWORK		SUBTOTAL	57,000	41,560	13,200	111,760
	ONE-TIME		57,000			
1.00	25000	25000	Multiuser computer (400 accounts)			
1.00	10000	10000	Software			
1.00	7000	7000	Optical disk drive (plus media)[2]			
1.00	15000	15000	Install X.400 connection via TELENET[3]			
	RECURRING			41,560		
1.00	5000	5000	Vendor service contract			
1.00	10000	10000	Cost of X.400 message traffic via TELENET			
2600.00	9.5	24700	Commercial network hourly connect charges			
12.00	155	1860	Commercial network to Internet connection (monthly charges)			
	PERSONNEL				13,200	
0.33	40000	13200	1/3 specialized network/e-mail support and administration[4]			
FIELD		SUBTOTAL	48,000			
18.00	2500	45000	Computer (laptop) + modem + commun. software			
1.00	3000	3000	Explore packet Internet Technology for Artic site			
ASSOCIATED		SUBTOTAL	12,000			
40.00	300	12000	Modems and communications software			
REMOTE ACCESS		SUBTOTAL	76,500			
51.00	1500	76500	Laptop computers for network access while traveling			

[1]The line costs and service costs depend on the location and local network organization. This figure is a rough estimate.

[2]The optical disk drive with its large amount of file space, although not absolutely required for network functionality, provides temporary mass storage capacity for use in the transfer of large files.

[3]X.400 is an international standard for the exchange of mail messages. The ability to receive and send X.400 messages will create a mail gateway between LTERNET and a large number of international networks that are otherwise unreachable. This gateway will also allow communication of LTERNET with the U.S. Forest Service and a number of other governmental agencies that communicate using X.400. Presently, LTERNET uses on an experimental basis an X.400 gateway operated by the National Aeronautics and Space Administration (NASA), but is is unlikely that this gateway will be available to handle the expected volume of mail traffic.

[4]This support cost is mostly incurred during the establishment phase of the system (400 user accounts), and is likely to decline in subsequent years.

Upgrading of LAN facilities at main locations and establishing electronic mail connections to large field sites.

			ONE-TIME	RECURR.	PERSONNEL	TOTAL
			695,000	20,000	238,000	953,000
MAIN LOCATION		SUBTOTAL	595,000	0	238,000	833,000
	ONE-TIME		595,000			
17.00	20000	340000	Multiuser computers, incl. software			
17.00	5000	85000	Optical disk drives			
17.00	10000	170000	LAN server and software			
	PERSONNEL				238,000	
17.00	14000	238000	17 x 1/3 specialized computer and networking support			
FIELD		SUBTOTAL	100,000	20,000	0	120,000
	ONE-TIME		100,000			
10.00	10000	100000	Small UNIX computer running UUCP, and modem			
	RECURRING			20,000		
10.00	2000	20000	Annual phone communication charges			

Full Internet connection of large field sites and establishment of a LAN infrastructure at these sites.

			ONE-TIME	RECURR.	PERSONNEL	TOTAL
			250,000	67,500	0	317,500
FIELD		SUBTOTAL	250,000	67,500	0	317,500
	ONE-TIME		250,000			
5.00	40000	200000	Connect site to Internet			
5.00	10000	50000	Establish LAN within buildings			
	RECURRING			67,500		
5.00	13500	67500	Line and service for Internet connection			

"Bare-Bones" Cost Estimates

Totals			ONE-TIME	RECURR.	PERSONNEL	TOTAL
			1,016,000	156,060	251,200	1,423,260
MAIN LOCATION		SUBTOTALS	520,000	27,000	238,000	785,000
	ONE-TIME		520,000			
2.00	40000	80000	Connect site to Internet			
10.00	10000	100000	Establish LAN within buildings[1]			
17.00	20000	340000	Multiuser computers or other network servers, incl. software			
	PERSONNEL				238,000	
17.00	14000	238000	17 x 1/3 specialized computer and networking support			
	RECURRING			27,000		
2.00	13500	27000	Line and service for Internet connection[1]			
NETWORK		SUBTOTAL	57,000	41,560	13,200	111,760
	ONE-TIME		57,000			
1.00	25000	25000	Multiuser computer (400 accounts)			
1.00	10000	10000	Software			
1.00	7000	7000	Optical disk drive (plus media)			
1.00	15000	15000	Install X.400 connection via TELENET			
	RECURRING			41,560		
1.00	5000	5000	Vendor service contract			
1.00	10000	10000	Cost of X.400 message traffic via TELENET[1]			
2600.00	9.5	24700	Commercial network hourly connect charges			
12.00	155	1860	Commercial network to Internet connection (monthly charges)			
	PERSONNEL				13,200	
0.33	40000	13200	1/3 specialized network/e-mail support and administration			
FIELD		SUBTOTAL	400,000	87,500	0	487,500
	ONE-TIME		400,000			
15.00	10000	150000	Small UNIX computer running UUCP, and modem			
5.00	40000	200000	Connect site to Internet			
5.00	10000	50000	Establish LAN within buildings[1]			
	RECURRING			87,500		
10.00	2000	20000	Annual phone communication charges			
5.00	13500	67500	Line and service for Internet connection[1]			
ASSOCIATED		SUBTOTAL	12,000			
40.00	300	12000	Modems and communications software			
REMOTE ACCESS		SUBTOTAL	27,000			
18.00	1500	27000	Laptop computers for network access while traveling			

[1]Cost estimates are general and may not be appropriate for any particular case.

APPENDIX C

Typical Cost Breakdowns for:

Attachment of a site to the Internet

Case 1 - direct connection of a site to a mid-level (regional) network. This would be a full Internet connection of a site to nearest mid-level network. Listed is the least expensive implementation, higher speed/capacity is more expensive. Similar costs occur in case of a connection through CSNET. (Note that the estimates are for the network connection only and do not include any computers (SUN, PC, etc.) on the site.)

Initial costs:		
2 dedic. routers (only one might be required)	10000	
2 modems, 9600 bit/s	1500	
Line installation	500	
Recurring costs:		
Line charges (depending on distance)	300	per month
Fee for membership in regional network organization (some sites may count as part of their main university, in which case there are no additional costs)	300	per month (3600 per year)

Case 2 - Connection of a site to an existing campus network that is on the Internet Serial line IP (SLIP) Internet connection to campus network.

Initial costs:		
2 routers (possibly PCs)	6000	
2 modems, 9600 bit/s	1500	
terminal server port	500	
Line installation	500	
SLIP software	1000	
Recurring costs:		
Line charges (depending on distance)	250	per month

Case 3 - CSNET connection (Computer and Science Network)

Case 3a - Phonenet (CSNET)

Initial costs:		
Multiuser computer (UNIX)	8000	
2400 baud modem	300	
Recurring costs:		
Annual management fee	1750	per year
(long-distance phone costs?)	....	

Case 3b - Full CSNET connection

Initial costs:		
Multiuser computer (UNIX)	8000	
Telebit modem	1200	
Recurring costs:		
Annual management fee	1750	per year
Long distance (@ 200/month)	2400	per year

Connection to campus network

This table lists the typical costs for connecting a building on a university campus to the campus network backbone. In addition to the solution below, it would also be possible to install a SLIP connection (possibly dial-up) to a central facility on the campus, thus gaining access to the campus network (SLIP costs are detailed in the previous section).

Initial costs:	
Router between campus broadband and building ethernet (many universities provide this router free as the campus data infrastructure)	13000
Campus broadband extension to to building depends on distance of building to backbone and on institution	...

Recurring costs:
Most universities maintain the connection of buildings to the campus backbone free of charge

Connection to ethernet backbone (building)

Costs for connecting a computer to the ethernet backbone of a building.

Network adapter (e.g. ethernet card)	500	per machine
Networking software (some netw. SW is free, e.g. NCSA Telnet)	200	per machine
Cabling from building ether to office room (includes transceiver)	300	per room

APPENDIX D

The LTER Computing Environment

To assess the connectivity of ”LTER computers,” we sent questionnaires to the data manager of each LTER site requesting information on ”LTER computers” (defined as computers important to conducting LTER activities, regardless of actual ownership). Despite some obvious differences between sites in the application of this definition (one site listed no personal computers of any type, only mainframe computers), reports on 306 computers were obtained from 17 sites. The most ubiquitous and common type of computer was a PC, running the PC-DOS or MS-DOS operating systems. PC’s were found at 16 of 17 sites and comprised 71% of all LTER computers (Table D.1). SUN computers, running UNIX, were the next most ubiquitous. They were in use at 10 sites, but only averaged two machines per site. Apple Macintosh computers were also found at numerous sites. DEC, Macintosh, and SUN computers were connected to a network at the majority of sites where they were found.

Table 1: Summary of LTER computing facilities.

Number of LTER sites is the number of sites that had one or more computers of a particular type. Number of networks is the number of sites that had at least one computer connected to a network.

Type of Computer	Number of LTER Sites	Number of Computers	Number of Networks
PC	16	216	8
MacIntosh	9	45	6
SUN	10	20	6
DEC/Vax	4	11	3
Apple	2	2	0
Other	3	12	2

LTER sites have a variety of computers at their main location (the location of the administrative headquarters of a site), but field locations were equipped with only small, personal computers (Table D.2). Computers at associated sites are probably under-represented because data managers were less familiar with computing resources at other campuses.

Table 2: Locations of LTER computers.

Main locations are at the administrative headquarters of an LTER site and are usually on the campus of a major university. Field locations are at, or near, the place where data is actually collected. Associated locations are campuses, other than the main location, where one or more LTER researchers are located.

Type of Computer	Number of Main Sites	Number of Field Sites	Number of Assoc. Sites
PC	13	4	2
MacIntosh	8	1	0
SUN	9	0	0
DEC/Vax	3	0	0
Apple	1	1	0
Other	2	0	0

The types of networking software used varied between sites and types of computers. No single type of network software was found at more than 7 LTER sites (Table D.3). NFS was used at the most sites, but Novell connected more individual machines. All of the network software can operate over an ethernet, except Appletalk (which can be connected to an ethernet using a gateway). NFS and TOPS use TCP/IP protocols.

Table 3: Summary of network software used at LTER sites.

Types of computers are: D=DEC/Vax, M=Macintosh, O=Other, P=PC and S=SUN.

Type of Network	Number of LTER Sites	Number of Computers	Types of Computers
NFS/SUN	7	42	D,O,P,S
Appletalk	4	19	M,P
Novell	3	85	M,P,O,S
DECNet	2	13	D,P
TOPS	1	42	M,P,S

APPENDIX E

Brief Descriptions of Sites

AND– Andrews Experimental Forest

Most of the AND LTER researchers are located at the campus of Oregon State University (OSU), Corvallis. A number of them are US Forest Service (USFS) staff. Rudolf Nottrott visited the OSU Corvallis and the Andrews Forest site on May 18-20, 1989.

The OSU main campus is well connected. Most of the LTER computers (SUNs and lots of PC's) are connected to the campus backbone, which is in turn connected to the Internet via NorthWestNet. The two major gaps are the USFS people and the Andrews field site (approx. 80 mile from Corvallis).

There are several machines at the field site, but only a 2400 baud modem on one machine to connect them. During the summer, often 20 or more scientists work at the site, with no real connection the outside world. Mark Klopsch has proposed a SLIP solution and his cost estimate is $11750. His arrangement would also provide a dial-up SLIP connection for any of their researchers working at home or anywhere in the field. (The availability of stand alone PC SLIP software has still to be verified.)

A strong request has come from AND for network personnel support (they say that any amount will help).

Contacts:

Susan Stafford (sstafford), Gody Spycher (gspycher), Donald Henshaw (dhenshaw), data management, ...@lternet.washington.edu

Mark Klopsch, computer systems specialist, mklopsch@lternet...

John Skelton, Director of Computer Center and member of NorthWestNet Technical Committee, (503) 754-2489, skelton@ccmail.orst.edu

ARC– Arctic LTER

The Marine Biological Lab (MBL), which houses the LTER for most of the year, is connected to the Internet, but the Ecosystems building is not connected to a campus network. Currently, there is no campus network. A preliminary plan for a fiber optic-based campus network is in place, but requires funding and some further planning. Computers consist almost entirely of PC's and the SUN computers obtained through the MSI supplement. MBL was visted by the Connectivity Committee during October 1989.

The field site is extremely isolated, even from telephone service. Detailed estimates for connecting a phone to the site have been obtained.

Contacts:

Bernie Moller, LTER Data Manager. BMoller@lternet.washington.edu

Jim Laundre (jlaundre), Ed Rastetter (erastetter), PI's.

Andrew Maffei, WHOI network administrator. (508) 548-1400 ext. 2764

Cathy Norton, MBL library. (508) 548-3705.

BNZ– Bonanza Experimental Forest

Researchers associated with BNZ are located at the University of Alaska campus, Fairbanks, and at the Institute of Northern Forestry (USFS) building on the perimeter of the campus. One part of the campus, called West Ridge, is approx. one mile away from the main campus.

The BNZ site is located 30 miles west of Fairbanks. Researchers commute between Fairbanks and the site (no overnight facilities exist or are planned). Therefore, no data communications facilities are needed at the site. (Hand- held radios are used for voice communications.)

An ethernet (802.3) presently runs through part of the campus and supports TCP/IP as well as DECnet. This ethernet, however, does not extend to the buildings housing LTER researchers.

The university is in the process of installing a fiber optics backbone, first on the main campus and later to West Ridge. Cable entry points will be available across the street from the Forest Service (USFS) building. The fiber optics installation on main campus is expected to be completed early next year.

Funding will then be required to connect the USFS building to the backbone, to connect the West Ridge buildings to the backbone (when West Ridge has the backbone), and to connect the LTER computers to the building ethernets. One unusual problem at the U. of Alaska, Fairbanks, campus is a shortage of Internet addresses. This problem will have to be discussed with representatives of NorthWestNet and NSFNet.

Contacts:

Phyllis Adams, LTER Data Manager. padams@lternet.washington.edu

John Yarie (LTER, jyarie), Les Viereck (LTER/USFS, lviereck), Keith VanCleve (PI, kvanclev) ...@lternet....

Tom Healy, Director of Computer Center (also Dir. Netw. Operations), (907) 474-6280, thealy@lternet...

Jeff Harrison, ”connectivity” systems programmer (907) 474- 6329, jharrison@lternet...

Bill Gregory, Network Manager, (907) 474-5158, bgregory@lternet...

John Wasileski, Dir. Planning & Info Systems, (907) 474-6638 All are at U.of Alaska, Fairbanks,

CDR– Cedar Creek

The main site at Cedar Creek LTER is located at the University of Minnesota, which is connected to the Internet. No networking of LTER computers (almost exclusively PCs) exists. However, an ethernet based around a SUN computer is being developed. The Zoology building is connected to the campus fiber-optic network and has asynchronous terminal servers in place.

The field site is 35 miles distant and is used primarily on a seasonal basis and supports relatively few on-site computers. Nonetheless, there is an interest in upgrading the field station connectivity.

Contacts:

El Haddi, LTER Data Manager. aehaddi@lternet.washington.edu

Pradeep Sharma, Telecomm. Dept., IP address support. (612) 625-0821

Roger Gulbranson, Computing Services. (612) 626-0535

CPR– Central Plains

Colorado State University campus backbone is connected to the Internet. The LTER/NREL workstation computers are all connected to the campus backbone and function as part of JFREA (Joint Facility for Regional Ecosystem Analysis).

The field site is 40+ miles from campus and has telephone communications. There is a full-time site manager. There is a great deal of local interest in getting the field site connected to the Internet.

Contacts:

Tom Kirchner, Data Manager/PI, Colorado State University, 303-491-1987, tkirchner@lternet.washington.edu

Mike Moravan, NSFNet contact, Colorado State University, 303-491-7432

CWT– Coweeta

University of Georgia at Athens is connected to the Internet as part of SURANET. Access to the Internet was not generally available as part of the campus network services at the time of our visit (August 1989). Several of the buildings housing LTER investigators have ethernet backbones as part of previous biological research funding. The Institute of Ecology is one of several other buildings that is not currently connected. Routers for connecting building ethernets with the campus network can be leased, with support, from the campus computer center.

The Coweeta field site has a Forest Service Data General system with a satellite communications system and several phone lines, but access to the Internet is limited to modem connections the Univ. GA.

Contacts:

Gil Calabria, Data Manager, University of Georgia at Athens, gcalabria@lternet.washington.edu

Eddie Hunter, NSFNet contact, University of Georgia at Athens, 404-542-7949

HBR– Hubbard Brook

Hubbard Brook LTER is a ”distributed” LTER site with researchers at numerous universities and colleges throughout the Northeast. Most of the associated locations are connected to the Internet. Its ”main” location is at Cornell and is connected to the Internet. The data manager and the University of New Hampshire were visited by the committee in October 1989.

The center of LTER data management activities is the Forest Service office in Durham. That office is connected to the Department of Agriculture Data General network and has a modem link to the (nearby) University of New Hampshire. University of New Hampshire is planning on connecting to the Internet through NEARNET. Additionally, they are planning and implementing their campus fiber- optics network. The research site, Hubbard Brook Experimental Forest, is about 100 miles to the north and has a phone line connection to the Forest Service Data General System. Plymouth State College is connected with a 56KB link to a the University of New Hampshire, and is much closer to Hubbard Brook Experimental Forest.

Contacts:

Cindy Veen, LTER Data Manager, US Forest Service. 603-868- 5692, lternet.washington.edu

Bill Lenharth, University of New Hampshire, Research Computing Center.

Betty Le Compagnon, Executive Director, Univ. Computing, University of New Hampshire.

HFR– Harvard Forest

The Connectivity Committee visited HFR on October 10-12, 1989. Researchers associated with HFR are distributed over five different Institutions, but most PI's and the core set of researchers are located at the field site. No network connection to the field site exists at present. The HFR field site is extreme in that only recently was a primitive mail system (using a single OMNET account for all personnel) installed at the main site. At least one research team has a an experimental set-up that generates large amounts of data (on the order of several MBytes per day), which routinely need to be sent from the field site to the Harvard campus.

Options for an Internet connection include a SLIP or a full TCP/IP connection to Harvard's Office Information Technology Center (OIT), a NEARNET connection, a PhoneNet connection (BBN), and a CSNET connection (BBN). Technical support could be obtained from the respective organizations.

Contacts:

Emery Boose, LTER Data Manager, (508) 724-3302, eboose@lternet.washington.edu

Steve Hall, Harvard networking administration

Scott Bradner, Harvard "pinball wizard", sob@harvard.edu

Lance Jackson, Network Project Manager, Harvard OIT

Steve Wofsy, LTER investigator at Harvard with strong interest in connecting HFR field site; he may also provide temporary accounts for HFR people on his SUNs

John Rugo, NEARNET Representative, Cambridge (617) 873-8730,

JOR– Jornada

New Mexico State University is connected to the Internet via Westnet. The biology building there is equipped with an ethernet backbone that runs down the hallway housing most of the LTER investigators. PI's have asynchronous links on to the campus TCP/IP server via NIU's connected to PC's and terminals. The GIS SUN4 is connected to the ethernet backbone.

The PI's communicate via the Internet with the Systems Ecology Research Group at San Diego State University where other LTER investigators are located.

The Jornada field site has no communication links except the university ranch hand's telephone.

Contacts:

Dave Lightfoot, Data Manager, New Mexico State University, 505-646-5818, dlightfoot@lternet.washington.edu

Jeff Harris, campus computer support group, 505-646-5110

KBS– Kellogg Biological Station

KBS is one of the two sites whose main site is not located at an institution with a current or planned internet connection. Nonetheless, the Internet is accessible via a DECNET link to Michigan State University. A proposed TCP/IP connection to Merit in Kalamazoo will require approximately $30,000 of funding. The site supports several VAX computers and PCs. The PCs are being incorporated into the DEC network using PCSA software.

Contacts:

John Gorentz, LTER Data Manager. jgorentz@lternet.washington.edu

Stephan Ozminski, LTER and KBS Computer Center. sozminski@lternet.washington.edu

Doug Nelson, MSU IP address support. Nelson@MSU (517) 353- 2980

Network Support Services, MSU. (517) 353-9991

KNZ– Konza

Two buildings on the campus of Kansas State University house most of the LTER activity and those were scheduled to be connected mid-September to the campus network which is on the Internet.

Field site is 10 miles from Campus. Konza PI's have expressed a great deal of interest in getting the field site connected.

Contacts:

John Briggs, Data Manager, Kansas State University, 913-532- 6629, jbriggs@lternet.washington.edu

Brick Verser, NSFNet Contact, 913-532-6311

LUQ– Luquillo

Luquillo LTER is on the edge of having the main site in Puerto Rico fully connected, but needs to fill in some gaps to do so. An Internet connection to UPR is now in place. The campus network extends into the building where the LTER is located (Biomedical Building), but is not connected to their computers. The main site uses PCs, some are currently hooked to a LAN using G- NET with a G-ethernet gateway running Novell networking software. Unfortunately, increasing connectivity to the main site does not meet all networking objectives. Sixteen of the 36 investigators are at other institutions located throughout the continental U.S. Most of these are at sites with Internet access.

The field site is currently unconnected, although a telephone link using a cellular phone is in place. Because the field site presence is not large, full network access to the field site is probably not required. However, a modem link is desirable.

Contacts:

Eda Melendez, LTER Data Manager. emelendez@lternet.washington.edu

Joey Mendez, campus network support. J_Mendez@acupr.upr.cun.edu (809) 250-0000

NIN– North Inlet

North Inlet LTER was visited by the Connectivity Committee in August 1989. North Inlet LTER is moving rapidly towards full connectivity with the Internet. Its main building at the University of South Carolina has an ethernet backbone that is soon to be connected to the Internet. Many of the LTER investigators are using stand-alone PCs that would benefit from connection to a network. There are also (in the School of Public Health) a few investigators that are making extensive use of MacIntosh computers running an AppleShare network. Complicating factors at the main campus are the variety of networking hardware configurations. Appletalk, ethernet, token ring and SNA connections all coexist.

The field laboratory (now recovering from damage caused by Hugo), is large and clearly rates a high-speed network connection. In the past it has used a 9600 baud data line to operate IBM terminals using SNA. Costs of upgrading a network link to the University of South Carolina may be ameliorated by using a link between Coastal Carolina College.

Contacts:

Bill Michener, LTER data manager. wmichener@lternet.washington.edu

Troy Travis, College network system manager. (803) 777-6630.

Arthur Yeh, Computer services, IP address support. (803) 777-4409.

Jim Morris, Computing services. (803) 777-7474.

NTL– North Temperate Lakes

The campus of the U. of Wisconsin, Madison, and the Trout Lake Station field site are the two locations at which NTL researchers are concentrated. The Madison campus has a CATV-based ethernet backbone that serves 50 buildings, including the buildings that house LTER researchers. The majority of the computers used by LTER at the campus is connected to the Internet via this backbone.

A network connection to Trout Lake has been listed as a main requirement. Trout Lake, 220 miles from the Madison campus, has 7 permanent and 15 seasonal researchers.

The 12 campuses of the University of Wisconsin System, together with eight private colleges and universities in the state, have submitted a proposal to NSF for partial support of WiscNet, a 56kbps network. WiscNet will provide IP service to the 20 participating institutions and be open to other educational sites. Tad Pinkerton has indicated strong interest in accommodating Trout Lake as a WiscNet site.

WiscNet would be of use in connecting Trout Lake to the Internet, because it would provide a closer connection point, cutting the communication costs considerably, as compared to a direct connection to Madison. The main problem is considered to be the funding for the communications line. (Mike Dorl estimates a 9.6 line would cost about $800/month and a 56kbps line would cost $1600/month. WiscNet might cut that cost by half.) It is unclear whether digital service is available at Trout Lake, as it’s far removed from any populated area. If approved, WiscNet is expected to be operational in mid 1990. Other Internet sites in the area are fairly scarce. UW-Milwaukee operates a link to UIUC and there are sites at Minnesota in Minneapolis and at Duluth.

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NWT– Niwot

The University of Colorado is connected to the Internet. LTER/INSTAAR computers are connected to the campus ethernet but are currently communicating using DECNET protocols. They function as part of the Joint Facility for Regional Ecosystem Analysis (JFREA), which includes INSTAAR, CESES, and NREL.

The field station at Niwot Ridge has no electronic communication channels.

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SEV– Sevilleta

Both buildings housing LTER Investigators at University of New Mexico have ethernet backbones that are connected to the campus broadband which is connected to the Westnet/Technet fiber optics leg of the Internet. The LTER workstation computers are all connected to the network, as are 2 PC’s, an Appletalk network (via a gateway) and numerous investigator PC’s (via asynchronous link to Network Interface Units [NIU’s]).

The field site has minimal telephone communication (sometimes it works, sometimes it doesn’t) but is located very near the fiber optics line that connects NMSU, NMT and UNM.

Sevilleta has associated researchers at the New Mexico Institute of Mining and Technology in Socorro New Mexico. The Internet is there but not in the biology building. Socorro also represents the nearest access to the Internet from the field site.

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VCR– Virginia Coast Reserve

This site is well-connected at the site level, but needs further work on connections at the machine level. The University of Virginia is on the Internet, and the primary building (Clark Hall) has an ethernet backbone connected to a campus-wide CATV-based broadband cable network. Most of the PCs used by investigators are connected to mainframe computers via 9600 baud asynchronous connections. UNIX workstations, a few PCs and all MacIntosh computers are connected directly to an ethernet.

The single PC at the field site is linked by modem to the main site.

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