LTER Strategic Plan

A long-range Strategic Plan for the Long Term Ecological Research Network

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Executive Summary

The LTER Network is a collaborative effort of LTER sites to facilitate and extend the capabilities of the individual sites and to promote synthesis and comparative research.
The mission of this LTER Network is to conduct and nurture ecological research by-
(1)understanding general ecological phenomena which occur over longer temporal and spatial scales;
(2)creating a legacy of well-designed, documented long-term experiments and observations for use of future generations
(3) conducting major syntheses and develop theory,
(4) providing information for identification and solution of societal problems.

The primary goals of the Network are to:
1. Conduct comparative and manipulative experiments across sites and test predictions, including predictions of global climatic change and sensitive indices of change
2. Develop ecological principles by synthesizing long-term data from broad spatial Landscape, region, globe) and temporal scales
3. Develop Network capabilities for computer networking, for GIS technologies and remote sensing 4. Contribute significantly to Global Change programs, such as U.S. GCRP (CEES), as well as IGBP 5. Develop question-driven, inter-site databases and interactive computer-based database management systems for data sharing
6. Develop a body of expertise for solving fundamental problems and applied problems
7. Contribute significantly to development of a "national center for analysis of ecosystems'
8. Foster research with persons and sites outside of the LTER Network
9. Educate and train persons in comparative ecosystem analysis

The LTER Network Office facilitates activities needed to achieve the Network's mission objectives:

1. Facilitating communication and data sharing among the LTER program

and other scientific communities;

2. Supporting the planning and conduct of collaborative research efforts including provision of some technical support services;

3. Leading intersite scientific activities; and

4. Providing a focal point and 'collective' representation of the LTER Network in its external relationships.

In furthering these goals, a number of tasks or action items have been developed, primarily by the LTER Coordinating Committee (LTER/CC) at the October 1989 Strategic Planning session:

I. Sites need to identify what data and core datasets are available, and to document these.

2. Standardization is useful, particularly for synthetic multi-site projects, and for multi-site experiments, and for exchange of data.

3. Workshops dealing with each of the 5 Core Areas would be very useful in developing broad ecological principles, as well as in designing new projects and experiments at larger time and space scales.

4. Continuity of LTER sites can be nurtured by encouragement of 'group leadership," development of a critical mass of scientists, both within the site and,outside the site, activities like the AN Scientists' Meeting, and by rotating representation at LTER/cc meetings.

5. Network activities are a collective effort to expand the/scientific and educational capabilities of individual sites, particularly in comparative analysis and synthesis.

6. The LTER Network should expand to additional sites to include other diverse ecosystems and provide for the support of continental and global research programs. Linkages to other ecological networks and sites is also a high priority.

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Abbreviations:
LTER= Long-Term Ecological Research (refers to the NSF-funded 18-site network; LTER/CC LTFER Coordinating Committee; LTER/EXEC = LTER Executive Committee;
NSF = National Science Foundation; BBS = Biological, Behavioral, and Social Sciences Directorate; BSR = Biotic Systems and Resources Division;
NAS National Academy of Sciences; DOI = Department of Interior, USGS = U. S. Geological Survey; USFS US. Forest Service; DOE = Department of Energy, NPS = National Park Service; EPA
Environmental Protection Agency; CEES = (US.) Committee on Earth and Environmental Sciences;
LTER Sites:
ARC, arctic tundra, Alaska; AND, Andrews Experimental Forest, coniferous forest,
Oregon; BNZ = Bonanza Creek Experimental Forest, Fairbanks Alaska; CDR, Cedar Creek Experimental Area, Minnesota; CPR, Central Plains Experimental Range, Ft. Collins, Colorado; CWT, Coweeta Experimental Forest, North Carolina; HBR, Hubbard Brook Experimental Forest, New Hampshire; HFR, Harvard Forest, Massachusetts; JRN, Jornada Experimental Range, New Mexico; KBS, Kellogg

Biological Station, Michigan; KNZ, Konn Prairie Natural Area, Manhattan, Kansas; LUQ, Luquillo Experimental Forest, Puerto Rico; NIN, North Inlet, North Carolina; NTL, North Temperate Lakes, Wisconsin; NWT, Niwot Ridge alpine, Colorado; PAL, Palmer Station, Antarctica; SEV, Sevilleta Experimental Range, New Mexico; VCR, Virginia Coast Reserve, Virginia; NET, LTER Network Office, Seattle WA.

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3. Develop LTER Network capabilities for computer networking, for GIS technologies and remote sensing
4. Contribute significantly to Global Change programs, such as U.S. IGBP and CEES, as well as international IGBP
5. Develop question-driven, inter-site databases and interactive computer-based database management systems for data sharing
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5. Network activities are a collective effort to expand the scientific and educational capabilities of individual sites, particularly in comparative analysis and synthesis.

6. The LTER Network should expand to about 20 sites to include other diverse ecosystems. Linkages to other ecological networks and sites is also a high priority.

(summary statement)

I. Introduction

1.1 Background

The Long-Term Ecological Research program, consists of 18 site-based projects individually funded by the National Science Foundation (Table 1). More detailed information on the sites and programs can be found in Appendix I. The individual LTER projects decided to formalize a network-level organization very early in the program in order to facilitate the development of multi-site long-term research. The governing body for this network is currently the LTER Coordinating Committee (LTERC/C) which consists of one representative from each site and a chairman. J.F. Franklin has chaired LTER/CC since 1983.

Development of the network-level program in LTER has been a gradual and

sometimes difficult process. For reviews, see Callahan (1984), Swanson and Franklin (1988) and Franklin et. al. (1990). To briefly summarize, activities began in discussions at NSF in the BSR Division among Dr. John Brooks and various scientists, both within NSF and outside. In 1977, a series of three workshops considered the content and structure of a program of long-term ecological research (NSF 1977, 1978). These efforts became the basis for the first LTER "Request for Proposals" in 1980. Five Core Areas of Research were identified and became a major programatic commonality among all sites. Since 1980, a total of 20 research projects have been funded as a result of 5 separate NSF competitions, the most recent in 1990. Special panels were created for peer review of each set of proposals. Site selection was based on quality of the science represented by the proposals, not upon their potential place within the larger network. Awards have usually been for 5-year periods, after which, sites are required to submit new proposals. Two projects were originally funded and then not renewed at the reevaluation point by NSF.

1.2 Mission

The mission of the LTER Network, as defined in its strategic planning exercise, is to conduct and nurture ecological research by:

-identifying and understanding general ecological phenomena which occur over longer temporal (e.g., decadal) and spatial (e.g., regional and global) scales;

-creating a legacy of long-term experiments and observations, soundly designed and adequately documented, for the use of future generations of scientists;

-advancing ecological science by conducting major synthetic and theoretical efforts, especially those differing in perspective and scope from those developed by individual site programs; and

-providing information for identification and solution of societal problems.

The Network is identified as a collaborative effort of these sites to facilitate and extend the capabilities of the individual sites and to promote synthesis and comparative research.

1.3 Vision of LTER's Future

At two LTER/CC meetings (April 1989 and October 1989), the group discussed what their vision of LTER was. Dr. Jack Hautaluonia, a management consultant from Colorado State University, assisted the group both times.

A summary of these discussions is the following:

Locally, LTER programs would conduct site-specific science (long-term and wide-area) which would recognize important, new factors affirming the environment, develop findings to problems of sustainability of natural resources.

Nationally, LTER would interact with the entire ecological community, helping to solve global problems. Further, LTER would be a national resource for the scientific community, integrating long-term ecological research with natural resource management. The LTER Network would be organized around scientific

issues, supplying leadership and models to the ecological community. Internationally, LTERwould become denser", with sub-sites, and with connections to an international network, working to solve global problems. In several of the discussions, participants were asked to draw their "vision" of the LTER Network- Three of these are shown below:

1.4 Legacies of LTER

The following Comments about LTER legacies was taken from a small group discussion at the October 1989 LTER/CC meeting on Strategic planning. The group included (Vande Castle, chair, NET; Viereck (BNZ), Foster (BFR), Robertson (KBS), Webber (KBS), Brown (SEV), and Brooks (invited participant, former NSF/BSR Division Director). The group asked themselves, Is creation of a legacy of long-term observations and experiments an important function of LTER? If so, how well are we doing it?

The importance of a legacy is that the observations and experiments transcend those from individual sites. Continuing experiments/long-term experiments form the basis of this legacy. The Network is the link to long-term global issues. Sites already have a legacy from the data which they have already coffected/archived as well as the historical data most sites have (weather data as an example). It is important to consider that data and design may be applicable to research to which it was not originally intended, just as data are even now being applied. Documentation is needed as to the methods and the data (an audit trail needs to be preserved).

The group also considered nhow good a legacy" LTER is currently creating. They suggested that LTFER is not always doing well due to documentation, gaps, techniques, and data forms. 7le LTER Network should take advantage of what has already been done by having and maintaining a backbone of data. Within sites, LTER is doing better than between/among sites or the network itself. LTER needs to ident what data we have (e.g. lists of data available at all sites and CORE data sets). The Network needs to impose some standards/methods. It would be good to use past data with feedback with workshops, etc. Across sites, it is more difficult to create legacies of long-term data and experiments; standardization is important.

ACTION ITEMS

1. Initiate workshops which deal with the '5 Core Areas', perhaps beginning with Core Area #1, primary productivity

2. comparability of site's data

3. emerging/EXCITING research possibilities

2. LOng-Term Goals and Objectives

In a series of discussions at LTER/Cc meetings, the group listed, modified and prioritized their goals for LTER-both Research Goals and Operational Goals. qle top ten goals in each category are listed in order of priority, #1 being most important.

RES ARCH GOALS:

I Conduct parallel manipulative experiments across sites and test predictions

2 Conduct comparative studies to test ecological theories in a broad array of ecosystems

3 Predict effects of climate change on ecosystems and test predictions

4 Synthesize long-term landscape-level ecological principles across sites 5 Develop predictions across scales, from small to global

6 Determine sensitivity indices for directions of ecosystem change

7 Compare ecosystem processes that buffer change

8 Extrapolate LTER results to a broader geographic region

9 Conduct comparative analyses with remotely sensed data

10 Incorporate studies of biodiversity into LTER research

OPERATIONAL NETWORK GOALS:

I Develop network capabilities (LAN, WAN)

2 Develop GIS capabilities

3 Develop LTER as a leader in U.S. IGBP

4 Develop question-driven inter-site databases

5 Transfer information from basic research to applied problems

6 Develop interactive computer-based database management systems 7 Develop a body of expertise for solving fundamental problems

8 Develop LTER as a leader in creating a 'center for analysis of ecosystems'

9 Foster research with persons and sites outside of the LTER Network

10 Educate and train persons, particularly women and minorities, in comparative ecosystem analysis 9

3. Historical and Current Context for LTER

The National Science Foundation has begun a major biological activity, funded at about $7 million dollars per year. This activity, called the Long-Term Ecological Research (LTER) activity, is a large-scale coordinated research effort supported by NSFs Division of Biotic Systems and Resources (BSR). This exciting experiment is the first sustained, long-term and large-scale project in biology funded by NSF.

From 1967 to 1979, the basis for LTER developed from a series of 3 workshops involving many members of the scientific community (Callahan 1984). In recognition of the advantages of long-term research programs and the historical difficulty of sustaining such research efforts, the NSF instituted LTER in 1980 [Callahan, 19841 with funding of six sites, a number that has now grown to 18. The existing sites span a great array of terrestrial and aquatic ecosystems - desert, prairie, tundra, forest, small stream, big river, lakes, and estuaries.

There are at least three major strengths of this LTERactivity. One major strength is the developing network, which allows comparative experiments to be made. The network can evaluate intensive investigations at single sites within the context of larger scales. Data management can be coordinated, providing convenient, accessible databases for development of theories, testing of hypotheses and building of models. This accumulation of information at many levels of organization and spatial and temporal scales is an extremely valuable resource. This resource can study phenomena at higher or lower organizational levels, which may have in the past been treated as insignificant.

A second major strength is the long-term nature of the research. Ecological phenomena occur over decades, centuries and longer, yet these time periods are beyond the scope of most short-term (2-5 year) NSF awards. Sufficient knowledge of year-to-year variability is needed to interpret trends, particularly in non-equilibrium biological systems. Trends can be evaluated, separating unidirectional changes from cyclic changes or background variability.

A third major strength is the preservation of natural ecosystems for study by present and future generations of scientists. Examples of plant, animal, soil, water, and other components can be archived, analyzed and used for future comparisons. Biodiversity can be preserved. Long-term studies of change, such as global climate change, can be initiated.

There are common threads that tie these diverse LTER sites together and facilitate collaborative research. These threads include: (a) established research sites with long-term records of environmental and biological variables; (b)assurance of continued security and availability of research sites; (c) areas of relatively pristine, preserved ecosystems, as well as areas where large-scale manipulative experimentation is possible; (d) established interdisciplinary teams of researchers with stable leadership and institutional support; (e) programs of research in five core areas (described below), and (o a commitment to work with other sites in the LTER network.

LTER involves groups of investigators working at representative sites located in diverse biogeographic regions. Investigators focus on a series of 5 core research topics, coordinate their studies across sites, utilize documented and comparable methods, and are committed to long-term research.

The core research areas are:

(1) pattern and control of primary production:

(2) spatial and temporal distribution of populations selected to represent

trophic structure: (3) pattern and control of organic matter accumulation in surface layers and sediments:
(4) pattern of inorganic inputs and movements of nutrients through soils, groundwater, and
surface waters; and
(5) pattern and frequency of disturbance to the research site.
There are currently (September 1990) 18 sites in the LTER network; these sites are located in
Antarctica, and in the United States in 13 states, and in the territory of Puerto Rico:

ALASKA	Bonanza Creek (BNZ), Arctic Lakes (ARC)
COLORADO	Niwot Ridge (NWT), Central Plains (CPR)
KANSAS	Konza Prairie (KNZ)
MASSACHUSETI'S	Harvard Forest (BFR)
MICHIGAN	Kellogg Biological Station (KBS)
MINNESOTA	Cedar Creek Experimental Area (CDR)
NEW HAMPSHIRE	Hubbard Brook Experimental Forest (HER)
NEW MEXICO	Jornada Desert (JRN), Sevilleta Range (SEV)
NORTH CAROLINA	Coweeta Hydrologic Lab (CWT)
OREGON	Andrews Experimental Forest (AND)
SOUTH CAROLINA	North Inlet (NIN)
VIRGINIA	Virginia Coast Reserve (VCR)
WISCONSIN	North Temperate Lakes (NTL)
PUERTO RICO	Luquillo Experimental Forest (LUQ)
ANTARCTICA	Palmer Staton (PAL)

3.3.

These sites are generally associated with one or more academic institutions and a variety of government and private agencies, as illustrated in the following table, which summarizes the major supporters of LTER activities at each site.

Site	Primary Institution	Other supporting groups
AND	Oregon State Univ	USFIS \
ARC	Marine Biol Lab	
BNZ	Univ Alaska	USFS CDR Univ Minn
CPR	Colo State Univ	USDA
CWT	Univ Georgia	USFS (SE region)
HBR	Cornell Univ	Syracuse U., Carey Arb.,USFS,
HFR	Harvard Univ	Marine Biol Lab
JRN	N Mexico State Univ	San Diego State U., Duke U
KBS	Michigan State Univ	Kellogg Foundation
KNZ	Kansas State Univ	Nature Conservancy
LUQ	Univ Puerto Rico	USFS
NIN	Univ S Carolina	Baruch Institute
NTL	Univ Wisconsin	
NWT	Univ Colorado	USGS

PAL	U.CA Santa Barbara	Old Dominion Univ, VA; Pt. Reyes Bird Observatory, CA
SEV	Univ N Mexico	US Fish & Wildlife
VCR	Univ VA Charlottes-	Nature Conservancy ville VA

LTER sites are selected on the basis of peer evaluation of proposals submitted to the NSF. After site selection, sites carry out substantive research programs at each individual site. The substantial effort that goes into intersite activities is led by a coordinating committee (LTER/CC) consisting of one representative from each site.

The 17 LTER sites are loosely collected into an integrated group, organized for the purposes of conducting similar experiments across sites, carrying out collaborative research, fostering comparative studies and serving as a model for large-scale, long-term research in ecology. This integrated group is called a 'network.' There is a centralized network office, located at the University of Washington in

Seattle WA, where the chair of the LTER/CC, Dr. Jerry Franklin, is located. The Coordinating Committee (LTER/CC) has as many members as there are sites in the Network. These representatives are selected by the individual sites, the procedure being decided by the sites. The representatives elect a chair, either from their group or someone associated with a site. There have been 2 chairs of this group - Dr. Marzoff from Konza LTER (1981-) and Dr. Jerry Franklin (Andrews LTER,

198- - present). The length of the term of the chair is at the discretion of the LTER/CC. The LTER/CC meets regularly, generally twice a year - spring and fall. Meetings are usually at one of the sites.
3.2

LTFER Strategic Plan
4. Critical Issues 4.1 Site-based Issues
4.1.1 Research programs
Research programs at the sites are a combination of site-initiated research and 'core-area research". The success of LTERdepends upon the interest, creativity and productivity of individual scientists, working alone and worldng together within their site and working together with other sites in the network. This success depends on finding creative ways to support both site-initiated research and networked-research.
4.1.2 Organization
At the Fall 1989 LTER/CC meeting on Strategic Planning, a number of topics were discussed, including aspects of organization and continuity of sites. 7le following discussion originated from working group #6.
How to Nurture Continuity within Network? Group 6 also considered how LTERcan nurture continuity in leadership, given the hightly individualistic nature of edsting programs. Their suggestions are:
(a) It is important to distinguish that of the sites from that of the network

(b) Insure critical mass of people senior personnel rather than just I distinguished P.L
(c) It is possible to recruit the critical mass of people for a site from other sites (although this doesn't guarantee it)
(d) to some extent this requires some degree of altruism from within
(e) provide the excitement of the collective enterprise
(f) provide support of 'troubled' sites (leadership, move of P.1 etc.) to preserve the legacy
(g) it is not outside the possibility of a site being taken over if this is what is needed to be sustained
(h) executive group with revolving members provides changing/wider view (i) Leadership should be not only be from exec or above
j) most adequate mechanisms are already in place
(k) AU scientists meeting is important, including interaction, and teleconferencing
(l) the network should encourage interaction
(m) there is a need to put LTER science to the outside by means of publications and special symposia at meeting such as ESA

4.1.3 Technological needs and opportunities. Two important meetings were held to discuss technological needs and opportunities. Reports from these meetings are informally referred to as the "Shugart' report and the 'Gosz' report (see Appendix). The Shugart report (Januaxy 1988 meeting, Washington DC) recommended that the LTER Network acquire technological capabilities in GIS, remote sensing, database management and electronic network connectivity. ne Gosz report (January 1989 meeting, Washington DC) built on the Shugart report and examined other technologies and their importance to long-term, broad-scale ecological research. This Gosz report emphasized the critical importance of acquisition of remote images for all sites as soon as possible, with secondary emphasis on .....
Following the Gosz report, LTER sponsored a two-day workshop on remote sensing was held at the university of New Hampshire to determine the role of remote sensing for the LTER Network, stimulate cross-site research projects and build a network of scientists interested in remote sensing within LTER. The research focus of the meeting centered on the need for vegetation indices analysis, the integration ofremote sensing into ecological analysis and modeling, and the need and support for high resolution remote sensing systems such as those planned under NASAs Earth Observing System (EOS) program. The plan for initial remote sensing data acquisition for the LT'ER Network was formulated for a recently funded proposal submitted by the NETWORK Office as a result of this workshop.
A GIS workshop held in September 1989was held at Colorado State University, and hosted by the Central Plains Experimental Range (CPR) LTER site. The nine-day training session provided lessons and training in ARC/INFO and ERDAS, which are part of the Minimum Standard Installation for each site.
The workshop was designed to enhance the investment in GIS tools for analysis and modeling as well as the integration of remote sensing technology into

ecological research of Network. The workshop report is included in the Appendix.

4.2 LTER Network Issues

4.2.1 Inter-site experimental science.

At the October 1989 LTER/CC meeting on Strategic Planning, Group 4 discussed this topic.

Members included: Melillo (FIFR), chair, Hobbie (ARC), Meyer (CWT), Cunningham (JRN), Bowser (NTL), Funk (affiliation ?), Schindler (NSF). The group emphasized this concept:

Scientists are the source of questions and the network should facilitate their development.

The group discussed a series of 3 questions, then developed 9 specific Action Items.

Question l. How do we identify the scientific issues to be addressed? Questions should be those that require a network of sites to be answered rather than questions that can be answered at individual sites. This does not mean that all questions must be addressed at all sites. Questions should ideally relate to long-term phenomena, although (especially initially) short-term questions are also of interest. A series of criteria that are not necessary met by all proposals

1) Important question at a large scale

2) Important social issue

Question 2.How does the network facilitate this? A continuum of approaches with workshops at one extreme and an individual pursuing a question of interest at the other. Coordinating committee funds workshop with input from Pls on what should be funded. Non LTER scientists welcome to participate. Requires rapidly circulated report--perhaps the newsletter

Question 3. How do we promote use of site resources? Continue to develop minimum standard technologies, an inventory of data, a resource inventory (what long-term experiments are being done at the sites) , encourage acquisition of technologies that can be shared (e.g., shared technological tools - global positioning modules, etc.).

ACTION ITEMS

1. Continued support of workshops designed to address multiple-site research questions.
2. Devote a section of LTER newsletter to reporting above workshop results
3. Make database catalogs and publication list a high priority

4. Develop annotated list of ongoing long-term experiments
5. Develop and support shared technologies, such as centralized facilities, and portable measuring equipment
6. Establish intersite training paradigm--ongoing, e.g., modeling and trace gas measurements
7. Promote efforts of wider ecological community to establish center for synthesis
8. Establish a small number of FLAGSHT experiments

9. Continue to act on the MSI or "minimum standard installation" concept for development of technological items (computer communications, datamanagement, GIS, remote sensing, etc.)

Further Developments after October 1989 LTER/CC Meeting. A number of the action items have been initiated. A large number of research projects involving multi-site comparative analyses have been undertaken and completed by the LTER Network. AU have involved development and analysis of pooled databases and several have developed into major syntheses. The LTER Newsletter reports on workshop activities (Action Item 2). The LTER Data Managers have compiled a Core Dataset Directory, with publication anticipated in Fall 1990 (Al 3). 'Be LTER Network will acquire both remote sensed data for all sites and has purchased shared GPM (global positioning module) equipment (Al 5). At the All

Scientists Meeting, an inter-site (both LTER and other sites) research project for a large ('Flagship') experiment on soil warming was developed (Al 8).

4.2.2 Synthesis and modeling (to be written)

4.2.3 Data Management and Data Sharing.

Report from the LTERLCC Meeting, Oct)ber 1989

At the LTER/CC meeting on Strategic Planning, the Data Management working group included Van Cleve (BNZ), chair; Swank (CWT), Whitford (JRN), Dueser (VCR), Gosz (SEV), Edwards (NSF), and Stafford (AND and chair LT'F-R Data Managers Committee). The group discussed the following topics:

Kinds of Information. What kinds of data - site characterization, baseline data, weather, question- driven, core area data.

Availability of Data. Availability would be at the discretion of the investigators, with the ultimate goal of making information accessible to the general scientific community. LTER is committed to common data sharing with appropriate safegards. At present, it is not feasible to have all databases on- line, but databases can be exchanged without on-line capabilities (e-mail, hard copy, disk exchange, tape exchange, etc.).

Larger pooled databases will be created in response to inter-site, question-driven activities. Centralized dtatbases are not necessary within a fully

functioning network. We propose a flexible
approach to maintenance of pooled databases, which are at the discretion of the individual investigator, but with the eventual objective of inclusion within a network archives
Leadership in Data Management Research. LTER can become a leader in information
management as a result of the unique nature of long-term ecological data. Research on information management within the LTER Network will result in more timely, efficient, interactive processing,
interpretation and publication. Long-term archiving will be assured by this approach.
Protocols. Protocols for information use and exchange are essential, especially for: (a) data collection (b) storage
(c) access and retrival
(d) acknowledgement of shared data (e) documentation
(o quality assurance
Discussion of Data Sharini!
Data Sharing, a complex issue, includes these topics:
1 sharing selected data sets
2 development of "meta-datan databases

3 development of specific inter-site databases for use in solving specific scientific questions (e.g. the 'decomposition' and 'variability" databases)

4 development of protocols for storing and retrieving datasets

5 compatibility and access among different site database management systems (DBMS)
6 discussion of the desirability or undesirability to select a common DBMS.

In discussing these topics, a major contribution has been made by the LTER Data Management Committee (see list of committees in the Appendix). The following text includes materials developed by this committee, as well as information from LTER/CC meetings and workshops. Although 6 topics are listed, consensus has not been reached on several topics, and only topics 1 and 2 are discussed here. Further work is needed on the remaining 4 topics.
The LTER Network's substantial advances in data management include development of protocols for data documentation and archiving and the MSI. These have substantially improved the Network's ability to exchange and pool data-Signficant steps in developing on-line, data bases have also been taken. Several pooled data bases now exist as a result of Network-sponsored workshops and individual research projects.
4.2-3.1 Sharing selected data sets. Perhaps the first LTER inter-site database was developed in conjunction with the Variability Workshop at NTL, Dr. John Magnuson as leader. This workshop is summarized below.
Sharing of LTER data among LTER sites was essential to the intersite variability project which examined and compared the temporal and spatial

variability of 11 of the LTER sites. This constiuted one of the very first efforts in the network to jointly provide and analyze original data collected by the sites.
The procedure involved Magnuson visiting almost all of the participating sites to explain the project. Then each site sent the appropriate data to Dr. Tim Kratz, also from the NTL site, who prepared a data base which is now public and on file electronically at the network office. Three intersite papers are in progress (two in press, one in manuscript). Each participant at the analysis workshop held at the north temperate lake site at Trout Lake is an author on at at least one of the papers. To further ease this early effort in
data sharing, the public data base only includes derived variability estimates of measurements at the sites,
rather than the original site data.

(insert statement describing the access policy adopted at the workshop)

4.2.3.2 Development of "meta data databases". 71c LTER Data Managers developed the following statement at their annual August 1990 meeting. (DRAFT - Contents under Revision)

Minimum Set of Meta-Data (Documentation) for all Data Abstracts of LTER Data Sets.
Meta-data is that data needed to access, retrieve, and interpret scientific data. After some review of how the various sites organized and maintained their meta-data, the discussion shifted to the role of the data manager in acquiring this documentation. Based on comments from the LTER Data Managers, one major problem is receiving necessary data abstract information which only the principal investigator can provide. A considerable quantity of information may need to accompany a given data set, but certain key information must be available before a data set can be properly installed for access in a long-term
database.
Ideally, this information should be provided in the early planning process of a study.

Unfortunately, investigators sometimes forget that including the Data Manager in planning discussions will improve data collection and processing. Furthermore, we are not suggesting that PI(s) involvement with data set documentation should end here, rather we recommend that the PI and Data Manager establish a long-term symbiotic relationship. From the Data Manager's perspective, it would be ideal if the principal investigators viewed installing data in a long-term database as highly desirable, and viewed cooperation with the site data manager on data documentation as critical to long-term database value.
We are proposing the following minimum set of standard information for data abstracts which the PI(s) must provide:

Study title: The title of the study.

Keywords: Keywords that will aid other researchers in review and retrieval of study
data (a prototype list is available in the LTER Core Data Set Catalog for review by the PI(s) if necessary).
Parameters: The primary variables that occur in the study.

Site location: The specified study site location(s).

Purpose,goals: A statement of the objectives and goals of the study as they relate to study data sets.

Exp'tl design: An outline of the experimental or sampling design of the study in sufficient detail to describe the basic experimental or sampling approach, plot size and shape, experimental unit(s), sampling unit (s), timing of sample, etc.

Methods: A description of the method by which measurements were taken (both
field and laboratory) with adequate detail provided to judge the propriety of potential comparison of data sets with regard to methodology.

Proprietary limits: Specify access restrictions and an expected date when data become public property-
The above informational categories can initially be easily ignored by a data manager, as data set formatting and error checking are more immediate tasks. However, this documentation is essential in maintaining data set integrity; data managers must be vigilant in securing this information, and this commitment must be supported by the Pf's.

4.2.4 Standardization in science and in technology. At the October LTER/CC meeting on Strategic Planning, Group 2 discussed standardization. Members included Blood (NIN), Caine (NWT), Knapp (KNZ), Lattin (AND), Lauenroth (CPR), Rodman (NSF), and Yavitt (FMR). The group worked with an underlying premm that standards are useful. They discussed levels of standardization, from the "5 core research areas' at the sites, to network-wide standards for experiments (similar to NADP (National Acid Deposition Program)), to regional, national and global standards for research, communication and data exchange.
The group agreed that standards are not required for hardware, but may be useful; rapid information exchange over a network communication system would be very useful. Information exchange will also facilitate the development of common measurements when desirable. For common experiments, a hi.ah level of standardization is needed. The group supported the efforts of the LTER Data Managers Committee to develop standard criteria for data management, although the "methods themselves do not have to be standardized. The group recommended

3 action items:
ACTION ITEM #1: Certain parameters should be measured and data collected across all sites. Examples include remotely-sensed images, GIS data, maps of sites with geopositioning modules, etc. LTER should
not 'set standards" for other sites or programs, but could be an example and could create opportunities for information exchange with others.
ON I hM #2: LTER Network should develop a bulletin board or 'clearing house' for exchange of information about hardware, software, methods, datamanagement, etc.
ACMON ITEM #3: LTER should periodically review Thethodsn and look for opportunities to standardize. One possible area for review might be the nS core areas of research'.
Further Developments. Since the October 1989 meeting, LTER scientists and data managers have continued to develop standardization in some areas of science, particularly areas in which inter-site comparisons are important. It is recognized that any discussion must be an an ongoing discussion, as goals, technologies and scientific objectives change. The following paragraphs describe 5 areas in which standards have been or are currently being implemented, and suggest future areas for discussion:
I the "MSI" concept
2 the "Connectivity" concept,
3 GIS and remote sensing standards 4 the 'core data set' concept
5 standard protocols for common inter-site experiments
The MSI Concept. The LTER Network has developed, adopted, and implemented a set of standards for the types of equipment and software necessary to for communication and exchange of data--the MINUMIUM STANDARD INSTALLATION (MSL see Appendix). These technologies include 3 areas: (a) LAN and WAN hardware and software; (b) GIS systems; and (c) high-capacity data storage system. Briefly, all 17 LTER sites and the Network Office have (or are) acquired computer equipment to link scientists in an electronic network (see the Connectivity Report, Appendix).
Sites have also purchased GIS systems (often SUN computer work stations) and GIS software (often ARC/Info and ERDAS). Standards for parameterization of LTER Network Oceanographic Information Systems (GIS) are under preparation. The LTER Network is also continuing to develop additional standards for selection and measurement of parameters as has already been done forclimatological and some ecological processes, such as tree population studies. Many sites have optical disk drives for data storage. Most sites are acquiring the expanded standardized needed for processing remote imagery. The images themselves (AVHRR, SPOT, HAP, etc.) will be purchased by the Network Office with a group license, allowing access to all images by scientists within the network

The 'Connectivity" Concept. In the summer and fall of 1989, NSF asked the LTER Network to evaluate the status of electronic connectivity within the network. Dr. Franklin, chair of LTF-R/CC, appointed 3 members - James Brunt (SEV), chair; John Porter (VCR), and Rudolf Nottrott (NF,-f), LTER Data Manager. This 'Connectivity Team' collected information from all sites

(questionaires, phone calls, etc.) and visited 5 sites (CWT, NIN, HFR, HBR, ARC). Their report (see Appendix) made specific recommendations for enhancing the connectivity of the LTER sites (both main univerisity-based site and field stations). After a proposal was funded by NSF in the fan 1990, the Network Office has begun to implement some of these recommendations.

GIS/Remote Sensing. In the Fall 1990, the Network Office was funded to acquire various remotely-sensed data for all sites in the Network (AVHRR, SPOT, HAP, etc.)(see Appendix,
"Connectivity/Remote Sensing Proposal'). At the September 1990 AU Scientists Meeting, several working groups discussed development of standards, common protocols and inter-site research, using GIS and remote sensed data. The reports from these groups are pending.

The Core Data Set Concept. There is an LTERNETWORK CATALOG OF CORE DATA SETS as a first step ingeneratinga searchable on-line data base. This catalog identifies core data sets from all of the LTERsites, includingmany of the older sets that have not been readily accessible to all interestedscientists, both inside andoutside LTER. The catalog includes investigator, subject keyword, site, and core area indices and has beenproduced in both electronic and printed form.

In addition to assembly of this catalog, there is interest in the Network in a re-evaluation of this concept, and discussion of how more comparable data might be collected. This discussion will continue at the Spring 1991 LTER/CC meeting.
Standard Protocols for Inter-Site Baeriments. The first major intersite experiment was proposed by John Magnuson (NTL), for a comparison of variability (in numerous parameters) across a number of sites within the Network- Magnuson contacted sites and 12 joined the experiment by supplying data from which various variability parameters were calculated. A workshop was held at the NTL field site in spring 1988, where participants spent 4 days working on computers, examining the 'variability database". Several papers have resulted from this workshop (see Appendix, Publications).. The database collected for the worskhop is now open to interested persons outside the Network; the database.is stored at the LTER Network Office.

A second major intersite experiment was developed at a 'Decomposition' workshop at the Woods Hole MA (Melillo and Nadelhoeffer, conveners). 'ne representatives from most of the 17 sites developed a common litter bag experiment and outlined the common methods and protocols (see Appendix for 'Decomposition Protocols"). This litter bag experiment is probably the first major experimental inter-site research undertaken by the Network Sites in addition to the LTER Network were added to the experiment in order to obtain the necessary ranges of ecosystem types, temperatures, and moisture regimes.

Other major intersite experiments are in the planning stages, some of which were initiated at the LTERGlobal Change workship, November 1989, Denver

Colorado. As these programs develop, further information will be added to this Strategic Plan.

4.2-5. Electronic comniunication and networking.

A Highly Functional Network Support System has been developed at the Network Office to facilitate communication and data sharing among the LTER sites and between LTER and non-LTER scientists. Initial capabilities include an electronic mail forwarding system using a Vax Station 2000 computer (LTERNET) which simplified communication within the network; use by network scientists increased dramatically during the last year(to 71% of the 424 scientistsusted in the LTER Personnel Directory). This system includes direct connections to such disparate systemsas ONU-;ET, MCImail, TELENET, NASAMAIOL, DialCom (EPA), DG (US Forest Service), and SPAN(NSA/JPL). These abilities are being expanded with current funding to provide a central access point tolntemet which has not previously been available to all scientists. In 1990 at the request of NSF, theLTERNetwork conducted a comprehensive study of the potential benefits and costs of various levels ofelectronic networking capability. A report, 'INTERNET CONNECTIVITY IN LTER. ASSF-SSMENTAND RECOMMIP-NDATIONS', (Brunt, Porter and Nottrott 1990-, Appendix 1) was developed whichrecommends expanded efforts at networldng, i.e., improved electronic connectivity within LTER and thelarger ecological community and provides a prioritized plan
for implementation.

4.2.6. Role of the LTER/CC, LTER/Exec and LTER Network Office.
The LTER/CC, which was formed in 198 - (???), to make decisions on behalf of the LTER network of sites. In 1988, the LTERICC decided to create an executive committee, who would meet more frequently than the LTER/CC, which meets twice a year. This LTERIEXF-C would meet 4 times a year and act for the LTERICC. Dr. Jerry Franklin is currently chair of the LTER/CC and has served since 198- (???). The LTER Network Office was initially established in Corvallis OR, where Dr. Franklin was stationed as a member of the U.S. Forest Service. On Franklin's move to the University of Washington in 1989, the Network Office also moved to UW. The Network Office expanded from a single staff person in its early years to the current staff of four - Network Manager (Dr. Vande Castle), Data Manager (Mr. Rudolf Nottrott), Publications Editor (Ms. Stephanie Martin) and Administrative Assistant (Ms. Adrienne Whitener). The roles of the LTER/CC, LTER/FXEC and LTER Network Office have changed over their existence, as the LTER Network expanded and changed itself. A number of discussions have been held within the LTER Network on these changing roles. A few of these discussions are summarised below.

LTER/CC Meeting on Strategic Planning, October 1989: At this meeting, Group 6 discussed the following question:
What can the network do that the individual sites cannot?
Their answers included:
(a) facilitate data, information, and methods exchange among sites;

(b) provide a link to larger spatial resolutions - regional and global; the network gives us the capability to look at the 'big picture' rather than local view
(c) global issues are now being 'forced on use' requiring investigations of links such as life and the atmosphere
(d) incorporation of 'outside' technologies into the LTER network (link to atmospheric and other scientists which are not formally associated with LTER) availability of technology within the network ('sharing' of specific technologies at individual sites)
(e) provide other types of research (i.e. via research at individual sites applied to other sites), such as:
-changes in land use/planning, global change and links to the presence of people, need to look at the whole system, Is our research or "monitoring" representative by sampling the reserves rather than including he human system, and social issues need to be included in our research.
The Network Office was created by the LTER Network to facilitate activities needed to achieve the LTER mission and objectives. Specific responsibilities of the Network Office include:

(a) Facilitating communication and data sharing among the LTER sites and between the LTER program and other scientific communities;

(b) Supporting the planning and conduct of collaborative research efforts including provision of some technical support services;

(c) Leading some intersite scientific activities; and

(d) Providing a focal point and 'collective' representation of the LTER Network in its external relationships.

Since the Network Office is the primary entity focused at the network rather than at individual sites, the office often plays an active role in stimulating or catalyzing network activities rather thanfunctioning comletely in a passive or support role.

4.2.7. Future expansion of the network.
At the October 1989 LTER/CC meeting on Strategic Planning, Group 6 discussed this question:
What are the practical limits to the size (sites, activities) of an 'intimate' LTER network? What are some alternative structural models for enlarging LTER activities?
They concluded that a size of about 20 is probably about max due to funding, personnel, interaction, group dynamics. However, the current size (17) does not include some important biomes (e.g. tropical, Mediterranean, Antarctic, high mountain forest, etc.). Also there is a need to incorporate satellite sites, linking to other networks. They emphasized the need to focus

on the extreme as well as the norm.

Permutation of Sites, Data and Facilities. The group also considered what needs to be done to assure continuity of the long-term research at the sites, including perpetuation of the sites, data and facilities. They concluded that continuity is a very difficult issue. However, the LTER Mission Statement (see Section 1.2) suggests that sites which focus on this mission will also probably build strong links between themselves and other sites, and thus help to ensure their own continuity. The group also noted that some sites work to build continuity by encouraging a rotating leadership and by expanding the

4.3 National (US.) Issues

4.3.1. Linkages to the larger ecological community, other scientific disciplines, U.S. agencies, science programs and networks.
At the October 1989 LTER/CC meeting, Group 3 discussed the relationship of the LTER Network to other scientists, scientific disciplines, and organizations. 'Me group included Magnuson (NTL), chair; Burke (CPR), Callahan (NSF), Covich (LUQ), Davis (Invited participant, Univ. N4N); Shaver (ARC), Waide (LUQ). The group discussed a number of topics, which are summarized here, as are the Action Items. Importance of Why should LTER expand to interact with other groups? Suggestions were: improve research quality, convert competitors to users and enablers, expand scope and applications of LTER research, test predictions that were based on LTER sites alone, expand pool of users, increase resarch dollars, access new ideas and expertise, improve extrapolation to global issues, improve understanding at the interface between ecological disciplines, increase political influence.

Encouragement of Others to Use LTER sites. How can LTER encourage others to use LTER sites?

ACTION nEM: Maximize incentives for scientists to work at or with LTER sites and scientists. Tasks:

(a) Actively promote LTER to colleagues, by writing article for ESA describing opportunities at LTER sites (Network Office might do this), or by advise potential users about funding opportunities to work at LTER sites. At NSF, these might include funding for: (i) Women and minorities

(ii) LTERsupplement program (EROL)
(iii) LTER Program (Long-Term Research in Environmental Biology (iv) Research Opportunities at small schools (v) BSR postdoctoral fellowships (Vi) BSR Nfid-Career fellowships
(vii) Regular BSR competitive proposals (viii) Dissertation improvement grants
(ix) SOER, small grants for exploratory research

(b) Ask workshop organizers to invite at least 15% of participants from outside the Network_
(c) Identify target groups with potential interests in LTER Network, such as systematists, small college faculty at institutions near LTER sites, population and evolutionary ecologists, physiological ecologists, etc.
Should LTER associate with Other sites or long-term ecological research programs? Yes, if there are substantial scientifc research to be done. How?
(a) Develop regional affiliations of sites based on geographic or biotic similarities. An LTER site might, for example, form a sub-network with nearby nonLTER sites and exhange scientists and
data; conduct joint comparative research; regionalize general models; encourage standardization. Several sites, including CPR and SEV, have already begun this effort.
(b) Form network to network athations, and lead by example. LTER could work with other ecological groups or networks, such as DOE's ParkNet, the USFS, EPAs EMAP program, DOI/National Park Service, etc. These affiliations could encourage activities as listed in (a) above,
as well as coordinate activities and conduct joint planning.

What are the models by which LTER can provide ecological leadership into the next century?

(a) By example.

(b) By training and education.

ACTION ITEM: Agressively pursue the recruitment of women and minorities into Ph.D.-level graduate programs in the LTER Network.

ACTION ITEM: Develop an NSF RTG (Research Training Grant) proposal, with the goal of developing a group of Ph.D. ecologists with multi-disciplinary training and broad knowledge of different ecosystems (as represented by LTER Network), and of training students to address questions with implications for solving societal problems.

4.3-2. Application of LTER Research to societal problems.
At the October 1989 LTER/CC meeting, which was devoted to Strategic Planning, one of the working groups (Group 1) discussed whether and how LTER might alter its' "political' environment and further the application of LTER research to societal problems. Members included Bledsoe (NSF), Inouye (CDR), Shugart (VCR), Seastedt (KNZ), Swanson (AND), Torrey (FIFR), and Vemberg (NIN). Group I
specifically addressed 3 questions.
Questions:
(1) How aggressively should LTER seek to alter its "Political" environment, e.g. educate and influence decision makers or modify their

expectations?
(2) To what degree should the LTER network seek applications of its ecological findings or should this come primarily through site-level or traditional (e.g. EPA) structures?
(3) What level of integration should LTER seek with other disciplines, such as the geophysical sciences? the social and economic sciences?

These questions and the group recommendations are listed below:
(1) How aggressively should LTER seek to alter its 'political' environment, e.g. educate and influence decision makers or modify their expectations?
The group agreed that LTER should increase its visibility, its communication and influence with other groups. Many other scientific organizations are much more effective and agress than are biologists or ecologists. If LTER doesnt actively promote ourselves and highlight our scientific successes, we will lose funds and opportunities. The group believes that the network acting collectively for the sites can access funds not available to single sites or single scientists. Therefore we propose this action item:

ACTION ITEM: Increase the visibility of LTER and improve public understanding of the science conducted at LTER sites.
Steps:
(a) Create brochures, posters and other similar material aimed at public understanding of LTF-R's science. This activity might best be coordinated and originated in the Network Office. We hope
some materials might be available within I year, inorder to be used for the Nov 1990 LTERpresentation at the National Science Board.

(b) Identify, coordinate and develop priorities for network-wide funding initiatives. We suggest that the Executive Committee act as a clearing house for collecting these suggested initiatives. The initiatives might be suggested by individual LTER scientists, by individual sites, by the LTER/CC or the LTER/FXIEC, or other interested persons. 'ae Exec Committee only serves to coordinate the list, and, with the help of the LTER/CC, prioritize which initiatives will be developed first. This activity should be on-going.

(c) Establish liasons with other agencies and organizations. We would like the LTER/Exec, either
itself or through contact with other groups (such as the ESA Public Affairs Office in Washington
e), to begin letting other organizations know about LTERand its accomplishments. The LTER/Exec or a designated LTER committee should initiate this activity.

(2) To what degree should the LTER network seek applications of its ecological findings or should this come primarily through site-level or traditional (e.g. EPA) structures?

The group agreed that although LTER sites conduct basic research, most sites probably also have intentions to apply some of the findings of their basic research to problems of society. The group also supported strongly the concept that the LTER network would actively seek to find applications for some LTER basic research which is done at the network level (i.e., not site-specific). For example, the AND site is currently applying is basic ecological research on forest processes to management decisions on harvesting patterns. 'Me VCR and CPR sites are using models to understand why boundaries develop on continental scales, a basic research program with applications to problems of climate change.

The group encourages the LTER network to take a more active approach to 'brokering' LTER's basic research into applications, as long as there are sufficient safeguards to ensure that the network (or a subset of sites within the network) is interested in working on a particular application.
ACTION ITEM: Explore and exploit applications of ecological research at the network level. Steps:
(a) Facilitate the generation of network-wide applications of basic research to societal problems.
There are several mechanisms to accomplish this task. For example, workshops, LTER coordinating meetings, discussions at individual sites, or LTER executive meetings. 'Me November 1989 Global Change meeting is an example of an application of basic research to societal problems which was initiated by the executive committee.
(b) Develop procedures to insure network support. We want to be sure that initiatives have the
support of several sites and that persons that represent LTER are acceptable to the network, We suggest that the esecutive committee appoint a committee to develop these procedures.
(c) Identify and contact sponsors. Develop initiatives and secure funding.

(3) What level of integration should LTER seek with other disciplines, such as the geophysical sciences, the social and economic sciences?
The group was very interested in a high level of interaction with the physical sciences (global change initiative), but did not have sufficient information to comment on social and economic sciences.

ACTION ITEM: increase interaction with geophysical scientists. Steps:

(a) Designate liasons with geophysical science societies. Ask these individuals to attend meetings, develop contacts and report to the coordinating committee.

(b) Invite geophysical scientists to appropriate LTER meetings, workshops, all scientists' meeting etc.

ADDITIONAL ACTION ITEM: In addition to the recommendations listed above, the

LTER/CC decided to expand the attendance at their 'All Scientists' Meeting', held in Estes Park Colorado, September 1990.

They invited selected scientists (persons who received supplemental awards from BSR/NSF to extend their research to LTER sites, scientists from the LMFR program (Land Margin Ecosystem Research), scientists from other long-term ecological research programs, etc.) and representatives from agencies (DOE, USFS,

EPA, USGS, NPS, NAS, NSF, etc). This meeting drew interest within the LTER network outside agencies and NSF. Although this meeting, which is only held about once every 7-8 years, has traditionally been focused on LTER research activities, as with the changing focus of the network, the meeting was a key link for future collaboration between LTER scientists and other research groups.
'Me initial plans to accommodate 220participants has been expanded to more than 275, almost one-third of which will be from groups outside of the formal Network. This meeting provided a major focal point for future LTER collaborative research, as well as direct links to researchers in other agencies. A number of symposia were planned aspart of this meeting: intersite GIS and spatial analysis, remote sensing and vegetation index work biological legacies, and animals as agents contributing to the spatial redistribution of materials in ecosystems.
Interest across the Network has been very great with participation of 18-20 individuals requested by some sites. Similar interest from ecologists outside of the formal Network has resulted in participation by scientists on a truly global scale. Ecologists from England, China and Russia attended this meeting.
Even though the LTER core funding comes from the National Science Foundation for the support of basic research, a surprising amount of LTER research has application. The following examples highlight some of these applications.
(to be completed) Forest Landscape Approach to Timber Management The Andrews LTER site, a coniferous forest in western Oregon, has conducted research on how .....

Sustainable Agriculture through Rhizosphere Ecology (additional examples????) .....

4.3.3. Education and training.
At the LTER Global Change workshop in Denver Colorado, November 1989, the group discussed the importance of training students in interdisciplinary ecological research and the importance of helping to establish these students in careers. The workshop report, ml990's Global Change Action Plan' has a section on Education, which is summarized here.

There are major short- and long-term educational needs associated with implementation of a long- term research program in global change, broadly defined. Available scientific personnel are not adequate in number and

orientation. Deficiencies exist in many essential disciplines including scientists oriented toward: biological systematics, especially in identificaiton and functional roles of invertebrate, fungal and microbial organisms; ecological modeling, especially at larger spatial and longer temporal scales; applications of remote sensing; and interfaces between disciplines, such as between meteorology and ecology.

Heroic and immediate efforts are required to insure that the necessary scientific personnel are trained and employed in Global Chage research. In some especially critical cases, such as systematics, traditional academic programs must be expanded into specific training programs to create and support the
Necessary cadre of scientists.

Training might include 3-year, post-graduate fellowships. Operational support following graduation would be provided to hosting institutions or agencies based on a 50-percent cost share, including both salary and other support costs. Initial efforst should include development of personnel with expertise in both the systematics and ecological funcitons of invertebrates and other poorly known groups of organisms. Greatly expanded education of graduate students in the philosophy and methodology of research requiring interdisciplinary teams is critical. Most ecological students are still being trained in traditional approaches involving individual investigators and small scales of experimentation with a single disciplinary perspective. One outstanding value of the existing network of long-term ecological research sites is the existence of inter-disciplinary teams that can provide models for other groups and training grounds for students.

There is also a critical shortage of leadership for program development and for higher-level synthesis. Relatively few scientists can develop and direct the large ecological resarch programs that are required. Similarly, few personnel are available with the ability to provide either qualitative or quantitative syntheses in these complex, cross-disciplinary programs. Major efforts are needed to encourage and train potential scientific leaders.
A final important insitutional need is for traditional academic institutions to recognize and reward inter-disciplinary research and educational activities. Faculty should be encouraged to participate in research projects involving inter-disciplinary teams, rather than discouraged, as is often the case.

Action items for this topic are being developed by the LTER Network.
4.3.4. Support for a national center for ecological research, data sharing, and modeling.
The LTER Network supports the leadership of the AERC, Association of Ecosystem Research Centers, which has developed a proposal for such a center (see Appendix).

4.4. International issues

4.4-1. Linkages to international ecological networks.

The LTER Network is interested in forming links to international networks, most of which are currently being developed. For example, the Man and the Biosphere program is interested in establishing an international network of Biosphere Reserve sites for research on global climate change. Another international network is the Northern Sciences Network, a group of 12 nations who conduct research in the arctic, circumpolar. Another international network is the savannah network with membership in Australia, New Zealand, and SE Asia. The TSBP group, Tropical Soff Biology Program, is a more established network conducting research, primarily in Africa. 'Be IGBP program is also interested in developing a network (see next section). As these international networks develop, LTER will maintain contact and develop liasons.

As a first step, LTER sponsored a workshop in Bertesgaden West Germany in 1988, with a second workshop in Albuquerque New Mexico on 1989. The proceedings will be published; Risser and Melillo are the authors. 'Me book is expected to be available early in 1991. These two workshops further developed linkages among ecosystem scientists. Action Items are being developed.

4.4.2. Participation in global research programs.

The LTER Network is working to participate in at least 2 Global Change Research Programs - a U.S. program and an international program.

In the U.S., the CEES has developed a basic research program, coordinated among many agencies. Aspects of several agency programs are closely allied to LTER objectives - particularly programs of NSF, USFS, DOE, NPS, USGS and EPA. Internationally, the IGBP program of RRC or Regional Research Centers is designed to form networks or transacts with a RRC as the coordination center. As the IGBP program develops, LTER will maintain close contact and collaboration.

5. Implementation of a Strategic Plan

5.1. Selection of goals for 5 years, 1991-1995

In a series of group discussions, the LTER/CC members selected both scientific, research goals and operational goals for themselves and the Network. This list, adopted at a November 1988 LTER/CC meeting at KBS, includes the goals listed in section 2.

In another major planning activity, research goals related to global change were outlined at a workshop on Global Change (Denver CO, November 1989, see Appendix). This activity fitted well with a major collective research interest of the Network identified in the strategic planningprocess. However, the workshop was unusual in responding to a request for assistance from a NationaIScience Academy Committee on Global Change and broke new ground in the extensive involvement of other major long-term research sites, perhaps the beginning of a 'greater' long-term research site network.

The results of this workshop were published as '1990'S Global Change Action Plan Utilwng a Network ofecological Research Sites' (LTER Network Office 1990; Appendix). Twelve action items involving major experiments, modeling and synthesis projects, measurement programs, and development of Technologies were identified. This plan has already been the basis of several initiatives by scientific groups and agencies.

5.2. Development of action plans for each goal
5.2.1. Tasks. Action Items were developed by working groups at the October 1989 LTER/CC meeting on Strategic Planning at Harvard Forest. These Action Items are listed here.

1. Initiate workshops which deal with the "5 Core Areas", perhaps beginning with Core Area #1, primary productivity

2. Find out what long term data sets exist at sites and determine their comparability.

3. Seek continued support of workshops designed to address multiple-site research questions.
4. Devote a section of LTERnewsletter to reporting above workshop results

5. Make a network database catalog and a network publication list a high priority.

6. Develop annotated list of ongoing long-term experiments

7 Develop and support shared technologies, such as centralized facilities, and portable measuring equipment

8. Establish intersite training paradigm--ongoing, e.g., modeling and trace gas measurements
9. Promote efforts by other groups to establish center for synthesis.
10. Establish a small number of FLAGSHIP experiments

II. Continue to act on the MSI or 'minimum standard installation' concept for development of technological items (computer communications, datamanagement, GIS, remote sensing, etc.)
12. Measure certain parameters across all sites (e.g. remotely-sensed images, GIS data, maps of sites with geopositioning modules, etc.).
13. LTER Network should develop a bulletin board or "clearing house" for exchange of information about hardware, software, methods, datamanagement, etc.
14. LTER should periodically review 'methods' and look for opportunities to standardize. One possible area for review might be the 'S core areas of research'.
15. Maximize incentives for scientists to work at or with LTER sites and scientists.

16. Develop regional affiliations of sites based on geographic or biotic similarities (e.g., an LTER site linked with a sub-network with nearby nonLTER sites and exchange scientists and data; conduct joint comparative research; regionalize general models; encourage standardization.
17. Form network to network affiliations, and lead by example.

18. Agressively pursue the recruitment of women and minorities into Ph.D.-level graduate programs in the LTER Network

19. Develop an NSF RTG (Research Training Grant) proposal to train ecologists (multi-disciplinary)

20. Increase the visibility of LTER and improve public understanding of the science conducted at LTER sites.

21. Create brochures, posters and other similar material aimed at public understanding of LTER's science, coordinated by the LTER Network Office.

22. Identify, coordinate and develop priorities for network-wide funding initiatives, with the LTER/EXEC acting as a clearing house.

23. Establish liasons with other agencies and organizations, coordinated by the LTF-R/EXEC and in concert with the ESA Public Affairs Office and with AERC.

24. Explore and exploit applications of ecological research to solving societal problems at the network level

25. Increase interaction with geophysical scientists.

5.3.2. Responsibilities

It is the responsibility of the LTF-R/EXEC to discuss the above Action Items, make suggestions to the LTF-R/CC about priorities and ways to develop these actions into reality. The LTER/EXEC is presently engaged in this task

5.5.3. Resources - financial, personnel, facilities.
After selection of Action Items and development of Action Plans, the resources will be considered.

5.3. Implementation of action plans
Implementation of the action plans will be directed by the LTER/CC and the LTER/EXEC, acting on directions from the LTER/CC. To date (September 1990), some of these suggested Action Items have been developed. These include:

Action Item 2. Find out what long term data sets exist at sites and determine their comparability.

The LTER Data Managers Committee has complied a 'Core Data Set Directoq" which lists the key long-term data sets being collected by all the sites. This report is available in draft and win be published in late fall 1990, as well as on-line through the electronic network.

Action Item 5. Make a network database catalog and a network publication list a high priority.
See Action Item 2 above for the database catalog. No progress yet on the publication list.

Action Item 7. Develop and support shared technologies, such as centralized facilities, and portable measuring equipment
The Network has purchased GPS Modules (Summer 1990) with Michener at NIN being the coordinator. A session at the All Scientists Meeting was devoted to training LTER persons in use of this GPS equipment, which will be shared across the network.

Action Item 10. Establish a small number of FLAGSHIP experiments
At the LTER Global Change workshop in Denver, November 1989, three FLAGSHIP experiments were proposed. The '1990's Global Change Action Plan' publication (spring 1990) outlines these three experiments. At the All Scientists Meeting, the soil warming flagship experiment was developed further, and Dr. Wm Schlesinger (JRN) is coordinating efforts.

Action Item 11. Continue to act on the MSI or 'minimum standard installation' concept for development of technological items (computer communications, datamanagement, GIS, remote sensing, etc.)
Tle Network was funded in September 1990 for acquisition of remote images (AVHRR, SPOT, HAP, etc.) for all sites. 'Me network office has acquired the necessary hardware and software to make these images accessable across the network. Dr. John Vande Castle, LTER Network Manager, is coordinating these efforts. The Remote Sensing group at the All Scientists meeting also developed research activities utilizing this technology.

Action Item 12. easure certain parameters across all sites (e.g. remotely-sensed images, GIS data, maps of sites with geopositioning modules, etc.).
See Action Item 11 above, describing remote image data. See Action Item 7, describing the GPS modules. GIS activities are being developed by the LTER GIS comniittee and by a GIS working group which met at the AU Scientists Meeting, September 1990. 'Me GIS committee has also assembled a survey of GIS capabilities across the Network.

Action Item 13. LTER Network should develop a bulletin board or "clearing house" for exchange of information about hardware, software, methods, datamanagement, etc.
The LTER Network Office received funds for equipment to implement a buuetion board in the fall 1990. Mr. Rudolf Nottrott, LTER Data Manager, is presently testing an on-line buwetin board.

Action Item 15. Maximize incentives for scientists to work at or with LTERsites and scientists.

The following are examples of LTER-initiated activities with scientists and groups outside the Network.

The LTERNetwork has invited scientists to participate in a number of workshops and meetings. For example, scientists from at least 4 sites are currently participating in the LTER 'Litter Bag Experiment", as a result of their attendance at an LTER-sponsored workshop on Decomposition, Woods Hole, May 1989.
An LTER Global Change workshop (Denver, November 1989) included scientists from 4 of the DOE ParkNet sites and from 4 other sites (NPS-Sequoia Kings Canyon; Smithsonian's Chesapeake Bay Ub; IES Cary Arboretum group; NOAA!s Great Lakes Research "b). These participants helped draft the 12 Action Items in the Global Change document.
Representatives of the LMER, Land-Margin Ecosystem Research, program attended the LTER/CC meeting, spring 1990, in Puerto Rico, as well as the AU Scientists Meeting. These interactions are helping build contact and joint projects between the 2 groups. The LTER/EXF-C met with representatives of a number of US agencies at their June 1990 meeting in Washington DC: USGS, USFS, EPA, DOE.

Action Item 17. Form network to network affiliations, and lead by example. See Action Item 15 above.

Action Item 21. Create brochures, posters and other similar material aimed at public understanding of LTER's science, coordinated by the LTER Network Office.
'Me LTER Network Office has facilitated the publication of a number of publications, including a BioScience series of 3 articles on LTER (Franidin et. al. 1990-, Magnuson 1990; Swanson and Sparks,

1990). The "1990's Global Change Action Plan" document has been extensively distributed to agencies, members of the US Congress, and international organizations; this booklet outlines LTER's suggestions for global change research. 'Me Network Office is presently working on a brochure to describe the LTER program, as well as an updated version of the LTER Guide Book ("the blue book).

Action Item 93. Establish liasons with other agencies and organizations, coordinated by the LTF-R/EXFC and in concert with the ESA Public Affairs Office and with AFRC.
The LTER/FXEC has begun to contact other agencies and to discuss linking of networks with them - e.g. the USFS, USGS, NPS, DOE's ParkNet, etc.

Action Item 25. Increase interaction with geophysical scientists.

At the AU Scientists Meeting, one of the working groups interacted with the USGS, who described their new 'WEBB' (Water, Energy and Biogeochemical Balances) program. The USGS may work at several LTER sites in the WEBB program.

5.4. Annual evaluation of progress on action plans
The LTER/EXEC will be responsible for delegating this task to several LTER scientists.

5.5. Final evaluation of action plans in 1995
Tle LTER/EXEC will be responsible for forming a group to evaluate the action plans in 1995.

5.6. Reconsideration of goals and planning for second 5 year period, 1996-2000.
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6. Literature Cited (to be compiled)
7. Appendix to be developed, including such items as:

1. MSI document

2. Gosz' Sci/Tech report

3. Shugart Sci/Tech report

4. List of LTER Committees
From time to time, special committees or worldng groups are initiated by the Chair or the LTER/EXEC. Committees are generally standing committees of indefinite duration. Working groups are designed for shorter periods of time, in response to a specified task.

LTER Executive Committee: (to be added)

LTER Data Managers Committee:
'Be Data Managers Committee was initiated in 198, chaired by Dr. Susan Stafford, Andrews

LTER. Tte purpose of this comniittee is to facilitate exchange of information about data management within the network. The group has one representative from each site. ne group generally meets annualy in August in conjunction with the Ecological Society of America meetings.

1988 August Sacramento CA (with ESA)
1989 August Toronto Ontario (with ESA)
1990 August Snowbird, Utah (with ESA)

Climate Committee:
The Climate Committee was initiated in 19 and the chair is Dr. David Greenland (NWT). Members include: Lloyd Swift (CWT), Bjorn Kjerf@e- (NIN), John Tester (CDR), Dale Robertson (NTL), Bill Parton (CPR), Gary Cunningham (JRN), Art McKee (AND), Jack Waide (CWT), Bill Michener (NIN), Dean Bark (KNZ), John Magnuson (NTL), Tim Y@ittel (CPR), Tony Federer (MBR), Bruce Hayden (VCR), John Gorentz (KBS), Leslie Viereck (BNZ), John Hobbie (ARC), and James Cruni (KBS).

Scientific and Technology Planning Working Group:
The Scientific & Technology Planning committee was formed in the Fall of 1988 and Dr. James Gosz (SEV) was the chair. The purpose of this committee was to prepare a document evaluating the use of new technologies for research in the LTER Network. A copy of this report is included in the Appendices. The members of the committee are: Gosz (SEV), Jerry Melillo (HFR), Tom Lillesand (NTL), Pat Zimmerman (NCAR, Boulder CO), Stuart Gage (KBS), Susan Stafford (AND), Ross Virginia (JRN).

Geographic Information Systems Working Group:
The GIS working group was appointed in the Fall of 1988 to discuss GIS issues in the LTER Network. The committee consists of. David Foster (B:FR), Chair; Indy Burke (CPR), George Lienkaemper (AND), Mark MacKenzie (NTL), Bob Robbins (NSF) . ..... and others.

S. List of LTER Intersite projects:
PRODUCTIVITY ALONG LIFE FORM GRADIENFS D. Tilman, U. Minn.

Objective: Determine relationships between climate, soils, productivity, and plant allocation alongeontinental (SW desert to NE forest) gradient. Synthesis + some data collection. Two papers inpreparation.

Cross-SITE COMPARISON OF SOIL SOLUTION CHEMISTRY. P. Sollins, Oregon State U.

Objective: Development and application of a steady-state model of pH and chemical composition ofrooting zone solutions. Comparative analysis. One paper published, one in revie W.

INTERSITE DECOMPOSITION STUDY M. E. Harmon, Oregon State U.

Objective: Determine degree to which climate and substrate control formation of 'stable' carbon.Standardized experiment; 10-year litterbag study of leaf and fine root decomposition.

MODELING FOREST-STREAM HiTERAC71ONS H. McKellar, U. South Carolina.

Objective: Develop and test simulation model for forest-stream interactions

emphasizing hydrologiccoupling with nutrient and carbon exchanges and compare across widely varying watershed types.Comparative analysis.STABLE ISOTOPE APPLICATIONS
B. Fry, Woods Hole.

Objective: Use stable isotopes to detect nitrogen fixation and determine the structure of aquatic food webs.Multi-site data collection with analysis as part of training workshop. Publication in review.

PATTERNS OF TREE MORTALITY M. E. Harmon, Oregon State U. Objective-

COMPARATIVE ANALYSIS OF TEMPORAL AND SPATIAL VARIATION J.J. Magnuson, U. Wisconsin. Objective:

CLIMATIC VARIABILITY AT THE LTERS= D. Greenland, Colorado State U. Objective:

6. List of LTER Network Office Supported Workshops

LTER/CC activities completed for the 1988-1990 Collaboration grant. Included are type/location, date, individual responsible,and cost (not including participant travel support provided for LTER site and Network Office representatives).
Year I (July 1 1988 - June 30 1989)

Activity & Location	Date	Responsible	Cost	Product
Workshops:				
Modeling in Ecosystem Research University of Virginia Central Plains LTERCharlottesville	3/89	William Lauenroth	5	5000
Wide-Area Networking $3400 University of Illinois	4/89	Dan Robbins/Vanbellegheni/ Caroline Bledsoe Urbana-Champaign		
Decomposition Processes The Ecosystem Center Biological Laboratory Woods Hole, Massachusetts	5/89	Jerry Melillo Harvard Forest LTER Marine Knute Nadelhoffer Arctic Tundra LTER	s	5000
Workshops:				
Stable Isotopes	9/89	Brian Fry	$33000	

(workshop & sample analyses) Arctic Tundra LTER 'Me Ecosystem Center

Marine Biological Laboratory Woods Hole, Massachusetts

GIS Workshop & Training 9/89 Ingrid Burke $69000

Colorado State University Central Plains LTE R

Fort Collins

Global Change 11/89 Jerry Franklin $14000 Pubn

Englewood, Colorado H.J. Andrews LTER Network Office

Remote Sensing 11/89 John Aber S 2500

Institute for the Study Harvard Forest LTE R of Earth, Oceans, & Space

University of New Hampshire Durham

Tree Mortality 4/90 Mark Harmon $15700

Oregon State University H.J. Andrews LTER Corvallis, Oregon

Root Analysis/Techniques 4-5/90 Alvin Smucker S 7500

Michigan State University Kellogg LTER East Lansing

7. LTER Network Office Research Subcontracts, 1988-1990

Included are institution and title, individual responsible, and award amount.

Subcontracts:

Colorado State University Yr I Robert Woodmansee $33300
Fort Collins Central Plains LTER Predicting & Testing the Influence
of Global Change on North American Ecosystems at LTER Sites

Oregon State University Yr I Phil Sollins $10000
Intersite Comparison of Soil H.J. Andrews LTER

Solution Chemistry Yr 2 $15000

University of Minnesota Yr I David Tilman $20200

Productivity Along Lifeform Gradients Yr 2 Cedar Creek LTER $26000

University of South Carolina Yr 2 Henry McKellar $26960 Modeling Forest-Stream Interactions North Inlet LTER

Oregon State University Yr 2 Mark Harmon $30000 Intersite Litterbag Experiment H.J. Andrews LTER

University of New Mexico Yrs 2/3 James Brunt $ 6270 Pubn LTER Connectivity Assessment SeviUcta LTER

University of Virginia Yrs 2/3 Raymond Dueser $ 5320 Pubn

LTER Connectivity Assessment Virginia Coast Reserve LTER

University of South Carolina Yr 3 William Michener $11500 Pubn Core Datasets Catalog North Inlet LTER

Oregon State University Yr 3 Frederick Swanson $12000

Support of LTER Intersite Activities H.J. Andrews LTER

8. Connectivity Report (Brunt, Nottrott and Porter) 9. GIS Workshop report (Burke, October 1989)
10. AERC Report on a National Center for Synthesis in Ecology