Workshop Report

French (Zones Ateliers)

And United States (Long Term Ecological Research)

Network-To-Network Collaboration

In Long Term Integrated Environmental Research And Management

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Introduction

Different areas in integrated environmental research and management (IERM) have converged over the last twenty years along three broad lines of issues and themes, as reflected in the United States (U.S.) by changes in the scope and kinds of questions addressed by many sites in the U.S. Long Term Ecological Research (LTER) network (http://lternet.edu) and by the proposed National Ecological Observatory Network (NEON) initiative, and in France by the newly launched Zones Ateliers (ZA) network (http://www.cnrs.fr/cw/fr/prog/progsci/evs/02_zoom.htm).

- Many current questions and topics of interest require larger spatial and temporal scales of study than those previously investigated (example of broad research topic: estimating consequences of land management at regional scales, e.g., Quigley et al. 2001).

- Environmental science has increasingly required integrating basic information about the biological, physical, and socio-economic domains of ecosystems at all scales to advance knowledge (e.g., Holling 1978, Costanza et al. 1993, Pickett et al. 1997) and to be socially relevant (e.g., advent of the concepts of ecosystem health: Rapport et al. 1998a, 1998b; ecological services: Daily 1997, Daily et al. 1997; and ecosystem management: Bourgeron et al. 2001, Jensen et al. 2001).

- The environmental research and management community has increasingly realized that study areas representing different ecosystems (e.g., Baltimore Ecosystem Study urban LTER, Rhone ZA, Niwot Ridge alpine LTER) share theoretical and logistical frameworks (e.g., integrated modeling, information management). Therefore, a network such as the LTER network creates a critical mass to solve theoretical and logistical problems.

In this context, the international LTER network (ILTER; http://www.ilternet.edu) was created with the following goals:

- Promote and enhance the understanding of long-term ecological phenomena across national and regional boundaries;
- Promote comparative analysis and synthesis across sites;
- Facilitate interaction among participating scientists across disciplines and sites;
- Promote comparability of observations and experiments, promote integration of research and monitoring, and encourage data exchange;
- Enhance training and education in comparative long-term ecological research and its relevant technologies;
- Contribute to the scientific basis for ecosystem management;
- Facilitate international collaboration among comprehensive, site-based, long-term ecological research programs;
- Facilitate development of such programs where they currently do not exist.

A workshop funded by the French Centre National de la Recherche Scientifique (CNRS) and the U.S. National Science Foundation (NSF) was organized to explore the merits of the French-U.S. collaboration in long-term IERM (LTIERM) in the context of LTER and ZA networks, and to provide guidance on the substantive focus, institutional arrangements, and strategy for designing and implementing the proposed areas and mechanisms of collaboration. This workshop was one step in a series of meetings on collaboration in LTIERM held between CNRS and NSF.

The LTER program was established by NSF in 1980 to support research on long-term ecological phenomena in the U.S. (Callahan 1984). The LTER network has grown over the years from six to 24 sites. The ZA network (Leveque et al. 2000) was launched in 2000, with the first four ZAs formally funded in the first round of reviews. The LTER and ZA networks are manifestations of a growing need in LTIERM. It is no longer possible and tenable to study ecological, physical, and socio-economic systems in isolation from one another (Kinzig et al. 2000). The boundaries are breaking down, and this is becoming more evident with the recognition that almost all human activities have potential relevance to global environments. It has been recognized that LTIERM requires a conceptual approach that integrates the biological, biophysical, and socio-economic components of the study ecosystems (Kinzig et al. 2000, Bourgeron et al. 2001) at multiple spatial and temporal scales. Therefore, the integration of data, information, and knowledge is central to LTIERM.

The LTER and ZA networks are unique in LTIERM because they do not focus solely on the study of *a priori* defined research themes (e.g., global change, primary productivity, biological diversity), but on specific questions pertaining to understanding the functioning of the study ecosystems (Callahan 1984, Leveque et al. 2000). Another distinguishing feature of these two initiatives is their goal of developing networks of long-term research projects that, although studying varied aspects of widely different ecosystems, interact and collaborate on shared areas of interest, in contrast to portfolios of independent projects working on similar topics.

This report summarizes the findings and recommendations of the workshop participants. It is organized into eight sections: introduction; general and charge questions; workshop organization, participants, and products; network-to-network collaboration; answers to three charge questions; and summary of recommendations and areas of immediate collaboration.

General and charge questions

The main purpose of the workshop is to explicitly determine and evaluate the added value of a formal collaboration between the LTER and ZA networks, and by extension, of the membership of France in the ILTER network. Therefore, three general questions concerning the LTER-ZA collaboration were addressed (Table 1a). The workshop organizers acknowledged that answering these general questions would require more than one meeting. However, the workshop was designed to provide preliminary information on the general questions by addressing three specific charge questions (Table 1b). The specific questions were formulated to provide guidelines for effective, immediate LTER-ZA collaboration.

Workshop organization, participants, and products

Sixty-six participants (51 French, 13 U.S., and two other European; see Appendix 1) convened in Versailles from January 15-19, 2001 for the workshop. Attendees came from over a dozen disciplines (e.g., landscape ecology, biogeochemistry, social sciences, anthropology, hydrology, fish ecology, plant ecology, data management), and represented 21 French, 11 U.S., and two European institutions. Seven LTER sites were represented. Seven of the U.S. participants are actively involved in LTER network activities beyond the project-specific level, and five are involved in international efforts. French participants included scientists from the four ZAs funded at the time of the workshop. They also included many researchers working on projects that are already functioning as proto-ZAs, which have been or will be proposed for formal ZA funding in future review cycles.

Table 1. General and charge questions.

A.	**General Questions**
1.	What differences and similarities may exist in the development of national French (ZA) and U.S. (LTER) environmental research networks?
2.	How can the different national networks best be linked?
3.	What kind of process can best promote effective collaboration among sites of the different national networks?
B.	**Charge Questions**
1.	What are the challenges and potential contributions of the LTER-ZA collaboration to the integration of information and knowledge across disciplines, spatio-temporal scales, ecosystem types, and geographic locations?
2.	What principles of integration of information are best suited to an international environmental research network?
3.	What are some of the research and management themes common to the French and U.S. environmental research networks?

Five areas were recognized as requiring increased attention in LTIERM, especially in an international network-to-network collaborative effort:

- Integrated modeling.
- Instrumentation.
- Retrospective/prospective analysis.
- Integrated ecological assessments.
- Synchrony/asynchrony of processes.

Two criteria were employed in selecting these areas: (1) their relevance in LTIERM, and (2) their relevance to most study sites in an LTIERM network, regardless of the specific research topics and ecosystem of interest. The workshop participants were organized into five breakout groups, each addressing one of the areas listed above. Each breakout group was asked to address questions pertaining to an area. Some of the questions were similar among groups, while others were specific to the area of interest (Table 2, Appendix 2). Relationships among breakout groups and charge and general questions are shown in Figure 1.

The workshop schedule (Appendix 3) was designed to provide network, site, and organizational information on the LTER and ZA initiatives, scheduled opportunities for interactions among breakout groups, and time for synthesis of results and discussion by all workshop attendants.

The main products of the workshop include a synthesis report (this document) aimed at serving both as a proceedings and as a preliminary strategic plan for French-U.S. ILTER collaboration, and recommendations for immediate LTER-ZA collaboration based on shared questions and/or areas of study pertaining to the themes of the workshop. These two products are the basis for the formal membership of France in the ILTER. Additionally, technical summaries for each breakout group will be made available. Table 3 details the workshop products.

Table 2. Common purpose and sample topics/questions of the five breakout groups.

Common purposes of the five breakout groups:

- Explore the challenges brought by the study of systems in which biological, biophysical, and socio-economic patterns are linked.
- Define needs and priorities in the LTER-ZA collaboration context, and the benefits of that context.

Topics to be addressed by each breakout group:

- Conceptual relevance to the LTER-ZA collaboration.
- Feasibility and implementation.
- Benefits and challenges brought by the LTER-ZA collaboration.
- Most promising areas of research.
- Recommendations for immediate LTER-ZA collaboration.

Examples of topics and/or questions specific to each breakout group (BG):

BG1: Integrated modeling.
> **Topic:** Linkages of existing models versus developing new integrative models.
> **Question:** What are the benefits/problems involved and the implications of linking models with different spatial and temporal scales?

BG2: Instrumentation.
> **Question:** What principles should guide the evaluation of the relevancy of candidate data to the research/management questions of the project and to ecological, social, and political functions of interest?

BG3: Retrospective/prospective analysis.
> **Topic:** Retrospective/prospective analysis and theory.
> **Question:** What is the contribution of retrospective/prospective analysis (in the LTER-ZA collaboration context) to the development of theoretical frameworks concerning the dynamics of linked complex systems?

BG4: Integrated ecological assessments.
> **Question:** How can LTER-ZA science best be integrated within the scope and strategic elements of an integrated ecological assessment to develop and implement its technical phases?

BG5: Synchrony/asynchrony of processes.
> **Topic:** Variability in the timing and spatial extent of disturbances and changing process rates.
> **Question:** What are the sources of variability in the synchrony or asynchrony of occurrence and spatial distribution of disturbances and/or process rate changes that can and should be addressed in the LTER-ZA collaboration context?

Table 3. Workshop products.

- Synthesis report (to be made available on the Internet).
- Recommendations for immediate collaboration between the LTER and ZA networks.
- Decision regarding the membership of France in the ILTER network.
- Technical summaries for each of the breakout groups (to be made available on the Internet).
- Manuscript on a multi-network approach to integrated environmental research and management.

Network-to-Network Interactions

An important characteristic of the workshop was its focus on the added value of network-to-network linkages, rather than simply linkages among individual sites. Both the LTER and ZA initiatives are structured as research networks (Callahan 1984, Leveque et al. 2000). The network approach implies that projects within it are connected and that activities take place at different organizational levels. To define possible linkages between the LTER and ZA networks, similarities and differences between the two must be identified.

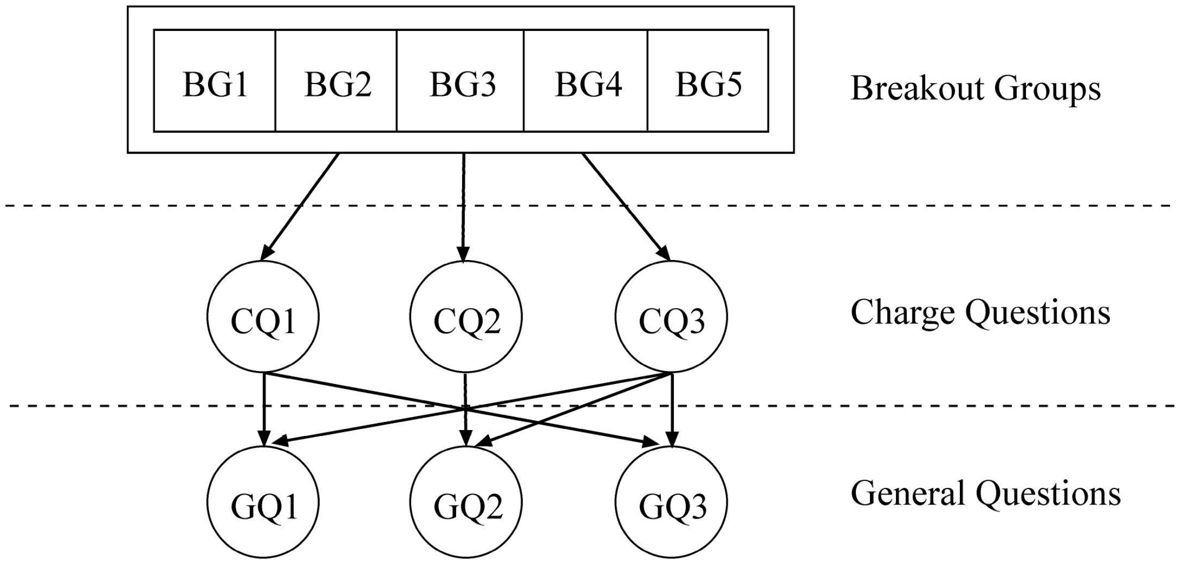

Figure 1. Relationships among breakout groups and charge and general questions.

The ZA network (Leveque et al. 2000) focuses on the study of anthroposystems (*sensu* Leveque et al. 2000). Anthroposystems are defined as ecological systems that have been subjected to the effects of human activities and therefore have biological, physical, and socio-economic components. This approach is very similar to the recent emphasis on interdisciplinary research and biocomplexity (e.g., Kinzig et al. 2000, Bourgeron et al. 2001) in the U.S. Figure 2 shows the evolution of LTIERM from the study of independent systems (e.g., ecological systems, land use systems) or aggregates of systems (Figure 2a), to the study of such systems, their interactions, and their drivers as components of integrated socio-ecological systems (Figure 2b).

Each ZA comprises a number of individual research sites ("sites ateliers", SAs) in a geographic unit (e.g., watershed, ecoregion). SAs are sites for intensive data collection that are intended to be representative of the different ecological-social systems found in the geographic unit of interest. Figure 3 (adapted from Leveque et al. 2000) shows the relationships among SAs, individual ZAs, the ZA national network, and potential international partners (e.g., the ILTER). Individual SAs are very similar to small LTER sites (that study a single ecosystem, e.g., Jornada, Niwot Ridge, Short Grass Steppe at the landscape scale) as originally funded. The conceptual spatio-temporal relationships between the LTER and ZA networks are shown in Figure 4. Over the years, some LTER sites have evolved from smaller to larger study scales and have changed their approach from the scheme shown in Figure 2a to that shown in Figure 2b (e.g., Coweeta)

Most recent LTER projects study the biological, physical, and socio-economic domains of socio-ecological systems (e.g., Baltimore, Phoenix) at the largest spatial scales in the LTER network. Initially, LTER sites were chosen based on their relevance to priority research themes and to represent the range of ecosystems found in the U.S. ZAs are selected mostly for their contribution to selected research themes and regional planning.

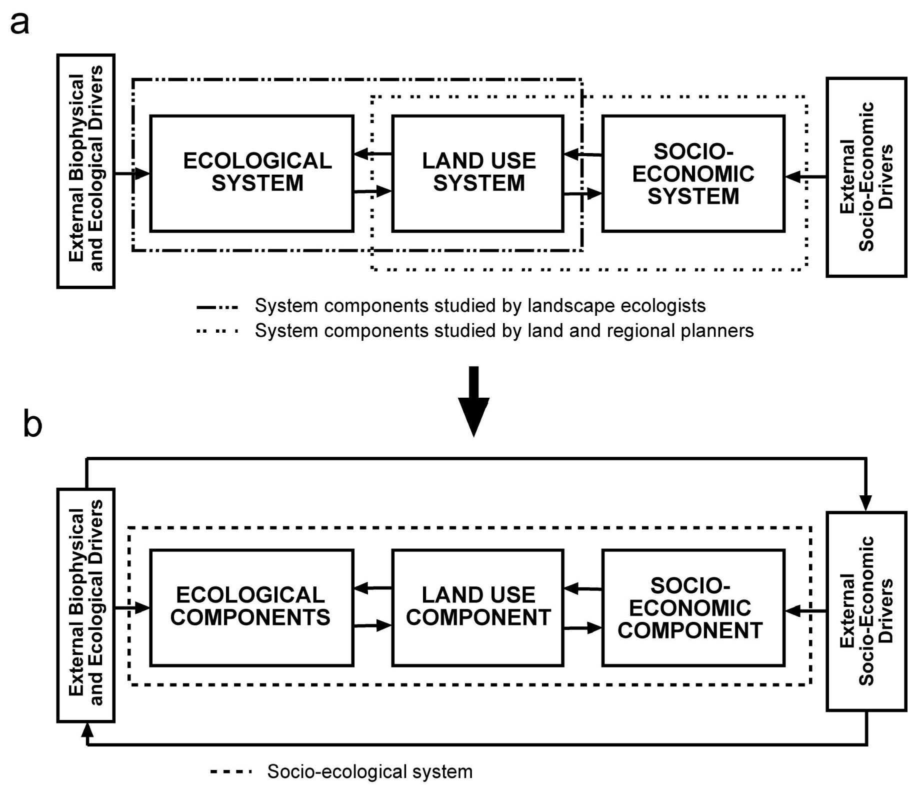

Figure 2. Simple model of relationships among ecological and socio-economic systems. a, Conceptual approach to the study of these systems as independent or as limited aggregations of systems. b, Conceptual approach to the study of these systems, their interactions, and drivers as a whole.

Network-to-network linkages take place at two of the three levels of activities conducted in LTIERM networks (Figure 5). Network-to-network collaboration can be performed by cross-site research (e.g., spatial and temporal variability, regionalization, biodiversity) and at the highest levels of network activities (e.g., technical committees, lessons learned). Results and recommendations from the workshop were formulated in light of the two possible scales of linkages. Challenges, contributions, principles of integration, and shared research and management themes were identified using the following criteria to assess network-to-network collaboration in each of the five areas of interest: why collaboration is done, how it is done, the role of theory and decision-makers in framing the problem/question/approach, and the challenges and benefits of the activity.

Charge Question 1

What are the challenges and potential contributions of the LTER-ZA collaboration to the integration of information and knowledge across disciplines, spatio-temporal scales, ecosystem types, and geographic locations?

This question addresses the potential added value of the LTER-ZA collaboration in identifying research and management challenges and in providing new knowledge. Table 4 summarizes the main challenges and contributions to integration of information and knowledge in the context of the LTER-ZA collaboration for each of the identified areas of priority.

Table 4. Challenges and contributions of LTER-ZA network-to network collaboration.

- Linkages of models of biological, physical, and socio-economic components of ecosystems.
- Broadening the scope of model comparisons.
- Design of nested sampling schemes to capture the range of spatial and temporal variability appropriate to a wide array of questions.
- Matching data among biological, physical, and socio-economic sciences.
- Construction of conceptual models for different biological, physical, and socio-economic ‘landscapes’.
- Assessing and remedying gaps in the training and preparation of scientists to analyze/model space-time interactions among processes pertaining to many disciplines at multiple scales.
- Testing the generality of concepts and theories in different cultures, organizations, and implications for LTIERM across global gradients of biological, physical, and socio-economic patterns and processes using uniform methods.
- Testing the general applicability of methodologies in LTIERM in different sites; development and diffusion of new technology and methodologies across sites; establishment of uniform, intercomparable information.
- Reconciliation of different approaches developed and based on personal preferences and site and cultural differences.
- Optimization of data collection.
- Opportunity to analyze/model new combinations of similarities and dissimilarities (among different components) across a large array of biological, physical, and socio-economic patterns and processes.
- Testing hypotheses across a wide array of biological, physical, and socio-economic patterns and processes.
- Analysis of observations across a wide array of biological, physical, and socio-economic patterns and processes at broad spatio-temporal scales, which make experimentation neither practical nor feasible.
- Developing a broader understanding of “histories” and “futures”.
- Linkage of retrospective studies, characterized by causality, certainties, and closed classification, and prospective studies, characterized by probability, risk, and open classifications.
- Enhancing ability and expertise to make the transition from retrospective studies to prospective analyses for complex coupled ecological, physical, and socio-economic systems.
- Assessment of the role of different political structures, cultures, and geographic regions in determining key components and scales of coupled ecological, physical, and socio-economic systems.
- Development of methodologies and techniques for scenario planning as a *bona fide* research topic.
- Development of approaches to regionalization. Current ability to extrapolate results to larger spatial and longer temporal scales is limited and is of crucial importance for networks like the LTER, where the site design tends towards intensive studies at small spatial scales, rather than extensive studies covering a greater spatial extent.
- Framing relevant, more integrative questions applicable to a wide array of coupled ecological/socio-economic systems to reveal critical gaps in knowledge.
- Fostering adequate communication across disciplines in different cultures and socio-economic conditions.

Some general challenges and contributions emerged from all breakout groups and from general discussions. The general consensus of the participants was that conducting LTIERM within an international context presents both a challenge and great potential for advancing knowledge and implementation. The study of socio-ecological systems has two characteristics:

- Social science research needs long-term involvement to build trust and involve local people.
- Interactions among the general public, scientists, and the environment require a long-term, consistent field presence.

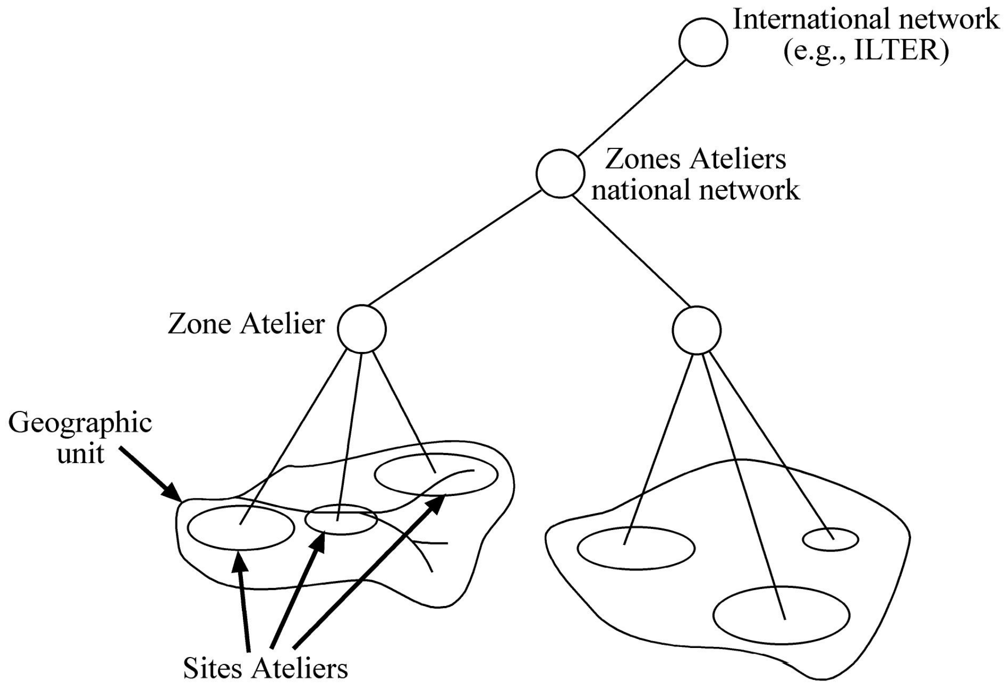

Figure 3. Nested structure of the ZA network.

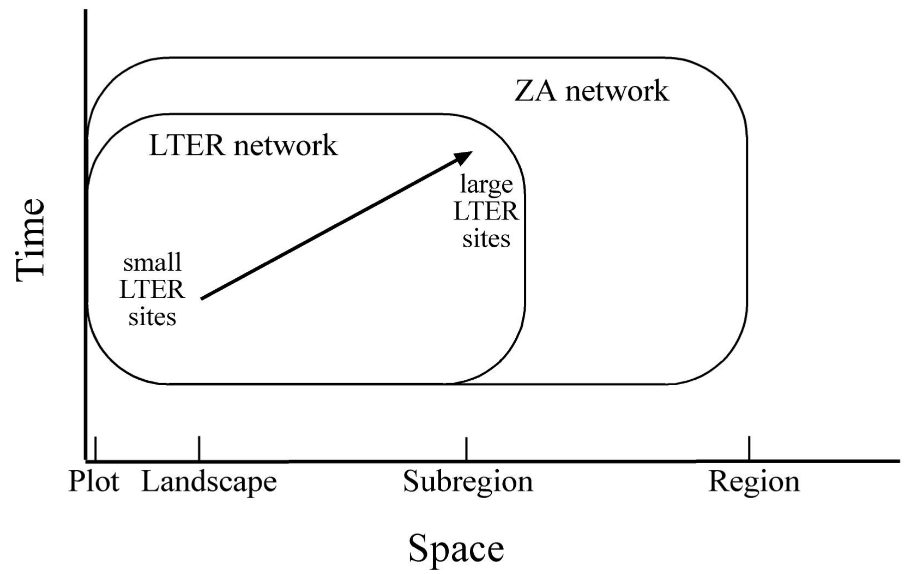

Figure 4. Conceptual spatio-temporal relationships between the LTER and ZA networks.

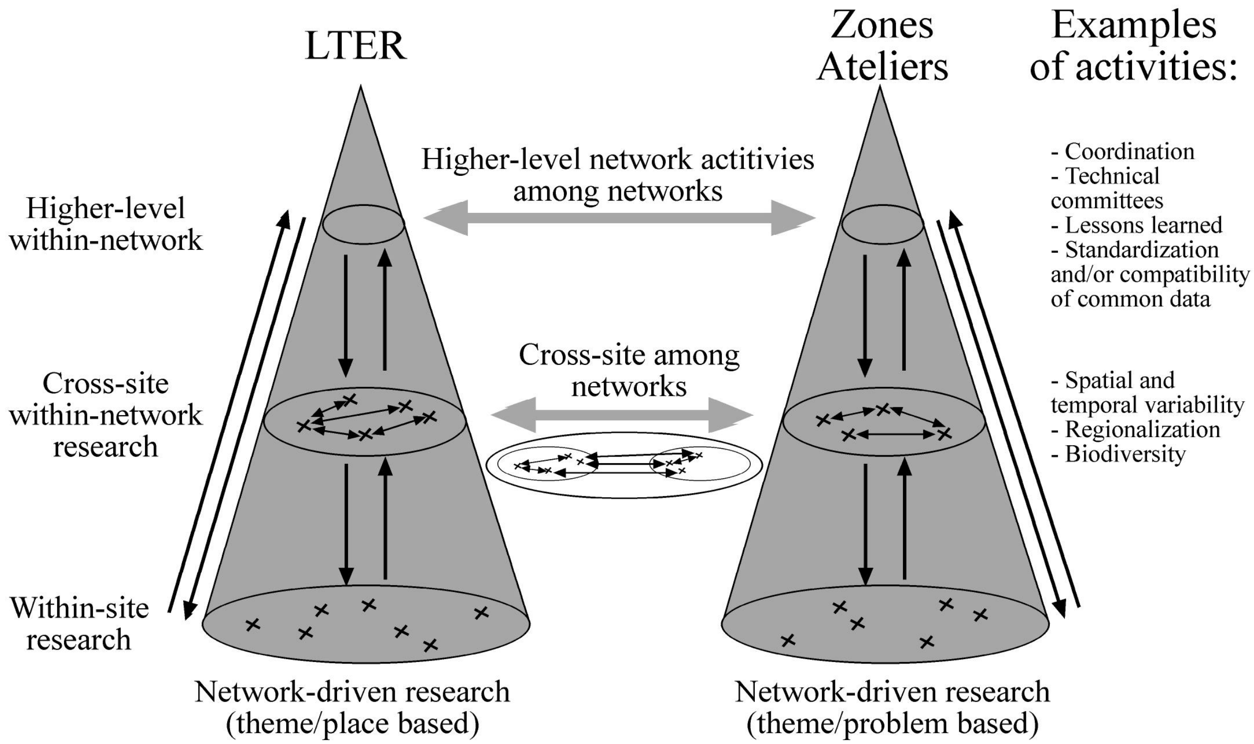

Figure 5. IERM network-to network linkages.

These two characteristics will require innovative ways of conducting LTIERM and will force the linkage of scientific activities with the decision-making process (Kinzig et al. 2000, Bourgeron et al. 2001, Haeuber 2001). One of the challenges posed by these characteristics is the need for relevant and effective interdisciplinary research, with funding mechanisms that promote well-conceived, multi-year, transdisciplinary efforts. While the LTER and ZA initiatives are laudable efforts in this direction, there is a pressing need for formalizing multi-year, stable funding sources for research in LTIERM (Kinzig et al. 2000). A major contribution of LTER-ZA collaboration is the opportunity to study culture as a factor in the functioning of socio-ecological systems. Geography has routinely been studied as a factor in the analysis and modeling of the distribution and functioning of ecosystems and their components (e.g., the use of geographic replicates in sampling, environmental stratification schemes). However, culture and its associated social, economic and political components has not been used similarly as a factor in LTIERM.

Based on the discussion of challenges and contributions, four specific added values of LTER-ZA network-to-network collaboration in LTIERM were identified and are summarized in Table 5.

Charge Question 2

What principles of integration of information are best suited to an international environmental research network?

Table 5. Selected added values of international network-to-network collaboration.

- Brings together scientists from many cultural and socio-economic backgrounds to work jointly on such aspects as the development of methodologies and definition/change of research agendas.
- Reflects national and regional differences while fostering international collaboration on common issues and research agendas.
- Serves a capacity-building role.
- Provides scientists and students with the opportunity to conduct across-site research within the international network.

Participants recognized that the needed foundations for integrated research have developed sufficiently to allow rigorous and informative interdisciplinary advances (Kinzig et al. 2000). After careful review of the article describing the evolution of the LTER Network Information System (Baker et al. 2000), a consensus emerged that data management is the device which allows translation in a common language, conversion in a common format, and accessibility and integration of information and knowledge (Stafford et al. 1994, Stonebraker 1994, Bowker et al. 1997, Kies et al. 1998). Development of integration principles in an international LTIERM network is an iterative process, which is conducted at the highest levels of network collaboration (Figure 5). The general principles summarized in Table 6 are *de facto* recommendations for LTER-ZA collaborative projects.

Table 6. Principles of integration.

- Network data management facilitates integrated science locally and across sites within and among networks.
- Communication among scientists, policy-makers, and the general public from different cultures and socio-economic conditions is essential to establishing and maintaining effective partnerships.
- Network development of integration principles should be an adaptive process.
- Standing committees should be established for priority issues.

Charge Question 3

What are some of the research and management themes common to the LTER-ZA networks?

A striking outcome of the work of the five breakout groups was the recognition that all research and management themes reviewed during the workshop (Appendix 2) are shared by the LTER and ZA networks. Participants realized the vibrancy of activities in the two networks. While some narrowly defined questions may be site-or network-specific, workshop participants emphasized the extent to which a LTER-ZA collaboration would provide coverage of a wider range of conditions in a gradient of biological, physical, and socio-economic patterns and processes, thereby allowing development, testing, and implementation of more robust theories, techniques, and methodologies. A few general common research themes emerged among the breakout groups and are summarized in Table 7.

Summary of recommendations and areas of immediate collaboration

Each breakout group made a set of specific recommendations for research in the context of the LTER-ZA collaboration. These recommendations comprise short-, mid-, and long-term projects.

They were discussed on the basis of the general challenges and contributions summarized in Table 4 and the general common research themes summarized in Table 7. The participants emphasized that the current interactive, mostly bottom-up LTER approach should be retained.

Table 7. Research themes common to breakout groups.

• Land-cover classification systems including vegetation characterization, currently developed at global scales, need to be developed at regional and subregional scales especially in areas that experience urban sprawl. The lack of these finer-scale systems may mask biological, physical, and socio-economic differences.
• Measurement and integration of biological, physical, and socio-economic attributes and processes.
• Methods of measurement and integration of material transformation and transport across distinct biomes, land-cover types, and climate zones. There is a specific interest in mixed land cover and urban-rural gradients, including instrumentation and sampling strategies, in joint scientific projects and applications.
• Assessment of environmental stratification schemes (also called ecoregionalization) as the basis for sampling, analysis, and modeling of complex, coupled ecological/socio-economic systems. Assessment is needed of the impact of these schemes on ecosystem characterization, data analysis and interpretation, model development and outputs, and extrapolation of results across spatial scales.
• Evaluation of spatial and temporal variability, and statistical assessment of likely variability in unexamined portions of the study landscapes/timelines.
• Calibration of integrated mechanistic models for existing data sets and systems, and evaluation of model performance at different spatial or temporal locations.
• Application of integrated models to the extrapolation of existing dynamics across space and time.
• Application of statistical models to existing sites and timescales of observation, and evaluation of their efficacy when extended to other sites and other time periods (extrapolation).
• Assessment and development of compatible LTER-ZA information management systems.

A consensus emerged that the immediate collaborative projects should meet the following criteria for selection:

- Be modest in scope but deliver significant results/products.
- Be completed within 12 months of the end of the workshop.
- Require little additional resources.
- Have minimal impact on the researchers involved.
- Lead to further, long-term, sustained collaboration in the area of interest that can be funded by existing CNRS and NSF programs.
- Fall under the heading of one or more identified challenge/contribution and common research theme.
- Collectively cover a variety of activities (i.e., cross-site research, workshops, and integrated information management).
- Contribute to building cross-cultural peer-group solidarity.

These criteria were chosen to collectively provide a sound basis for significant and sustained LTER-ZA collaboration without disrupting on-going activities and current funding sources.

Five initial projects meeting these criteria were proposed that included formulation of common specific questions, data analysis, data integration, prototyping of tools common to the two research networks, and data/question-driven workshops. They cover a broad spectrum of activities from cross-site to the highest levels of the networks (Figure 5). They are summarized in Table 8. Results from all the proposed projects would be applicable to a wide array of LTER sites and ZAs, either directly or as prototypes. It was agreed that the appropriate researchers would send formal letters of intent for each of these projects to CNRS and NSF for review. These initial projects will serve as the basis for CNRS-ZA membership in the ILTER network.

Table 8. Summary description of proposed initial LTER-ZA collaborative projects.

Topic	LTER and ZA Involved	Activities*	Main Challenges/ Contributions	Main Common Research Themes
Urban ecosystem impact on large river systems	Baltimore Ecosystem Piren-Seine Lyon	1, 3, 4	- Matching biological, physical, and socio-economic data - Reconciliation of approaches - Framing new questions	- Measurement and integration of social science and biophysical patterns and processes - Methods of measurement and integration of material transformation and transport
Test of environmental stratification scheme	Niwot Ridge Lyon	2, 3, 4	- Matching biological, physical, and socio-economic data - Regionalization - Reconciliation of approaches	- Assessment of environmental stratification scheme
Comparison of biogeochemical models from site to regional levels	Shortgrass Steppe Fontainebleau	2, 4, 5	- Model comparisons - Regionalization - Development of approach to regionalization	- Application of models to extrapolation
Assessment of research strategies	Palmer Antarctique	1	- Reconciliation of approaches - Fostering adequate communication	- Methods of measurement and integration of material transformation and transport
Assessment of a common information network strategy	LTER and ZA network information management teams	1, 4	- Matching data	- Measurement and integration of data - Compatible LTER-ZA information management systems

* 1, framing questions; 2, data analysis; 3, integration; 4, prototyping; 5, workshops.

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Appendix 1

Workshop Participants
15–19 January, 2001

France:

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Europe:

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Struwe, Sten, University of Copenhagen, Denmark

Appendix 2

Purposes, steps, and questions addressed by breakout groups (BG).

BG 1. Integrated modeling.

Purposes: Although it is recognized that modeling is multi-faceted and research efforts will be developed in multiple areas, modeling environmental systems at multiple temporal and spatial scales has brought new challenges. The purposes of this group are:

- To explore the challenges brought by modeling systems in which ecological, biophysical, and socio-economic patterns are linked.
- To define the research modeling needs and priorities in the LTER/NEON/ZA context, and the benefits of that context for modeling linked systems.

S1. Conceptual relevance of the modeling exercise to an LTER/NEON/ZA project.

General Question: How much time should be dedicated to assessing the relevancy of candidate models to the research/management questions of the project and to ecological, biophysical, and socio-economic functions of interest?

S1.1. Relevance to the problems/questions of the project (i.e., its mission, goals, and objectives).

S1.2. Relevance to ecological, social, economic, and political functions of interest.

- Are the models conceptually linked to the ecological, biophysical, and socio-economic functions of interest?
- Are the links direct or indirect?
- If the links are indirect or complex, to what extent should they be tested/validated and/or clarified?

S2. Linkages of existing models vs. developing new integrative models.

- What are the benefits/problems involved, and the implications of linking models with different spatial and temporal scales?
- What are the benefits/problems involved, and the implications of linking models with different "views" of the world?
- To what extent are the two approaches complementary?
- What are the most promising new research avenues?

S3. Feasibility of construction, validation, sensitivity analysis, etc.

General Questions: To what extent should integrated modeling for LTER/NEON/ZA projects be the object of formal feasibility assessments?
Should there be network-wide standards for this assessment?

S3.1. Data collection methods (see also W2, Instrumentation).

- What are the data requirements for integrated modeling in the LTER/NEON/ZA context?
- Do these requirements vary when multiple approaches to modeling are taken?

S3.2. Logistics.

- How practical is the modeling exercise?
- Is a logistics plan needed to identify requirements?
- Should the length of time required by the modeling exercise be estimated and compared among multiple approaches?

S3.3. Information management.

S3.4. Validation process.

S3.4. Monetary cost.

S4. Components of variability in the model(s).

General Questions What are the specific needs common to all projects within LTER/NEON/ZA for assessing the role of data/model errors vs. natural variability (temporal and spatial)?
When is it appropriate to emphasize the different components of model variability?

S4.1. Estimation of measurement errors (W2).

S4.2. Temporal variability at multiple scales (W2-W4-W5).

S4.3. Spatial variability at multiple scales (W2-W4-W5).

S5. What are the problems involved in applying the model at different spatial scales, including the regionalization of the models?

S6. Implementation and utility of the models.

- S6.1 What is the best use of the models in an LTER/NEON/ZA context?
- S6.2. How will model(s) results be linked to research, management, and social questions?

S7. Conclusions.

What are the particularities of integrated modeling in an LTER/NEON/ZA context?
What are the benefits and challenges/problems of an LTER/NEON/ZA approach and network for integrated modeling?
What drives the modeling exercise in an LTER/NEON/ZA context?
In the LTER/NEON/ZA context, how is balance achieved between research vs. applications?
What are the most promising avenues for integrated modeling?
What are the recommendations for immediate collaboration between LTER sites and ZAs in the area of integrated modeling?

BG 2. Instrumentation.

Purposes: The amount and complexity of information gathered for multidisciplinary environmental projects are increasing with the scope of the projects, advances in technology, and the multiplicity of analyses and display media. The purposes of this group are:

- To explore the kinds of data and the challenges to their measurement, storage, and retrieval required by analysis of systems in which ecological, biophysical, and socio-economic patterns are linked.
- To define the research instrumentation needs and priorities in the LTER/NEON/ZA context, and the benefits of that context for advances in instrumentation.

S1. Types of data required and their conceptual relevance to an LTER/NEON/ZA project.

General Question: What principles should guide the evaluation of the relevancy of candidate data to the research/management questions of the project and to ecological, social, and political functions of interest?

S1.1 Relevance to the problems/questions of the project (i.e., its mission, goals, and objectives).

S1.2 Relevance to ecological, biophysical, and socio-economic functions of interest.

- Are the data conceptually linked to the ecological, biophysical, and socio-economic functions of interest?
- Are the links direct or indirect?
- If the links are indirect or complex, to what extent should they be tested/validated and/or clarified?
- When should ancillary data be considered?

S1.3 Conceptual and theoretical underpinnings of data collection.

S.2 Data collection methods, feasibility, and implementation.

General Question: Are data collection methods repeatable, feasible, appropriate, and efficient for use in an LTER/NEON/ZA context?

S2.1 Data collection methods.

- Are data collection methods hierarchical?
- Do they allow aggregation and disaggregation of the data?
- When are new methods necessary?
- What is the impact of using multiple data collection methods on data compatibility within and among projects?
- Should compatibility among existing and *de novo* data be a factor?

S2.2 Tools for data collection.

- *In situ*.
- Remote.
- Airborne measurements.

S2.3 Logistics.

- How practical is the data collection plan?
- Is a logistics plan needed to identify requirements?

S3. Sources of errors.

General Questions: What are the specific needs common to all projects in LTER/NEON/ZA for assessing data errors?
When is it appropriate to emphasize the different components of data error?

S3.1 Estimation of measurement errors (W2).

S3.2 Spatial error at multiple scales (W2-W4-W5).

S3.3 Uncertainty analysis vs. error.

S3.4 Data error vs. natural variability (spatial and temporal) in the data.

S4. Information management.

General Questions: What are the requirements for storing, managing, retrieving, and displaying data in an LTER/NEON/ZA context?
What are the challenges and technological/conceptual needs for information management and sharing of such data?
How could an information management system be designed to handle ever-evolving and new data?

S4.1 Data processing and transformation in hierarchical systems.

S4.2 Data storage and retrieval in hierarchical systems.
S4.3 Metadata.
S4.4 Compatibility of the system with the needs of the project.
S4.5 Compatibility among different platforms.

S5. Assessment of quality, cost, and relevancy.

General Question: Are there network-wide principles for establishing data quality objectives?

S5.1 Data quality objectives (quality assurance).
S5.2 Estimate of the monetary cost of steps 2-4.
S5.3 Linkages to research and management questions.

S6. Conclusions.

What are the particularities and associated challenges in an LTER/NEON/ZA context?
What are the benefits of the LTER/NEON/ZA approach to the different components of instrumentation?
What drives the different components of instrumentation in an LTER/NEON/ZA context?
What new measurement tools are required by an LTER/NEON/ZA approach, and what could this approach contribute to their development?
What existing or new tools are required for information management, visualization, and display?
How could the information management tools best contribute to the integration of ecological, biophysical, and socio-economic data?
What are the best possible/innovative ways to make this information available (e.g., an ‘information’ network)?

BG 3. Retrospective/prospective analysis.

Purpose: Scientists and managers alike have increasingly recognized the utility of environmental history for understanding and managing ecosystems. Historical environmental information (retrospective analysis) has become a template for generating hypotheses and interpretations, evaluating our current knowledge of ecosystem dynamics, and making predictions about potential ecosystem trajectories (prospective analysis). The purposes of this group are:

- To explore the challenges in developing the knowledge and applications of historical environmental information (1) to understanding current conditions, and (2) as a basis for identifying spatio-temporal trends and variability of systems in which ecological, biophysical, and socio-economic systems are linked.
- To define research needs in the area of retrospective/prospective analysis in the LTER/NEON/ZA context, and the benefits of this context to retrospective/prospective analysis.

S1. Conceptual relevance of retrospective/prospective analysis to an LTER/NEON/ZA project.

General Question: Are the key premises of historical environmental reconstruction as a basis for understanding current and future dynamics of linked systems (e.g., the flux of nature, Pickett and Ostfeld 1994) relevant to the LTER/NEON/ZA approach?

S1.1. Relevance of historical data on patterns and trends to the development of questions, hypotheses, and conceptual or simulation modeling in the LTER/NEON/ZA context.

S1.2. Relevance of retrospective/prospective analysis to systems in which ecological, biophysical, and socio-economic components are linked.

S2. Analysis plan.

General Questions: What kind of information is required concerning the conditions of interest and their variation over set periods of time and space?

What analyses are required for linking past conditions to current and future conditions?

S2.1. Is there sufficient understanding about past conditions and variability?

- What kind of information is needed and at what spatio-temporal scales?

S2.2. Linking retrospective analysis to prospective analysis.

- How can scaled historical environmental information best be used for projections in the future at spatio-temporal scales that may differ from these available from the retrospective analysis?

S2.3. Impact of the fragmentary nature of history.

- How can analytical problems due to incomplete data, uncertainty about causation, and the potential role of unmeasured variables be circumvented?

S3. Predictability (prospective) and historical context (retrospective).

General Question: How can the historical context best inform us about present and future conditions?

S3.1. Potential causes of change and historical pathways.

S3.2. Historical reconstruction of processes and structures, and integrated modeling.

S3.3. Scaling up the frame.

- How can retrospective/prospective analysis best be used and results applied from sites to landscapes to regions?

S4. Retrospective/prospective analysis and theory.

General Questions: What is the contribution of retrospective/prospective analysis (in the LTER/NEON/ZA context) to the development and testing of theoretical frameworks concerning the dynamics of linked complex systems?

What is the contribution of theory to retrospective/prospective analysis in the LTER/NEON/ZA context?

S5. Conclusions.

What is the relevance of retrospective/prospective analysis in the LTER/NEON/ZA context?

What is the unique contribution of the LTER/NEON/ZA context to retrospective/prospective analysis?

What drives the study of retrospective/prospective analysis in an LTER/NEON/ZA context?

What are the challenges and most promising avenues of research for retrospective/prospective analysis in the LTER/NEON/ZA context?

What are the recommendations for immediate collaboration between LTER sites and ZAs in the area of retrospective/prospective analysis?

BG 4. Integrated ecological assessment.

Purpose: An integrated ecological assessment (IEA) is the process by which the ecological, biophysical, and socio-economic components of ecosystems are characterized and integrated at all spatial and temporal scales that are relevant to the goals and objectives of an assessment. The purposes of this group are:

- To explore the challenges brought by multi-scale IEAs of linked ecological, biophysical, and socio-economic systems in the LTER/NEON/ZA context.
- To define the IEA research needs and priorities in the LTER/NEON/ZA context and the benefits of this context for advances in concepts, tools, and knowledge.

S1. Relevance of IEA analyses to an LTER/NEON/ZA project.

General Question: To what extent are the steps involved in the design and implementation of an IEA relevant to an environmental research network such as the LTER/NEON/ZA?

S1.1. Development of research, management, and social goals: the scope of the IEA.

- What is the contribution of an LTER /NEON/ZA project to the different steps and the scope of an IEA?
- How can the LTER/NEON/ZA scientific approach be integrated within the development phase of an IEA?
- What is the contribution of the development phase of an IEA to the formulation of scientific questions in an LTER/NEON/ZA context?
- How should the assessment area be geographically stratified and the objects of study grouped in light of the issues and derived scientific questions?

The general initial elements of an assessment include definition of issues, identification of stakeholders, identification of the objects of study, delineation of geographic and temporal boundaries, and organization of the IEA. This step evaluates the role of LTER/NEON/ZA science in these elements, as well as the role of issues and stakeholders in the formulation of scientific questions. It also evaluates the respective role of the LTER/NEON/ZA research approach vs. management vs. social criteria in the developmental stages of an IEA.

S1.2. Conceptual model linking ecological, biophysical, and socio-economic patterns and processes for the definition of the IEA analysis plan.

- How can a conceptual model best be developed to define the IEA strategic and tactical plans ?
- What is the contribution of the LTER/NEON/ZA scientific approach to the development of the conceptual model ?

S.2. Strategic plan.

- What are the scientific principles applicable to a specific IEA?
- What is the contribution of an LTER/NEON/ZA project to defining the implementation plan of an IEA ?
- How can the LTER/NEON/ZA scientific approach best be communicated to managers, decision makers, and the public at large ?

S3. Tactical plan. In this step, the LTER/NEON/ZA approach has the most prominent role.

General Question: How can LTER/NEON/ZA science best be integrated with the scope and strategic elements of an IEA to develop and implement its technical phases?

S3.1. Information collection and management.

- How can the spatial and temporal domains of data collected in intensively studied landscapes (e.g., an LTER site) be assessed for use over larger regions?

S3.2. Basic tools and technologies.

S3.3. Data analysis and interpretation.

- How can uncertainty best be addressed?
- How should modeling and analysis of linked ecological, biophysical, and socio-economic systems be conducted in the context of an IEA?
- How can results of assessments at different scales be reconciled?

S3.4. Implementation and presentation of results.

- How can results of analyses conducted at different spatial scales be integrated?
- How should uncertainty be presented and communicated?

S4. Conclusions.

What are the particularities and challenges of IEAs in an LTER/NEON/ZA context especially in the following areas: knowledge based, socio-political, and institutional?

What are the benefits of an LTER/NEON/ZA approach and network for IEAs in these three areas?
What is the role of the LTER/NEON/ZA approach in scenario planning, especially from the perspective of uncertainty analysis?
What is the contribution of the LTER/NEON/ZA approach to the analysis of uncertainty in an IEA?
What are the challenges to integration that are specific to IEAs and that can best be answered by an LTER/NEON/ZA approach?
What are the recommendations for immediate collaboration between LTER sites and ZAs in the area of IEAs?

BG 5. Synchrony/asynchrony of processes.

Purpose: The effect of the timing and spatial extent of disturbances and changes in process rates on the distribution of landscape patterns is an active field of research, in particular concerning the "legacy" left by disturbances and process rate changes. The purposes of this group are:

- To explore the challenges to understanding the role and impact of disturbances and/or abrupt changes in process rates on systems in which ecological, biophysical, and socio-economic patterns are linked.
- To define the research needs concerning the timing and spatial distribution of disturbances and/or abrupt changes in process rates in the LTER/NEON/ZA context, and the benefits of this context to the analysis of the topic (e.g., specific areas such as thresholds and non-linearity in linked systems).

S.1 Conceptual relevance of selected disturbances and processes to an LTER/NEON/ZA project.

General Question: To what extent will the study of the timing and spatial distribution of disturbances and process rate changes contribute to understanding the nature of uncertainty (past, present, and future), and the resilience of linked systems.

- Relevance to the problems and questions addressed by the LTER/NEON/ZA project.
- Relevance to ecological, biophysical, and socio-economic functions of interest.

S.2 Analysis Plan.

General Question: Is there sufficient understanding of the spatio-temporal distribution of the disturbances and processes of interest?

S2.1 Screening of relevant disturbances and processes.

S2.2 Describing and understanding the effects of relevant disturbances and processes at multiple scales, from sites to landscapes to regions.

S3. Variability in the timing and spatial extent of disturbances and changes in process rates.

General Questions: What are the sources of variability in the synchrony or asynchrony of the occurrence and spatial distribution of disturbances and/or process rate changes that can and should be addressed in the LTER/NEON/ZA context?
When it is appropriate to emphasize the different components of variability in the context of an LTER/NEON/ZA approach?

S3.1 Sources of variability.

- What are the sources of variability in occurrence and spatial distribution of disturbances and/or process rate changes?
- What are the nature and effects of interactions among timing, place, and landscape?

S3.2 Nature and effects of interactions among spatio-temporal dimensions of disturbances and process rate changes.

S3.3 Landscape heterogeneity.

- To what extent do landscapes reflect the legacy of past disturbances and/or abrupt changes in process rates (e.g., the concept of the invisible past)?

S.4 Cumulative effects and system dynamics.

General Question: To what extent does landscape heterogeneity set the stage for differential responses of landscape patches to disturbances and process rate changes, and lead to non-equilibrium and non-linearities in ecosystem dynamics?

S.5 Integration.

General Question: How can disturbances and process rate changes of ecological, biophysical, and socio-economic components of the system be linked?

S.6 Conclusions.

What is the relevance of the study of synchrony/asynchrony in the occurrence of disturbances and process rate changes at multiple spatio-temporal scales in the LTER/NEON/ZA context?
What is the unique contribution of the LTER/NEON/ZA approach to synchrony/asynchrony studies?
What drives the study of synchrony/asynchrony in an LTER/NEON/ZA context?
What are the challenges and most promising avenues of research for the study of synchrony/asynchrony in the LTER/NEON/ZA context?
What are the recommendations for immediate collaboration between LTER sites and ZAs in the area of synchrony/asynchrony research?

Appendix 3

Workshop Schedule
January 15-19, 2001
Palais des Congrès, Versailles

Monday, January 15th

14:00–14:30	Opening and overview of the meeting by P. Bourgeron, M. Grove, C. Lévêque, A. Pavé
14:30–14:45	Overview of the CNRS international programs by Daniel Cadet, CNRS/DRI
14:45–15:30	Presentation of the French research program “Zones Ateliers” by C. Lévêque and A. Pavé.
15:30–16:00	Overview of US programs (LTER/ILTER/NEON) by T. Seastedt
16:00–16:15	Coffee break
16:15–17:00	Evolution of ecological research programs in the US by J. Magnuson
17:00–17:30	Presentation about the UK Environmental Change Network and the project Nolimits by T. Parr (UK)
17:30–18:00	Breakout groups: organization and products, by P. Bourgeron, M. Grove, C. Lévêque, A. Pavé

Tuesday, January 16th

09:30–11:00	Breakout groups (see handouts): Integrated modeling Instrumentation Retrospective / prospective Ecological assessments Synchronicity/asynchronicity of processes
11:00–11:15	Coffee break
11:15–13:00	Breakout groups
13:00–14:30	Lunch
14:30–16:00	Breakout groups
16:00–16:15	Coffee break
16:15–18:00	Breakout groups

Wednesday, January 17th

09:15–12:00	Reports from each breakout group: general discussion of preliminary reports and of the workshop questions
12:00–13:00	Lunch
13:15–14:15	Travel to Fontainebleau
14:30–17:00	Visits of ecological sites by L. Abbadie et P. Leadley
17:00–18:15	Return to Versailles

Thursday, January 18th

09:00–10:30	Presentations from specific Zones Ateliers (Alsace, Antarctique, Baie du Mont-St Michel)
10:30–11:00	Coffee break

11:00–11:30	The LTER/ILTER network: the NSF viewpoint, by D. Schindel (Europe NSF officer)
11:30–13:00	Presentations from specific US- LTER projects (Baltimore, Coweeta, Niwot)
13:00–14:00	Lunch
14:00–16:00	Breakout groups
16:00–16:15	Coffee break
16:15–18:00	Breakout groups: completion of work, preparation of reports *Breakout leaders meet with the organizers: preliminary answers to the workshop charge questions*

Friday, January 19th

09:30–10:30	Final presentation and discussion of the breakout groups' work and of their reports
10:30–11:00	Draft answers to the workshop questions and discussion of additional questions to be adressed by P. Bourgeron, M. Grove, C. Lévêque, A. Pavé. Discussion on the LTER/Zones Ateliers collaboration
11:00–11:15	Coffee break
11:15–12:30	Formal discussion of priority projects and interactions among US and French research groups
12:30–13:00	Closure
13:00	Lunch and departure