Chapter 27

Integrating Social Sciences into Long-Term Ecological Research

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Abstract In Europe and North America, long-term ecological research (LTER) networks are changing their treatment of human activity from exogenous 'disturbances' to endogenous behaviour. The engagement of social scientists in LTER networks currently takes forms ranging from nonexistent, to research in parallel with ecological research but with minimal interaction, to truly collaborative long-term socio-ecological research (LTSER). Successful collaboration of social and ecological scientists can be facilitated by a 'jazz band' approach that allows shifting multidisciplinary leadership along with disciplinary research solos. Socio-ecological simulation modelling can serve as a common tool for analysing complex dynamics of the interacting systems. The design criteria for an LTSER network should include socio-economic as well as ecological factors in order to ensure that findings can be extrapolated in both dimensions, an approach currently being followed in Europe. However, due to evolving societal needs, socio-ecological research should also be occurring outside the network of LTSER sites. New governmental initiatives on both sides of the Atlantic have the potential to enable more and better socio-ecological research than in the past.

Keywords Socio-ecological research · Shifting multidisciplinary leadership and disciplinary research solos · 'Jazz band' approach

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27.1 Introduction

At local, regional and global levels, human activity affects numerous ecosystem functions that are crucial for human well-being (MASR, 2005). The emission of greenhouse gasses influences climatic conditions (Oberthür & Ott, 1999). The release of ozone depleting substances jeopardises essential protection mechanisms of the atmosphere (Benedick, 1991). Extraction, transport and transformation of natural resources change our landscape, influence biodiversity and redefine the state of ecosystems (Tilman, Polasky, & Lehman, 2005). The multiple feedbacks between society and nature are fast, drastic and large scale; they condense to three words: *Global ecosystem change*.

Global ecosystem change needs to be understood better if it is to be managed effectively. During recent decades, global ecosystem changes have been increasingly driven by human activity. Past human activity generated numerous benefits for economic and social development. Today, however, we humans increasingly fear such negative consequences as the exhaustion of resources and nature's diminishing capacity to absorb and to neutralise human pollution and waste. These troubling aspects of global ecosystem change put at risk both present well-being and opportunities for future generations. These troubling aspects also explain why global ecosystem change shows up in various forms on both national and international political agendas (e.g. COM, 2005; UNMP, 2005).

The long-term ecological research (LTER) networks were established to monitor, analyse and predict the local impacts of global ecological change. Up to now, the networks have focused on biological science. However, in order to better understand the dynamics

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of the interaction of social and natural systems, a knowledge base of social and behavioural science is needed that is both supplementary and complementary to standard ecological research.

The integration of social and behavioural research challenges existing ecological research networks, like LTER, by raising questions about how to integrate and compare research foci, how to monitor linked environmental and socio-economic processes and how to identify suitable research sites designed to integrate socio-economic dimensions into traditional ecological research. In this chapter, from a social science point of view, we focus on the process of transforming LTER to LTSER – long-term *socio-ecological* research – both the efforts that have been made and the challenges that remain to be faced. The chapter is organised as follows: Section 27.2 elaborates on how socio-economic research has related to ecological research up to now and what factors have shaped the status quo; Section 27.3 presents how socio-ecological research is evolving and the path ahead.

27.2 Linking *Ecological* Research with Human Behaviour

The publication in 1997 of Vitousek et al.'s *Science* article on 'human domination of the Earth's ecosystems' shifted the centre of debate about the human role from interloper to dominator of the planet's ecosystems. The role of humans as intentional and unintentional drivers of global ecosystem change has been explored much more thoroughly through the Millennium Ecosystem Assessment (Nelson et al., 2006; Kareiva, Watts, McDonald, and Boucher, 2007). Among direct drivers, the study identifies climate change, agricultural nutrient use, land conversion and the spreading of diseases and invasive species. But the MEA highlights the importance of indirect human drivers, notably demographic and economic growth as well as social, cultural and technological change.

The recognition of the overwhelming importance of the human footprint has led social scientists to begin exploring ways to manage that footprint intentionally. Agricultural ecosystems, which are already managed by humans, have been proposed as useful learning opportunities to see how human management is influenced by spatial heterogeneity and scale, dynamic uncertainties and incentives from markets and policy (Antle et al., 2001; Swinton, Lupi, Robertson, & Landis, 2006; Swinton, Lupi, Robertson, & Hamilton, 2007).

27.2.1 *Overview of Literature on Site-Based Socio-ecological Research*

In the LTER system, research into how ecological and social systems are linked has followed several different models. The earliest LTER research focused on pristine systems where the human footprint was apparently absent. But in the 1990s LTER research began to examine systems that were increasingly disturbed by humans. In order to understand human effects on water quality in the North Temperate Lakes and on land use in the southern Appalachian mountains of North America, two LTER sites added social science research activities in 1994 (Gragson & Grove, 2006). The social scientists at these sites undertook parallel social research to understand why and how human systems had evolved to affect water and land use as they had. The social scientists expanded the geographic scale of research from the ecological observation sites to the surrounding area where human activity could influence those or similar biomes (a lake watershed in one case, a mountainous region in the other). Without special funding, other LTER sites, such as the crop agroecology site at the Kellogg Biological Station, have subsequently followed this approach.

A second model for socio-ecological research was inaugurated with two new urban LTER sites in 1996. At these locations, social and ecological scientists collaborated in geographic sampling plans to understand social–ecological linkages explaining the evolution of vegetation in the slow-growing city of Baltimore, Maryland, and the rapidly expanding city of Phoenix, Arizona (Gragson & Grove, 2006). The collaborative research design was established at a spatial scale relevant to both human and ecological research from the outset. The social scientists involved were primarily sociologists and geographers, working closely with ecologists on jointly designed research.

A third model of socio-ecological research is emerging in response to competitive grant funding for interdisciplinary science. Such projects often have social scientists in the lead, with research scale and sampling designed around human drivers. Examples of this are the U.S. National Science Foundation's (NSF's) Dynamics of Coupled Natural and Human Systems and Human and Social Dynamics programmes of the early 2000s. These programmes have attracted a wide variety of social science disciplines. In early 2007, the former became the NSF's first permanent interdisciplinary research programme. The design of the research framework programmes (FPs) in Europe also shows a clear trend towards integration. From the fifth to the seventh FP the European Commission launched more and more topics calling for integrated research activities of the applicants (http://cordis.europa.eu/en/sitemap.htm#eu-research); a trend which is also observed in EU's member states. In 1999, for example, the German Federal Ministry of Education and Research (BMBF) established the Social–Ecological Research programme (SÖF) focusing on sustainability issues at the interface between nature and society (http://www.sozial-oekologische-forschung.org/en/724.php).

Much LTER social science research to date has explored relatively disciplinary questions, disciplinary at least from a social science perspective. At the North Temperate Lakes (NTL) site, sociologists Peter Nowak and William Freudenberg have led in applying models of socio-economic inequality to explaining disproportional incidence of lake water pollution affecting less prosperous populations (Nowak, Bowen, & Cabot, 2006). In parallel, resource economist Bill Provencher has explored how water clarity affects lake-front home values (Spalatro & Provencher, 2001). At the Coweeta LTER in the southern Appalachian Mountains, anthropologist Ted Gragson has explored the effects of historical land use legacies on current ecosystem functioning (Gragson & Bolstad, 2006), while forest economists David Wear and David Newman have modelled spatial land use change (Wear & Bolstad, 1998). At the KBS-LTER row crop agroecological site, agricultural economist Scott Swinton has modelled the economic role of natural enemies in regulating agricultural pests (Zhang & Swinton, 2009).

The urban socio-ecological research sites have established a more interdisciplinary modus operandi. Their work includes exploration of social class interactions with urban ecosystems and the use of geographical information (remote sensing of vegetative cover and government or marketing databases on socio-economic status) to uncover human influences on land cover (Grove et al., 2006; Grimm, Grove, Pickett, & Redman, 2000; Pickett et al., 2001). In looking at social structure effects on ecology, they have refined spatial resolution to the parcel level, allowing examination of how parcel history and property rights regimes affect local ecology.[1]

Focusing on Europe we find that ecosystem research is on the one hand rich and varied but on the other hand dispersed and disconnected (Parr, 2006). Required information and knowledge for the implementation of policy responses to global ecosystem change phenomena are therefore not easily provided. Against this background the emerging LTER system serves as an archetype for the development of pan-European research. The aim is to develop a common understanding of the main drivers and pressures for global ecosystem change, the development of common frameworks for monitoring activities as well as methods, tools and policies for improvement and cost-effective management of ecosystems.

The European LTER network started to grow only recently. In 2003 representatives of 23 countries started discussions on how to strengthen and better integrate LTER activities in Europe. At present, 15 European countries have formal LTER networks, four countries have substantially developed networks and a further four are in the early stages of network development (http://www.lter-europe.ceh.ac.uk/European_LTER.htm). In terms of socio-ecological research the most developed site in Europe is 'Eisenwurzen' in Austria. It is designed as a multifunctional research platform (Mirtl, 2004). The focus of research interest is the whole landscape as a scientific basis for sustainable regional development. The site includes diverse spectrum of land uses, including wilderness, pristine forest, national park, and lake, agricultural and urban uses. Elements of this approach take into account regional characteristics and user groups, general conditions posed by global and social changes and national economic areas (http://www.umweltbundesamt.at/en/umweltschutz/oekosystem/lter_allgemein/).

The most recently selected site is Leipzig-Halle. Like 'Eisenwurzen', the region covers a spectrum of cultural landscapes, including former mining areas, urban and agricultural land, and different administrative units with explicit gradients of precipitation,

[1] Grove, J. Morgan. Personal communication by email to Scott M. Swinton, October 6, 2007.

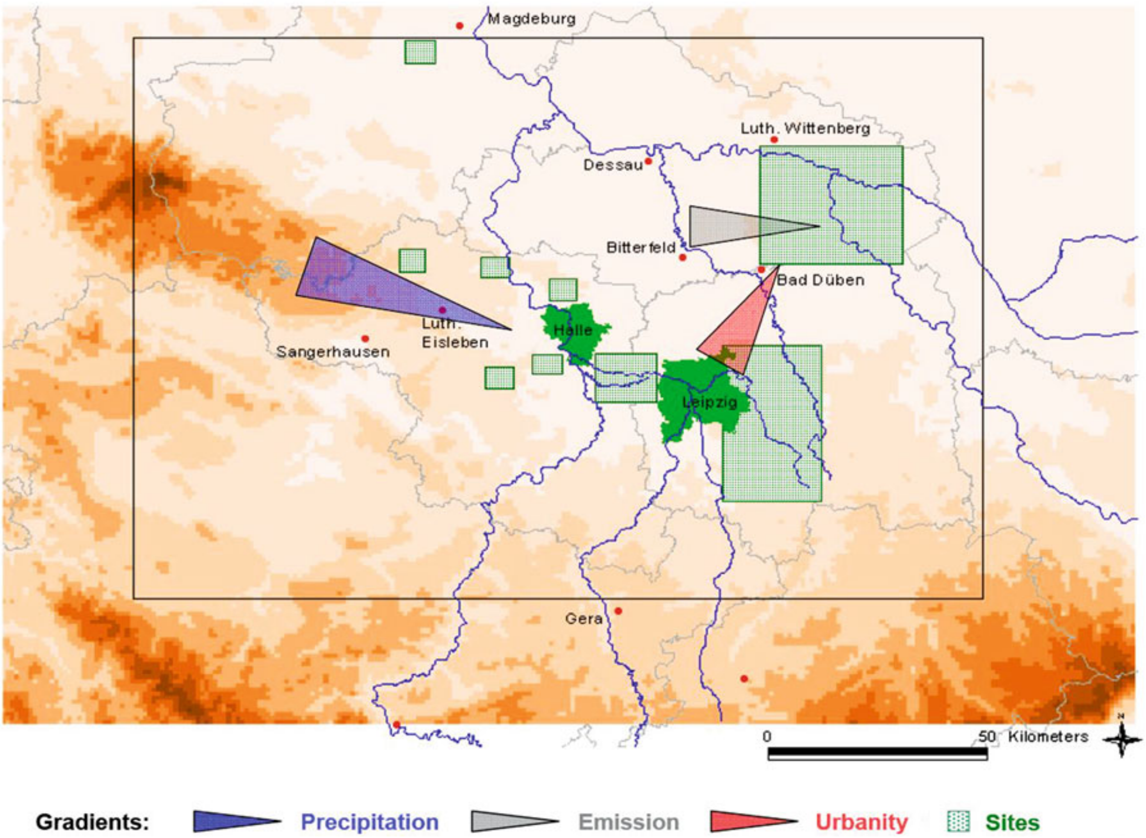

Fig. 27.1 LTSER site Leipzig-Halle, Germany (underway)

emissions and population density (see Fig. 27.1). The conceptual frame for the multidisciplinary approach, however, is still being developed. The idea is to concentrate research activities of natural and social scientists on a number of core themes, such as land use and institutional change. The research questions will be addressed via different so-called competence platforms, including monitoring and observation, experiments, modelling and concept formation, management support and policy design. A science–society interface will explicitly focus on collaboration of science and society to take up societal problems and needs, as well as the exchange of knowledge, ideas and experiences. It will organise networking on biodiversity issues and bring stakeholders and decision makers in contact with the scientists. See 'UFZ Biodiversity Research Strategy (2007)'.

In short, socio-ecological research in the European LTER network, like the network itself, is still emerging. National level efforts are being supplemented by funding from the European Commission for development of a pan-European LTER network. This period of rapid development of research infrastructure provides a rich opportunity to develop a balanced socio-ecological research approach.

Although the LTER system provides a valuable structure for understanding long-term ecological change, on neither side of the Atlantic has it yet met its potential for offering insights into how and why humans contribute to global ecosystem change. At present, there exist several sites where social science research is underway in parallel with ecological research, as well as a handful where truly collaborative socio-ecological research is happening. The system needs to adapt further if it is to make major strides towards understanding human behaviour with respect to ecosystems and inform insightful policy responses to undesired ecosystem changes. In short, the LTER framework needs to treat human behaviour and institutions as endogenous – rather than exogenous – elements of ecosystem change.

27.2.1.1 Impediments and Approaches to Integrative Socio-ecological Research

If more multidisciplinary integration remains to be done, it is because the task is not easy. Integrated models that treat both the human and the ecological dimension as interacting endogenous parameters are still the exception rather than the rule (e.g. Jentsch, Wittmer, Jax, Ring, & Henle, 2003; Perrings, 2002; Shogren, Parkhurst, & Settle, 2003). Two roadblocks for integrative research have been identified (Wätzold et al., 2006): On a practical level individual researchers fear a loss of in-depth, disciplinary knowledge in the course of integration (Roughgarden, 2001). Second, current institutional research structures and incentives that are organised around academic disciplines may be ill-equipped to address interdisciplinary research topics (Committee on Facilitating Interdisciplinary Research, 2004). One structural example of fiscally orphaned interdisciplinary research funding comes from the NSF Department of Environmental Biology, which overwhelmingly funds the U.S. LTER system but has no mandate to fund social science research. On a more abstract theoretical level, the methods and tools of single disciplines often ignore complexity relevant to other disciplines. Drechsler et al. (2007) surveyed 60 models related to biodiversity conservation that were randomly chosen from eight ecological and economic journals. They found that socio-economic models dealing with environmental behaviour of humans are usually formulated and solved in a static analytical setting that considers no uncertainty. On the other hand the ecological models are solved numerically or through simulations and deal with uncertainties and system dynamics explicitly.

Important mismatches exist between the scale of management and the scale(s) of the ecological processes being managed (Dirnböck et al., 2006 and the literature cited therein). Boundaries of the ecosystem may not coincide with political and administrative borders. And trade and communication are only two examples of societal activities that are widely independent of geographical scales (Haberl et al., 2006). Moreover the relevance of human interventions at particular scales (e.g. at upper policy levels) is sometimes disregarded by ecological scientists (Carpenter et al., 2006; Cumming, Cumming, & Redman, 2006). Ecological studies often focus on a well-defined study area and a time frame meeting the needs of the ecological problem only. Disregard for economic scale issues notoriously afflicted Costanza et al.'s (1997) estimates of the value of the world's ecosystem services (Bockstael, Freeman, Kopp, Portney, & Smith, 2000; Pearce, 1998). Reasonably, the report of the U.S. National Research Council on *Decision Making for the Environment* (2005) calls for fuller development of the social and behavioural science knowledge base for environmental decision making.

Integration is a means to improved knowledge generation and policy design; it is not an end in itself. Consequently the issue arises of precisely which disciplines are needed to conduct problem-oriented research, which methods and tools capture the most important aspects of the problem and which are most convenient to foster integrative research activities. Just as a botanist cannot ably handle all ecological science research topics, so a sociologist cannot ably handle all social science research topics. The selection of suitable disciplines and research methods needs to be driven by specific research problems and the resources available to address them. But there are at least two major approaches to aid in this process.

Computer simulation models can serve as useful integrating tools to analyse complex systems. They encourage an understanding of underlying mechanisms and the key factors and processes responsible for certain outcomes. Besides allowing prediction of future changes, simulation models can also be used for virtual experiments that would be impossible in nature but are relevant to support management decisions. Simulation experiments are especially suited to studying the effects of random processes over time to study uncertainty (King, Lybecker, Regmi, & Swinton, 1993). And in recent years, ecological-economic modelling has been developed to integrate ecological and economic knowledge and solve problems in nature conservation (Johst, Drechsler, & Wätzold, 2002; Drechsler et al., 2007; Tschirhart, 2004; Wätzold, Lienhoop, Drechsler, & Settele, 2008).

Multidisciplinary integration can also be achieved through careful team design. Based on the authors' experience, effective socio-ecological research teams can be developed according to what we term the 'jazz band' model. They are composed of members with strong disciplinary backgrounds who are individually capable of research leadership. Indeed, a key to success is recruitment of members possessing both strong disciplinary backgrounds and the interest and ability to listen and learn from scientists in other fields. Nourished by core funds, such teams can establish cross-disciplinary research priorities, whereby appropriate individual researchers take turns leading on priorities that fit their comparative advantage. Members take turns, alternately leading specific research efforts and supporting colleague research leaders by informing from a different disciplinary perspective. When successful, the jazz band approach resonates with both interdisciplinary harmonies and disciplinary solos. Jazz band research can operate at both the site level and across sites, but it is probably most practical at the site level.

An effective *modus operandi*, such as the jazz band model, is a necessary but not sufficient condition for effective, sustained multidisciplinary research. For enduring success, the integration of social sciences into multidisciplinary LTER research teams requires two added conditions: a way to attract top-level social scientists and the means to sustain their contributions. A system dominated by one community of scientists – ecologists, in this case – may have difficulty attracting top-level scientists from other communities. One successful model for attracting excellent social scientists to multidisciplinary teams with natural scientists has been competitive research funding where proposals are reviewed by leading scientists from all fields involved. The NSF Coupled Natural and Human Systems programme offers a successful model. A second sine qua non for sustained multidisciplinary integration is dedicated funding for that purpose. Disciplinary funding, such as that of the NSF Biological Sciences division that supports pilot social science activities in the U.S. LTER system, should not by itself be expected to sustain balanced long-term multidisciplinary efforts.

27.2.1.2 Conceptual Framework for Site-Based Research Treating Human Behaviour as Endogenous

Research on the human role in ecosystem change is making a much-needed transition to treating humans as endogenous to the system. Much early (and continuing) research in the LTER system has focused on how ecosystem structure and function responds to 'disturbances' caused by humans. Examples include changes in water-borne nutrient levels, wildlife habitat availability and ambient temperatures. However, in the years since Vitousek, Mooney, Lubchenco, and Melillo

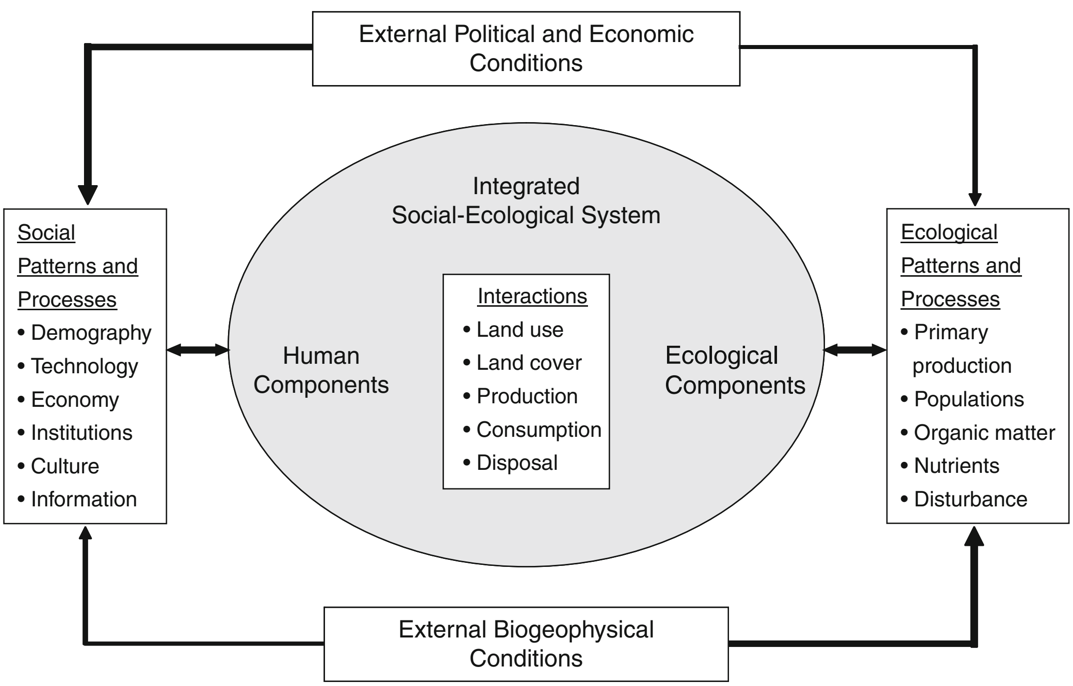

Fig. 27.2 Conceptual framework for socio-ecological systems from Redman et al. (2004). (Reprinted with kind permission from Springer Science+Business Media.)

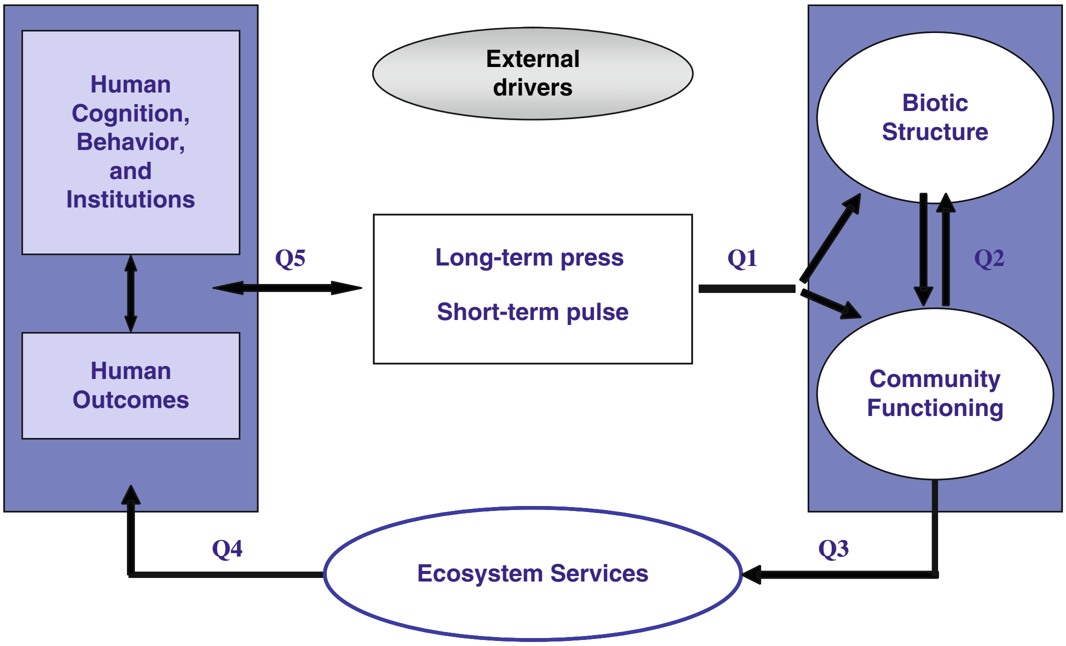

Fig. 27.3 Socio-ecological system diagram from *Integrated Science for Society and the Environment: A Strategic Research Initiative* (Collins et al., 2007)

(1997) call for studying the human role in ecosystem dynamics, alternative conceptual frameworks have begun to emerge that treat humans as endogenous. When presented in iconic form, these models typically illustrate the human environment on one side and ecosystems on the other side, and they focus on the nature of interaction.

Two conceptual frameworks for socio-ecological systems deserve mention, due to their influence on perceptions among LTER researchers in North America. Redman, Grove, and Kuby (2004) paint a picture with both exogenous political and economic conditions and exogenous biophysical conditions that affect both human and ecological systems (Fig. 27.2). Those forces act on patterns and processes that are on the one hand social and on the other hand ecological. The interaction of these sets of patterns and processes is the integrated social-ecological system, where interactions include land use, land cover, production and consumption and disposal activities. A very recent model, developed in a U.S. LTER network planning effort, presents a cyclical relationship that splits the interaction area into two parts, with one comprised of human actions towards ecosystems (long-term presses and sudden pulses) and the other comprised of services generated by ecosystem that are felt by humans (Fig. 27.3) (Collins et al., 2007). An ideal model would draw on both of these sources. The Redman et al. (2004) model explicitly recognises the important role of external forces, including biophysical ones like volcanoes and meteors, and socio-economic ones like human desires for wealth, fame and happiness. The Collins et al. (2007) model more explicitly details effects of one part of the system on another, rather than leaving that to a general interaction zone.

27.3 Progress Towards Long-Term Socio-ecological Research

27.3.1 Building ALTER Net, a European LTSER Research System to Link Ecological Research and Human Behaviour

'A Long-Term Biodiversity, Ecosystem and Awareness Research Network' (ALTER Net) is a 'Network of Excellence', organised as a partnership of 24 organisations from 17 European countries. It was created under the EU's sixth Framework Programme to develop integrated research capacity for long-term biodiversity and ecosystem research. Its goals are to integrate social and ecological research on the relationships between biodiversity, ecosystem services and societal responses at various levels and to design communication and outreach activities for transferring knowledge to and from scientists, policy makers and the public (Parr, 2006). An important means to reach these goals is the development of a network of research sites where problem-oriented research should be performed by natural and social scientists (Siepel & Furman, 2006).

ALTER Net has contributed to both the growth of nationally supported LTER Networks across Europe and the recent establishment of LTER Europe, which was officially founded in June 2007 (http://www.lter-europe.ceh.ac.uk/index.htm). One aim is to attract researchers from outside ALTER Net, mainly from the International LTER (ILTER) community. A second aim is the integration of the natural and social scientists at common spatial scales. This creates need for a new type of research sites – the LTSER sites.

In ecological research, the term 'site' is used to describe an area where natural processes are being studied in undisturbed or strictly controlled environments. In the past a host of ecological and taxonomical criteria have been applied to define and select the sites for ecological research. Recently a novel set of criteria was proposed to meet the needs of long-term *socio-ecological r*esearch (Ohl, Krauze, & Grünbühel, 2007). These criteria were proposed as guidelines for ecological research sites that intend to expand their research scope as well as for the purposeful design of new LTSER sites.

The proposed criteria are subdivided into five *site* and three *pool* criteria. Site-based research should allow for a better understanding of local sociological, political psychological and economic processes, which directly or indirectly reshape dynamics of ecosystems. Site criteria focus on (1) economic diversity, (2) conservation and environmentally relevant policy, (3) local conflict, (4) demography and (5) land use and cover.[2] Apart from selection of specific sites it is also crucial to focus on the characteristics of the whole pool of selected sites for purposes of cross-scale analysis, data aggregation and sharing. Proposed pool criteria focus on: (1) vulnerability of economic systems, (2) local trade relations and (3) differences in economic development. Both sets of criteria were derived on the basis of European Environment Agency's framework of 'driving forces – pressures – state – impact – response' (DPSIR) (EEA, 1999a, 1999b), which was adopted by ALTER Net for communicating knowledge on environmental questions such as those regarding biodiversity (Svarstad, Petersen, Rothman, Siepel, & Wätzoldt, 2008).

27.3.1.1 Site-Based Research

ALTER Net has developed the idea of long-term socio-ecological research (LTSER) sites to demonstrate their potential for interdisciplinary and policy-relevant research. In the past the LTER network used to limit the spatial extent of research sites to study ecological processes separately from human stimuli. In order to better understand human behaviour, ALTER Net (WP R1) has supplemented ecological criteria for research site selection by five explicitly human criteria:

- Criterion 1, *economic diversity*, is derived from the importance to ecosystem change of how people generate and spend their income. For example in the primary sector income is generated by fishing, forestry, hunting and agriculture, activities that impact ecosystems directly (e.g. by altering the stock of fish). Likewise, food and energy consumption have major effects on the use of renewable and non-renewable resources. Sites selected in accordance with the economic diversity criterion ensure that within the research sites a critical mass of people are found which derive income from different sectors of the economy.

[2] A criterion for the spatial extent of the sites to be selected - although important in ecological studies - was intentionally not included in the list. The size of the social system is determined by other criteria, such as income, markets and demography. Therefore the number and characteristics of ecological units (ecosystems, watersheds) should be adjusted to the meta-level aim of improving research collaboration between natural and social scientists to enhance our understanding of the interacting systems, society and nature.

- Criterion 2, *conservation and environmentally relevant policies*, influence human effects on ecosystems via laws and regulations (that restrict undesired behaviour) and taxes and subsidies (that stimulate desired behaviour). Long-term studies at the site level should provide insight into the success and failures of policy measures intentionally designed to manage the interaction of society and nature. They should also focus on the ecological implications of policy measures that have unintentional effects on the state of the ecosystem.
- Criterion 3, *conflicts and their resolution*, are at the root of various environmental change phenomena (e.g. climate change and biodiversity loss). A core focus of social science research at different LTSER sites should therefore be on local modes of conflict resolution and their abilities to resolve conflicts that affect ecosystems.
- Criterion 4, *demography*, focuses on more quantitative aspects of environmental change, specifically the demographic structure of the site population as well as human migration patterns. Demographic changes influence inter alia the type and intensity of urbanisation, the rates of resource extraction, consumption, waste production and pollution release.
- Criterion 5, *land use and cover*, reflects the interplay among the four aforementioned criteria. This criterion calls for including different land uses within each research site: natural/semi-natural, agricultural and urban or suburban land uses. This should allow for a differentiated assessment of the drivers of land use and cover change as well as of the impacts on the ecosystems and biodiversity in particular.

27.3.1.2 Pool-Based Research

A well-designed LTSER network should enable comparison of basic socio-ecological processes for identification of patterns of interaction as well as best practices adjusted for local context. Therefore the pool of selected sites should consist of a number of contrasting as well as similar sites. To find a set of such sites pool criterion (1), *vulnerability of economic systems*, explicitly calls for at least one site where the income of local people depends on a service provided by the ecosystem. Pool criterion (2), *local trade relations*, calls for areas with similar resource endowments but varying dependency on economic markets. And criterion (3) ensures that with regard to economic development, different sites are found along north–south and east–west gradients.

In a first step, the ALTER Net proposed ten sites to initiate long-term site and pool-based socio-ecological research. These are in Aberdeenshire in Scotland (UK), Nora in Sweden (S), Veluwe in the Netherlands (NL), Pilica catchments in Poland (PL), Pleine Fougères in France (F), Eisenwurzen in Austria (A), Balaton Lake and catchment in Hungary (H), Braila islands in Romania (ROM), Donana in Spain (ES) and Leipzig-Halle in Germany (D). The size of these sites, the number of administrative units and the main ecologically relevant types of land use and cover are shown in Table 27.1.

Table 27.1 Characteristics of LTSER sites in Europe

Name	Size (km^2)	Administrative unit(s)	Type
Nora (S)	1,200	2 communities (in 1 county)	Boreal forest
Aberdeenshire (UK)	6,317	1 county	Atlantic agricultural land
Veluwe (NL)	2,186	21 municipalities (in 1 province)	Atlantic lowland forest and agriculture
Pilica river catchment (PL)	3,921	23 districts (in 5 counties partial)	Continental agricultural land
Pleine Fougères (F)	90 (site)	Municipalities in 1 department	Atlantic agricultural land
Eisenwurzen (A)	5,522	25 municipalities (in 3 provinces)	Mountain forest and agriculture
Balaton (H)	6,367	4 counties (partial)	Continental lake and catchment
Braila (ROM)	2,439	3 counties (partial)	Inland delta of Donau
Doñana (ES)	1,100	1 municipality	Mediterranean delta
Leipzig-Halle (G)	25,000	3 federal states (partial)	Continental agricultural and urban land

Adapted from Siepel 2006.

Do these sites sufficiently consider the proposed socio-economic criteria and do those criteria capture the key individual and social behaviour needed to describe and explain the central interactions between society and nature? So far, this is an open question. Nonetheless, it is an important milestone to initiate site- and pool-based research that offers the possibility of analysing the co-evolution of society, biodiversity, ecosystems and management strategies in different regions at different spatial scales from an integrative, long-term point of view.

27.3.2 Socio-ecological Research Outside LTER Networks

While carefully designed, multidisciplinary LTSER site research holds great potential, there also exist important opportunities for socio-ecological research that do not readily coincide in scale with either LTSER sites or pooled sites. Important human activities coincide with institutions such as markets and governments. Geographic boundaries for these institutions pose both challenges and opportunities for socio-ecological research. Because these institutional boundaries often do not coincide with ecological boundaries, there may be inconsistencies. But there is also a wealth of natural experiments. For example, a national border like the one between Haiti and the Dominican Republic can offer an opportunity to understand how two governance regimes affect one eco-region. Larger human scales are also needed in order to understand human motives behind such major drivers of global ecosystem change as migration flows. Simply to observe that human populations are rising in migratory destination regions begs the question of why people are moving there.

Another reason for socio-ecological research outside of LTER networks is to compensate for the downside of long-term networks, which is their inflexibility. Once a long-term project is established, it can be difficult to adjust in response to changing environmental and policy needs. Inflexibility takes two forms: (1) the research site and (2) the researchers. Needs for both may change. Hence, research systems that incorporate the capability for flexible, competitive socio-ecological research will be better able to respond to inevitably changing needs – albeit without necessarily having all the strengths of long-term research.

27.3.3 The Path Ahead for Socio-ecological Research in Europe and North America

During the past decade, research into understanding human and social behaviour has made impressive advances in the context of existing LTER systems. Ecological researchers have shown not just openness but determination to incorporate the capability for high-quality social science research. That determination has given birth to the European ALTER Net and the growth of U.S. socio-ecological research at both the new urban LTER sites and at several existing LTER sites with human managed ecosystems. Despite these achievements, much social science research to date has been conducted in parallel with ecological research, but has fallen short of the multidisciplinary ideal of socio-ecological research.

Two new developments point towards a brightening future for genuine socio-ecological research. First, the European research network ALTER Net and the U.S. purpose-designed socio-ecological research sites are only beginning to reach the stage of development where their long-term nature is beginning to pay off. With attention to integrating teams successfully (whether by the simulation modelling or the jazz band research team approach or both), these new research institutions show great promise.

Second, in 2007, members of the U.S. LTER network developed a new plan for network-level research programme called 'Integrative Science for Society and Environment' (ISSE). The ISSE conceptual diagram (Fig. 27.3) explicitly calls for integration of ecological and social science. The planned programme would not only expand site-based and pool-based LTSER, it would also create a competitive research fund to support research on shifting topics by researchers who need not be members of the existing LTER network. Such competitive funding has the potential to attract new and excellent social science researchers into the existing LTER system. Of course, such integration will only be sustainable if funded as an explicitly multidisciplinary programme. A further approach is being explored in Europe. National governments provide basic support for the national networks (for example the German Research Foundation, DFG, supports parts of LTER Germany, the *DFG-Exploratorien*) and the research institutions take responsibility for running a L(S)TER site (as the Helmholtz Centre for

Environmental Research – UFZ does with Leipzig-Halle). But it is also expected that further research grants will be applied for on a competitive basis, e.g. under the EU's seventh Framework Programme. If the ISSE and EU initiatives can succeed in attracting fresh, able minds and addressing evolving socio-ecological research priorities, they will contribute further to strengthening the contribution of socio-ecological research to meeting the challenges of global ecosystem change.

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