Chapter 27
Expanding the Vision of the Experimental Forest and Range Network to Urban Areas

J. Morgan Grove

Abstract After 100 years, the USDA Forest Service has emerging opportunities to expand the Experimental Forest and Range (EFR) network to urban areas. The purpose of this expansion would be to broaden the types of ecosystems studied, interdisciplinary approaches used, and relevance to society of the EFR network through long-term and large-scale social–ecological projects in urban areas. The goals of these urban long-term research areas (ULTRAs) are to create scientifically rigorous knowledge of our urban regions and provide information needed to address current and future social–ecological problems.

The first of the four sections of this chapter explains the importance of understanding cities. Motivations for understanding cities are practical, scientific, and fundamental to the Forest Service's mission. The extension of the EFR network can play a critical role in understanding the social and ecological dynamics of cities and serve the majority of Americans directly, where they live. In the second section, I identify key traits of ULTRA projects: What features they share with existing EFR sites and how they differ? A key feature of the EFR network is its focus on applied research. An example from the Baltimore Field Station illustrates how ULTRAs can catalyze and inform partnerships between research and decision making. In the third section, I detail the current status of the ULTRA effort. I conclude with a look at how the ULTRA program can continue its contribution to science and society.

Keywords Interdisciplinary · LTER · Social–ecological · Sustainability · ULTRA

27.1 Introduction

One hundred years since the establishment of the US Department of Agriculture, Forest Service, opportunities are emerging for the agency to extend the Experimental Forest and Range (EFR) network to urban areas. The expansion would be designed to broaden the types of ecosystems studied, increase the variety of

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interdisciplinary approaches used, and enhance the EFR network's relevance to society by incorporating long-term and large-scale social–ecological projects into urban areas. These urban long-term research areas (ULTRAs) are intended to generate scientifically rigorous knowledge of our urban regions and provide information needed for the identification and solution of current and future social–ecological problems (Rains, this book).

ULTRAs exist in several forms. One type comprises the urban field stations initiated by the USDA Forest Service and its partners in New York City, Philadelphia, Baltimore, Chicago, and Los Angeles. The Baltimore Field Station is also a key member of the Baltimore Ecosystem Study (BES), which is a long-term ecological research (LTER) project funded by the National Science Foundation (NSF). Another type of ULTRA consists of sites funded jointly by the Forest Service and NSF and selected through a competitive process. The current form of these projects is called ULTRA-Ex. Twenty-one ULTRA-Ex projects are currently funded. Despite differences in types, ULTRAs share many traits in terms of goals, requirements, approaches, and relevance to the EFR network. A primary aim of this chapter is to discuss these traits.

In the first section of this chapter, I explain why it is important to understand cities. Understanding of the social and ecological dynamics of cities is needed for reasons that are practical, scientific, and fundamental to the Forest Service's mission. The extension of the EFR network can enhance knowledge about urban areas and directly serve the majority of Americans where they live: in urban areas. In the second section, I identify key traits of ULTRA projects: the features they share with existing EFR sites and the ways they differ from them. A key trait of the EFR network is its focus on applied research. I use an example from the Baltimore Field Station, which participates in the BES urban LTER project, to illustrate how ULTRAs can catalyze and inform partnerships between research and decision making. While ULTRAs draw substantially from the experiences and lessons learned from EFR sites, I note lessons from ULTRA projects that are likely to contribute to new avenues of research and application on EFR sites. The third section describes the current status of the ULTRA effort. I conclude with a sense of future directions for the ULTRA program.

27.2 The Need for Understanding Cities

27.2.1 Practical Motivations

27.2.1.1 Urbanization of the Planet

There are several motivations for expanding the EFR network to urban areas that are practical, scientific, and central to the Forest Service's mission. From a practical perspective, it is essential to recognize that *we are an urban planet* (Fig. 27.1). In 1800, about 3 % of the world's human population lived in urban areas. By 1900, this propor-

Fig. 27.1 NASA global composite of nighttime lights. Urbanization, indicated by the density of nighttime lights, is now visible from space. (http://visibleearth.nasa.gov/)

tion had risen to approximately 14 % and in 2008 exceeded 50 %. Nearly every week, 1.3 million additional people arrive in the world's cities for a total of about 70 million a year (Brand 2006; Chan 2007). The urban population on a global basis is projected by the United Nations to climb to 61 % by 2030 and eventually reach a dynamic equilibrium of approximately 80 % urban to 20 % rural dwellers that will persist for the foreseeable future (Brand 2006; Johnson 2006). This increase in the share of the urban population from 3 % to the projected 80 % is a massive change in the social–ecological dynamics of the planet (Brand 2009; Seto et al. 2010).

The spatial extent of urban areas is growing as well. In industrialized nations, land is being converted from wild and agricultural uses to urban and suburban settlement at a faster rate than the growth in urban population. Cities are no longer compact (Pickett et al. 2001); they sprawl in fractal or spider-like configurations (Batty 2011; Makse et al. 1995) and increasingly intermingle with rural and wild lands. Even in many rapidly growing metropolitan areas, suburban zones are growing faster than other zones (Katz and Bradley 1999). The resulting new forms of urban development include edge cities (Garreau 1991) and a wildland–urban interface in which housing is interspersed in forests, shrublands, and desert habitats.

Accompanying this spatial change is a change in constituencies and perspectives among the world's population. Although these habitats were formerly dominated by agriculturists, foresters, and conservationists, they are now increasingly dominated by people possessing resources from urban systems, drawing upon urban experiences and expressing urban habits. An important consequence of these trends in urban growth is that cities have become *the dominant global human habitat* of this century in terms of geography, constituency, experience, and influence. This reality has important consequences for social and ecological systems at global, regional, and local scales, as well as for natural resource organizations attempting to integrate ecological function with human desires, behaviors, and quality of life across all of these scales.

27.2.1.2 Cities' Vulnerability to Climate Change

Urbanization creates both ecological vulnerabilities and efficiencies. For instance, coastal areas, where many of the world's largest cities occur, are home to a wealth of natural resources that are rich with diverse species, habitat types, and productive potential. They are also vulnerable to land conversion, changes in hydrologic flows, outflows of waste, and sea level rise (Grimm et al. 2008). In the USA, 10 of the 15 most populous cities are located in coastal counties (National Oceanic and Atmospheric Administration 2004) and 23 of the 25 most densely populated counties are in coastal areas. These areas have already experienced ecological disruptions (Couzin 2008).

27.2.1.3 Cities' Critical Role in Climate Change: Mitigation and Adaptation

Although ecological vulnerabilities are significantly associated with urban areas, urbanization also fosters ecological efficiencies. The ecological footprint of a city, i.e., the land area required to support its inhabitants, is quite large (Folke et al. 1997; Grimm et al. 2008; Johnson 2006). Cities consume enormous amounts of natural resources, while the assimilation of their wastes—from sewage to the gases that cause global warming—also are distributed over large areas. For example, London occupies 170,000 ha and has an ecological footprint of 21 million ha—125 times its size (Toepfer 2005). In Baltic cities, the area needed from forest, agriculture, and marine ecosystems corresponds to approximately 200 times the area of the cities themselves (Folke et al. 1997).

Ecological footprint analysis can be misleading, however, for numerous reasons (Deutsch et al. 2000). It ignores the more important question of efficiency, defined here as persons-to-area: How much land area (occupied area and footprint area) is needed to support a certain number of people? From this perspective, it becomes clear that urbanization is critical to delivering a more ecologically sustainable and resource-efficient world because the per-person environmental impact of city dwellers is generally lower than that of people in the countryside (Brand 2006; Grimm et al. 2008; Johnson 2006). For instance, the average New York City resident generates about 29 % of the carbon dioxide emissions of the average American. By attracting 900,000 more residents to New York City by 2030, New York City can actually save 15.6 million t of carbon dioxide a year relative to the emissions of a more dispersed population (Chan 2007). The effects of urbanization on ecological efficiency may mean that social–ecological pressures on natural systems can be dramatically reduced in terms of resources used, wastes produced, and land occupied. Cities thus have the potential to provide essential solutions of mitigation and adaptation to the long-term social–ecological viability of the planet given the current population trends for this century.

Current global demographic trends are paralleled by changing conceptions of cities and urbanization. In very broad historical terms, we have begun a new paradigm for cities. Since the 1880s, a great deal of focus has centered on the "Sanitary

City," with concern for policies, plans, and practices that promoted public health (Melosi 2000). While retaining the fundamental concern for the Sanitary City, we have begun to envelope the Sanitary City paradigm with a concern for the "Sustainable City," which places urbanization in a social–ecological context at local, regional, and global scales (Grove 2009).

Urban ecology and long-term, place-based approaches have a significant role to play in advancing our concepts of sustainable cities (Grove et al. 2013; Pickett et al. 2013). Urban ecology already has an important applied dimension as an approach used in urban planning, especially in Europe (Singh et al. 2013). Carried out in city and regional agencies, the approach combines ecological information with planning methodologies (Hough 1984; Pickett and Cadenasso 2007; Pickett et al. 2004; Schaaf et al. 1995; Spirn 1984; Thompson and Steiner 1997).

Major investments in urban ecology theory, data, and practices are required to meet the needs of cities and urbanizing areas. Cities face increasingly complex and uncertain challenges. Many of these complexities are associated with changes in climate, demography, economy, and energy at multiple scales. Because of these complex, interrelated changes, concepts such as resilience, vulnerability, and ecosystem services may be particularly useful for both addressing current issues and preparing for future scenarios requiring long-term, and frequently capital-intensive, change.

Cities have already begun to address these challenges and opportunities in their policies, plans, and management. For example, on June 5, 2005, mayors from around the globe took the historic step of signing the Urban Environmental Accords—Green City Declaration with the intent of building ecologically sustainable, economically dynamic, and socially equitable futures for urban citizens. The Accords covered seven environmental categories to enable sustainable urban living and improve the quality of life for urban dwellers: (1) energy, (2) waste reduction, (3) urban design, (4) urban nature, (5) transportation, (6) environmental health, and (7) water (www.urbanaccords.org). International associations such as *ICLEI-Local Governments for Sustainability* (http://www.iclei.org/) are developing and sharing resources to deal with these issues. The ability to address these seven categories will require numerous, interrelated strategies and scientific domains. New York City's "plaNYC for a Greener, Greater New York" (City of New York 2007), for example, includes 127 different but interrelated strategies for making the city more sustainable, dynamic, and equitable.

27.2.2 Scientific Motivations

Existing EFRs and LTERs have broadened our scientific understanding of ecological systems in rural and wildland areas. ULTRAs would complement the existing EFR network by providing a more complete and comparative understanding of social–ecological systems in urban areas through the enhancement of existing theories, methods, and data previously developed in rural and wildland areas as well as the development of novel theories, methods, and data for built environments.

For instance, the existing urban LTER sites—BES and Central Arizona-Phoenix (CAP)—demonstrate the high level of scientific diversity and productivity of urban long-term social–ecological research platforms. BES and CAP study regions that span their central cities and the surrounding urban, suburban, and rural counties that constitute the Metropolitan Statistical Area for the Baltimore and Phoenix regions, respectively. Both sites include numerous investigators from academic, governmental, and nongovernmental organizations as well as biophysical, social, and technical sciences. All told, more than 80 principal investigators currently work on BES and CAP projects.

The diversity of organizations and expertise enables BES and CAP to address a wide range of social–ecological topics, such as links between urbanization and changes in hydrologic and atmospheric cycles; long-term trends in environmental justice and environmental amenities, disamenities, and ecosystem services; urbanization and changes in plant and animal communities; and long-term drivers of and responses to land-use change. Through these and other investigations over their first 10 years, BES and CAP produced more than 470 journal articles and 120 book chapters, and included more than 250 undergraduate and 240 graduate students, and 30 postdoctoral fellows. Results from BES and CAP research have led to changes in regional policies, the development of new management strategies such as urban tree canopy (UTC) goals (Grove et al. 2013; Pickett et al. 2007), and support for sustainability programs at local and state levels.

27.2.3 Caring for the Land and Serving People: Fulfilling the Forest Service Mission through ULTRAs

The ULTRAs play a fundamental role in the Forest Service's mission to "Care for the Land and Serve the People." The Forest Service was established to fulfill this mission in 1906 and the Experimental Forests and Ranges program was initiated soon after in 1908 (see Shapiro, Chapter 1, this book). At that time, the nation's population was predominantly rural. After this early phase of the Forest Service's history, the nation's population reached an equal proportion of rural to urban in the 1920s and an equilibrium of 20% rural to 80% urban that persists today and is likely to continue into the future. During this time, however, the location of EFR sites has not followed the changing demographics of the nation. There are no Experimental Forest or Range sites located in urban areas, and the two LTER sites—Baltimore and Phoenix—were established only in 1997 (Fig. 27.2).

The Forest Service recognizes that "Caring for the Land, Serving the People" also means "all lands and all people." The ULTRAs represent a foundation for the Forest Service to fulfill its mission by developing scientific information and practices that can serve the majority of Americans directly, where they live. A critical feature of this initiative is to address the fact that public land ownership is not extensive in urban areas. For example, the division between public and private ownership in the City of Philadelphia is 33% public and 67% private (Fig. 27.3). Of those

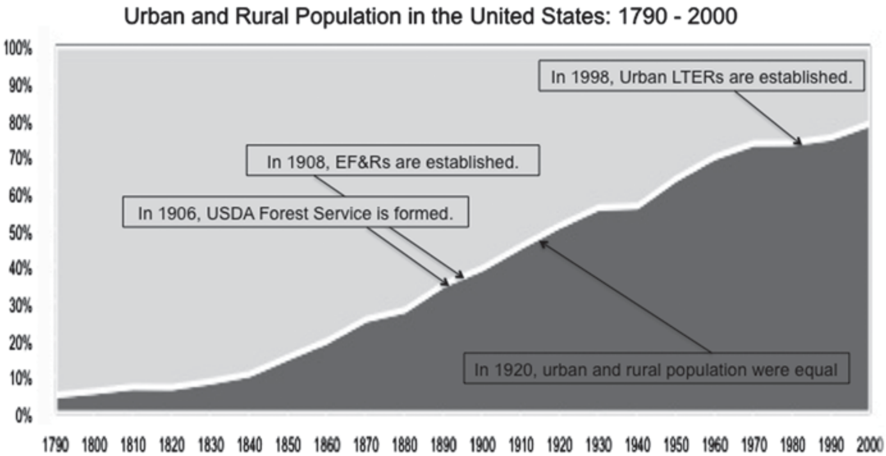

Fig. 27.2 Changing proportion of urban and rural populations in the USA (1790–2000) and the establishment of long-term research sites. The establishment of long-term research sites focused on urban areas has lagged significantly behind the growing proportion of urban population in the USA. Rural population corresponds to *light gray* area, urban population to *dark gray* area

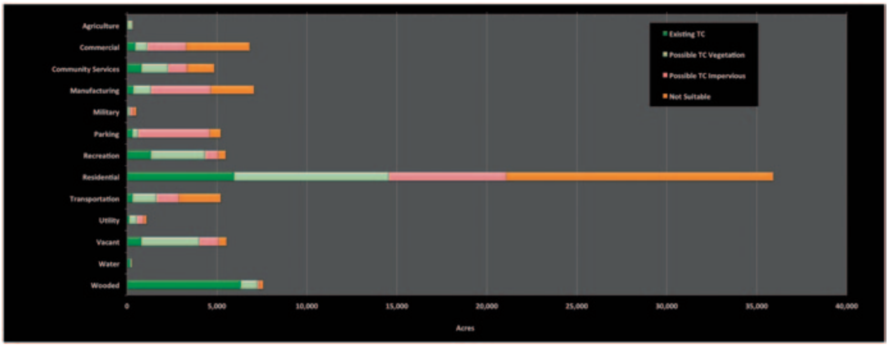

Fig. 27.3 Distribution of existing and possible urban tree canopy (UTC) in the City of Philadelphia by land ownership type. The distribution of existing and possible UTC is dominated by residential areas. (O'Neil-Dunne and Grove 2011)

private lands, 85 % are residential lands, with 459,524 individual parcels. Thus, the new "forest owner" in urban areas is in many cases a residential homeowner.

This social–ecological fact in urban areas parallels much of the Forest Service's experience and organizational culture east of the Mississippi River, where nearly 90 % of all lands are in private ownership. But this situation is very different from the Forest Service's experience west of the Mississippi, where only 10 % of all lands are in private ownership, and the landscape is dominated by extensive federal ownership. Regardless of region, however, private ownership prevails in urban areas. The role of this new forest owner in the stewardship of urban ecologies will be particularly important to understand and assist in order to mitigate and adapt to climate change and promote urban sustainability. The ULTRAs can play an important role in addressing the challenge of this new forest owner while fulfilling the Forest Service's mission.

27.3 The Ultra Program as Part of the Experimental Forest and Range Network

27.3.1 A Vision for ULTRA Projects

The USDA Forest Service has worked to develop different permutations of the ULTRA concept since the first urban LTER projects—BES and CAP—were funded in 1997. A key partner has been NSF, and this partnership has built upon the Forest Service and NSF's considerable interest in the long-term, dynamic interactions among people and natural ecosystems. As the LTER network has developed since 1980, the Forest Service has collaborated in supporting seven LTERs—six EFR sites and BES. Furthermore, BES is recognized as a "cooperating" member of the EFR network.

The momentum for a concerted, program-level focus on urban and urbanizing areas has been growing. Recent strategic planning by the LTER community has highlighted the need for greater integration of the social and ecological sciences across the LTER network, as evidenced in its decadal plan and the strategic research initiative entitled *Integrative Science for Society and the Environment* (Collins et al. 2007, 2011). This planning, in combination with the success of the urban LTERs and of the Dynamics of Coupled Natural and Human Systems Program (also co-funded and coordinated by NSF and the Forest Service), has led Forest Service and NSF leaders to jointly explore possibilities for the development of an additional program of large-scale ULTRA projects, described later in this chapter.

27.3.2 Traits Common to the ULTRAs and the Existing EFR Network

ULTRA projects share many traits with existing EFR and LTER sites. For instance, the EFR and LTER networks have similar structural characteristics. Because of the need to study ecological patterns and processes that cannot be understood with short-term funding cycles or other existing funding opportunities, the EFR and LTER networks provide long-term agency support and oversight while supporting research initiatives by individual scientists, teams, and sites. Research in the EFR and LTER sites has occurred over the long term, blending sustained, long-term studies with short-term initiatives focused on contemporary issues. Many studies outlasted an individual scientist's career. Research spans spatial, temporal, and hierarchical scales, and addresses multiple stressors (Grove et al. 2013).

The EFR and LTER networks include four types of environmental research—long-term monitoring, experiments, comparisons, and modeling (Carpenter 1998; Grove et al. 2013)—and an emphasis on education. To support analyses of long-term data and comparisons among sites, the EFR and LTER networks emphasize standardized methods for data collection and information management, including long-term data storage, curation, access, and discovery (see Ryan and Swanson, Chap. 24, in this book). Additionally, LTER projects include partnerships among the arts, humanities, and sciences (Swanson et al. 2008; www.ecologicalreflections.com).

A distinguishing characteristic of the EFRs has been a concern for the connection between research and application. The EFR Program has had an enduring philosophy of addressing land management problems at local and regional scales where they occur. EFRs are living laboratories or "seedbeds of discovery" that serve as demonstration, education, and training sites for cooperators and stakeholders. Similarly, the involvement of decision makers and educators is critical to the success of individual ULTRAs. Each ULTRA needs to engage decision makers and educators in the research-application cycle of (1) identifying questions, (2) collecting and analyzing data, (3) interpreting results, (4) disseminating and applying findings, and (5) identifying new questions.

EFRs are located in a wide variety of eco-regions and in varying states of ecological health, including sites that might be considered the "worst of the worst": deforested, overgrazed, or degraded. Thus, studies of restoration or reclamation can be an important focus of study. EFRs range in size from 47 ha (Kawishiwi Experimental Forest in Minnesota) to 22,500 ha (Desert Experimental Range in Utah). EFRs have not been limited to Forest Service lands and have included state and privately owned properties. Likewise, ULTRAs facilitate comparisons among urban regions in different climates and with different ecological, cultural, and economic histories. They include areas in need of restoration or reclamation and diverse land ownerships.

A broad range of topics have been studied in the EFR network. EFRs have examined the long-term role of climate change and land-use change on carbon sequestration, water yield, biodiversity, ecosystem productivity, and other ecosystem goods and services. Management and restoration are important considerations. Long-term studies of silviculture, hydrology, fire ecology, and other aspects of vegetation change have been essential to EFR sites. Most of these basic and applied topics are relevant ULTRA topics as well. To consider these topics in an urban context, however, the ULTRAs will have to address two important challenges. The first challenge is how to understand these topics in a coupled social–ecological system framework where people live. The second challenge is the development of novel methods for understanding these topics and their social–ecological dynamics over extensive areas, the long-term and multiple social and ecological scales.

27.3.3 Differences Between the ULTRAs and the Existing EFR Network

The existing EFRs and the ULTRAs overlap in many ways but also differ significantly. First, the ULTRAs add certain traits related to the types of sites examined, the conceptual framework and data employed, and the topics studied. Second, ULTRA projects are different from EFRs in that they focus on lands dominated by human influence *and* human settlement. As part of a network, ULTRA projects stimulate comparisons among urban areas in different climates and with different ecological, cultural, and economic histories. Third, ULTRAs require site-specific conceptual frameworks that incorporate methods and data from the geophysical, biological, social, and engineering sciences.

The most widely accepted template for social–ecological research is the press-pulse dynamics (PPD), which has been adopted by the LTER network and some of its international partners (Collins et al. 2007, 2011). It is useful for advancing social–ecological research and promoting multisite comparisons. The PPD was developed over 3 years by members from the ecological and social science communities in the USA to promote long-term social–ecological research. The PPD (Fig. 27.4) incorporates methods and data from the geophysical, biological, social, and engineering sciences but is not a theory or a model in and of itself. The PPD focuses on (1) "press and pulse events" that may drive social–ecological systems and (2) the linkages between social and ecological templates in terms of changes in the quantity and quality of ecosystem services. The PPD adds to the traditional topics of existing LTER—i.e., the biophysical template (structure and function) and regulating and provisioning ecosystem services shown in Fig. 27.4—by including topics such as cultural and supporting ecosystem services, the social template, social pulse and press drivers, and the relationships between these topics.

The intention of the PPD is to provide a generalizable, scalar, mechanistic, and hypothesis-driven framework to promote social–ecological research within existing LTER projects, the development of new long-term socio-ecological research, and comparisons among existing and new projects and networks (Grove et al. 2013). The PPD can be used to focus a long-term social–ecological research agenda through the identification of and connections among six strategic research questions (Collins et al. 2011):

1. How do long-term press disturbances and short-term pulse disturbances interact to alter ecosystem structure and function (H1)?
2. How can biotic structure, including built structure, be both a cause and consequence of ecological fluxes of energy and matter (H2)?
3. How do altered ecosystem dynamics affect ecosystem services (H3)?
4. How do changes in vital ecosystem services alter human outcomes (H4)?
5. How do changes in human perceptions and outcomes affect human behaviors and institutions (H5)?
6. Which human actions influence the frequency, magnitude, or form of press and pulse disturbance regimes across ecosystems and what determines these actions (H6)?

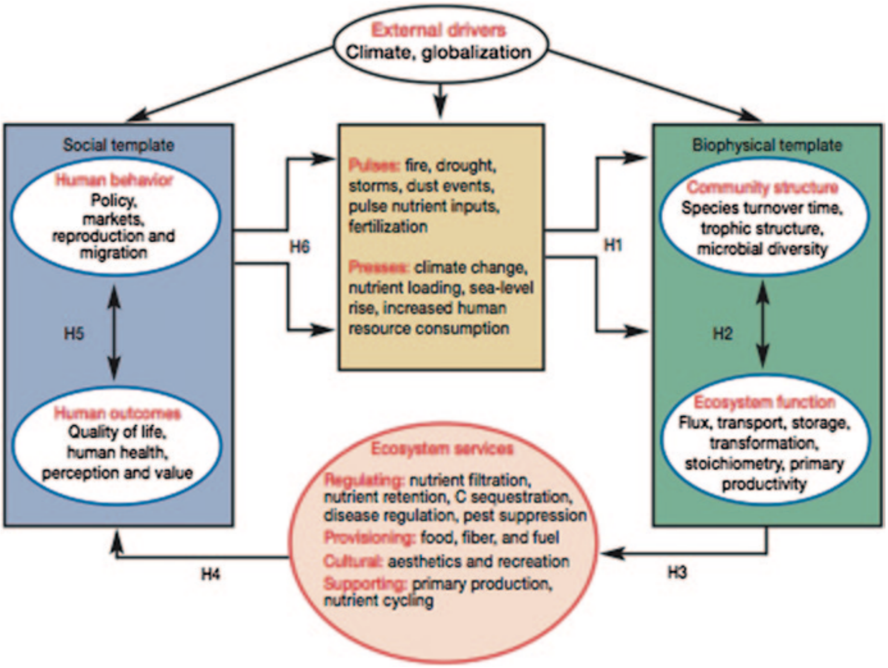

Fig. 27.4 Press–pulse dynamics (PPD) framework. The PPD framework provides a basis for long-term, integrated, social–ecological research. The *right-hand side* represents the domain of traditional ecological research; the *left-hand side*, traditional social research associated with environmental change. The two are linked by pulse and press events influenced or caused by human behavior and by *ecosystem services*, *top* and *bottom*, respectively (Collins et al. 2011). Individual items shown in the diagram are illustrative and not exhaustive

Because the PPD framework focuses on press and pulse types of disturbance, it is important to define the term. Disturbance is a technical term when used in social–ecological research. It was originally used to refer to events with sharp onset, short duration, and the ability to affect the physical structure of an ecological system. The term was provocative when first introduced because such events disrupted some aspects of ecological systems yet generated positive results for some other features of ecological systems. For example, disturbance often created opportunities for disadvantaged species to persist or enter an ecosystem, or provided locations in which resource conversion rates increased, facilitating access by suppressed or newly establishing organisms. Disturbance as originally introduced was distinct from ecological stress, which was often a longer-lasting event that directly affected the function or metabolism of a system. Both disturbance and stress can be unified as perturbations, and this term reminds researchers that the effects on any specific system component or entire system may be positive, negative, or neutral. Since its introduction in the mid-1980s, the concept of disturbance has been refined, and has led to a new consideration of ecological events in general. Events are now considered to be complex occurrences characterized by an onset, a duration in time, and potentially a later decline. Ecologists recognize that the complexities of onset, duration, and demise of events will result in different effects. A short flood may not kill many plant species on a floodplain, while an unusually long flood may cause mortality and may even remove sensitive species from the system.

The complexity of ecological events can be abstracted in the contrast of pulses and presses. Although this contrast does not consider all possible combinations of sharpness of onset, duration, or existence or rate of decline (Pickett and Cadenasso 2009), it focuses attention on two end members of that rich array of events: those that are transient and those that are persistent, at least for a relatively long time. Pulse events have sharp attack and quick demise, though they may have substantial effects on ecological systems. An earthquake is a good example of a pulse event. Press events alter the conditions in a system over a long time, and may in fact be more akin to stresses. A shift in a climate regime from wet to dry and the injection of a new level of resource supply through pollution are examples of biological pulses. Social pulses and presses are also important. New investment in a neighborhood may be a pulse. A shift in demographic composition in a district of a city would illustrate a press. Presses and pulses are raw materials for advancing integration between bioecological and social structures and processes in human ecosystems.

27.3.4 An Illustration of Dynamic Feedbacks Between Science and Decision Making: From Urban Hydrologic Drought to an UTC Goal

The ULTRAs can lead to a dynamic coupling between scientists and decision makers (Fig. 27.5). An example from BES illustrates this opportunity. The Baltimore region is characterized by ecologically functional watersheds and stream valleys that have contributed to Baltimore's economic and cultural history. An early test of the BES project was to apply and demonstrate the utility of forested watershed studies from the Coweeta (North Carolina), H.J. Andrews (Oregon), and Hubbard Brook Experimental Forests (New Hampshire)/LTERs (Bormann and Likens 1979) to an urban watershed system. One of the initial questions that BES asked, using a watershed approach, was: "Do riparian zones, thought to be an important sink for nitrogen in many non-urban watersheds, provide a similar function in urban and suburban watersheds?"

Somewhat surprisingly, BES analyses found that riparian areas had the potential to be sources—rather than sinks—of nitrogen in urban and suburban watersheds. This finding could be explained by the observation that hydrologic changes in urban watersheds, particularly incision of stream channels and reductions in infiltration in uplands due to stormwater infrastructure, led to lower groundwater tables in riparian zones. The resulting "hydrologic drought" created aerobic conditions in urban riparian soils which decreased denitrification, an anaerobic microbial process that converts reactive nitrogen into nitrogen gases and removes it from the terrestrial system (Groffman and Crawford 2003; Groffman et al. 2002, 2003).

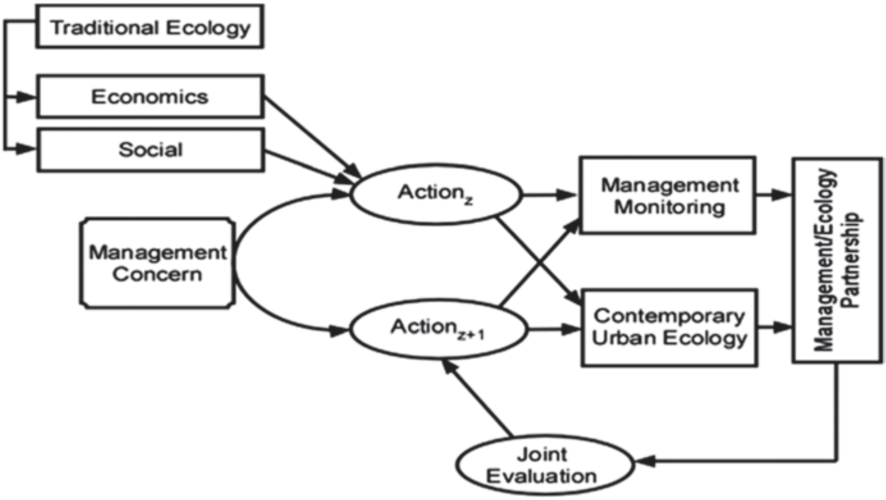

Fig. 27.5 An abstracted cycle of interaction between research and management. The cycle begins with the separate disciplines of ecology, economics, and social sciences interacting with a management or policy concern. In the past, ecology has neglected the urban realm as a subject of study, leaving other disciplines to interpret how ecological understanding would apply to an urban setting. A management or policy action (*Action$_z$*) results. Management monitors the results of the action to determine whether the motivating concern was satisfied. Contemporary urban ecology, which integrates with economics and social sciences, is now available for scientists to conduct research that recognizes the meshing of natural processes with management and policy actions. Combining this broad, human ecosystem and landscape perspective with the concerns of managers can generate a partnership to enhance the evaluation of management actions. New or alternative management actions can result. (*Actions$_{z+1}$*; Pickett et al. 2007)

Based upon these urban riparian results, the Chesapeake Bay Program reassessed its goals for riparian forest restoration in urban areas. Given that riparian zones in deeply incised urban channels were not likely to be functionally important for nitrate attenuation in urban watersheds, the program focused instead on establishing broader UTC goals for entire urban areas (Fig. 27.6). Increases in canopy cover across the city were expected to have important hydrologic and nutrient cycling benefits to the bay (Raciti et al. 2006).

This science-decision making cycle is dynamic and iterative. The UTC example has already progressed through seven cycles (Grove et al. 2013). After establishment of the City of Baltimore's UTC goal, analyses of the relationship between property regimes and UTC found that an "All Lands, All People" approach would be critical for achieving the city's goal (Action$_{z+2}$). Private lands under the control of households are a critical component to reaching any vegetation management goal in the city. Total existing canopy cover is 20 %, with 90 % of that cover located on private lands. Likewise, about 85 % of the unplanted land area where potential planting could occur in the future is on private land, as compared to less than 15 % on public rights of way (Galvin et al. 2006).

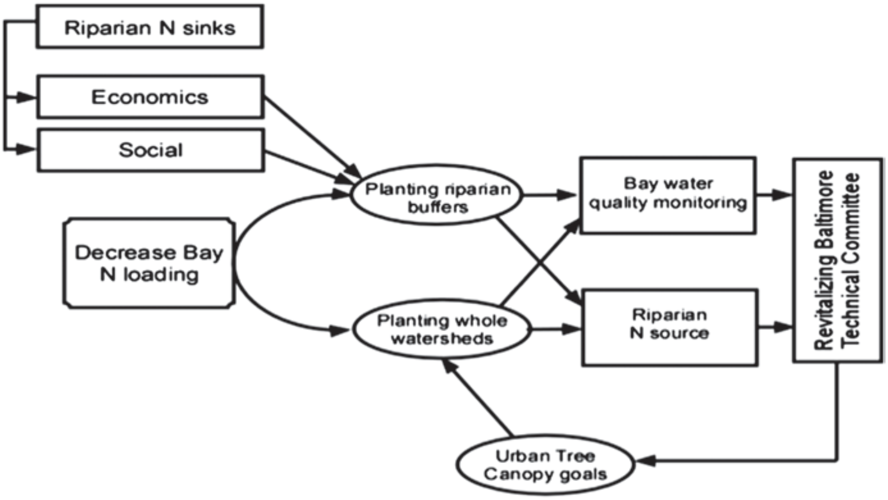

Fig. 27.6 An example of the management–research interaction in Baltimore City Watersheds. Traditional ecological information indicated that riparian zones are nitrate sinks. The management concern was to decrease nitrate loading into the Chesapeake Bay. In an effort to achieve that goal, planting trees in riparian zones was proposed. Management monitoring indicated that progress toward decreasing bay nitrate loadings was slow. Results from BES research suggested that stream channel incision in urban areas has resulted in riparian zones functioning as nitrate sources rather than sinks. In partnership with managers and policy makers in Baltimore City and the Maryland Department of Natural Resources, BES reevaluated strategies to mitigate nitrate loading, leading to a decision to increase tree canopy throughout the entire Chesapeake Bay watershed. Baltimore City adopted an urban tree canopy goal, recognizing both the stormwater mitigation and other ecological services such canopy would provide. (Pickett et al. 2007)

The importance of residential households to achieving Baltimore's UTC goal led to research addressing the relationships among households, their lifestyle behaviors, and their ecologies (Boone et al. 2009; Grove et al. 2006; Troy et al. 2007; Zhou et al. 2009). A critical finding from this research was that lifestyle factors such as family size, life stage, and ethnicity may be weakly correlated with social–economic status, but these lifestyle factors also play a critical role in determining how households manage their properties. These findings suggested the need for novel marketing campaigns that promoted UTC efforts while differentiating the marketing approach by type of neighborhood (Action$_{z+3}$). The need to "market" differently to different neighborhoods led to the need to understand existing and potential gaps in stewardship networks (Romolini 2013; Romolini and Grove 2010; Svendsen and Campbell 2008)—both functional and spatial dimensions of the network as a mechanism to communicate and organize local, private stewardship (Action$_{z+4}$).

Benefits from ULTRA projects are not limited to an ULTRA site. The findings and methods developed in Baltimore through these successive science-decision making cycles have had widespread utility in other urban areas. For instance, the tools developed in Baltimore to assess and evaluate existing and possible UTC have been disseminated through existing Forest Service networks and applied to more than 70 urban areas in the USA and Canada.

27.3.5 The ULTRAs' Potential Contributions to the Existing EFR Program

The ULTRAs can contribute to the existing EFR program in terms of scientific practice and knowledge and public awareness and use. The addition of ULTRAs to the existing EFRs represents a unique opportunity for long-term, standardized comparisons to understand how human activities modify ecological systems as well as respond to ecological change. For instance, the ULTRAs represent new opportunities for comparison with existing EFRs to examine ongoing changes in basic ecological patterns and processes, such as carbon sequestration, water yield, biodiversity, ecosystem productivity, and other ecosystem goods and services.

The ULTRAs can contribute to nascent EFR social science efforts for both on-site and regional EFR research. Although social science has not constituted a significant portion of on-site EFR research, examples can be found at some EFR sites (Charnley and Cerveny, Chap. 25, this book). Examples include (1) assisting in the development and application of socially acceptable and economically feasible natural resource management practices; (2) providing insight into how human activities, past and present, shape forest and rangeland ecosystems; (3) helping to solve resource management problems and to promote sustainable land-use practices; and (4) improving understanding of the social environment surrounding EFRs. These examples may be enhanced by interdisciplinary approaches emerging from the ULTRAs, including conceptual frameworks; novel approaches to long-term monitoring, experiments, comparisons, and modeling; innovative methods and data; and systems of practice with decision makers, educators, and diverse publics. Further, the adaptation of approaches from ULTRAs to on-site EFR activities can be relevant to EFR regional activities. This is an emerging and critical issue because EFRs are increasingly surrounded by growing urban and suburban sprawl (Charnley and Cerveny, Chapter 25, this book).

The ULTRAs can increase awareness of and support for existing EFRs. The EFR program is not well known to most Americans because EFRs are often in remote locations and because the connection between findings and applications from the EFR network and research implications is not often direct, immediate, or clear to most Americans. In contrast, the ULTRAs are located where most Americans live and ULTRA projects are more tightly coupled with the science findings and applications that directly and immediately benefit the majority of Americans.[1] Because of these connections, the ULTRAs have numerous and diverse opportunities to connect to the majority of Americans' perceptions, attitudes, and knowledge about their local, regional, and global environments. Further, knowledge about the ULTRAs can be a portal to increasing awareness of and support for the larger EFR network.

[1] Examples of recognition of the links between science findings and local benefits can be found from the BES, which was recognized through official proclamation for its service to the City of Baltimore by both Mayor Martin O'Malley (2004, 2006) and Mayor Sheila Dixon (2007, 2008).

27.4 Current Status of ULTRA Projects

There are currently several permutations for ULTRAs. The urban field stations initiated by the USDA Forest Service's individual Research Stations and its partners in New York City, Philadelphia, Baltimore, Chicago, and Los Angeles work together informally as a network. The Baltimore Field Station is also a key member of BES, which is an LTER project funded by NSF. BES participates in the LTER network and is considered a "cooperating EFR" in the EFR network.

In another type of ULTRA, projects are funded jointly by the Forest Service and NSF and selected through a competitive process. In April 2009, in anticipation of the full development of ULTRA projects based upon a competitive process, NSF and the Forest Service solicited proposals for exploratory ULTRA research—ULTRA-Ex projects—that would "identify and investigate topics and approaches that could advance both fundamental and applied knowledge regarding people and urban ecosystems," as stated in the NSF Program Announcement 2009. In the words of the program announcement, the intent of the ULTRA-Ex project awards is "to support research teams to conduct one or a limited number of related projects that will draw on and show promise of enhancing fundamental theory with respect to both human and biophysical systems as well as human–natural system interactions. Research teams will also generate knowledge about human–natural system interactions that can be used by government agencies, NGOs, businesses and individual citizens to improve the livability and sustainability of urban and urbanizing areas."

NSF and the Forest Service were surprised by the substantial response from the scientific community to the ULTRA-Ex solicitation, given the short time to prepare and submit proposals, limited project funding (US $ 300,000 total) and project length (2 years), and large expectations. More than 70 complete proposals were received. ULTRA-Ex proposals were reviewed in July 2009 for intellectual merit and broader impacts of the proposed project; the nature and scope of the partnerships; and the distribution of study areas in the USA by geographic location, size, age, and climatic zone. Funding was awarded to 21 proposals, with substantial diversity in terms of climate, size, and ecological, cultural, and economic histories. Additionally, some ULTRAs include urban gradients or multicity comparisons (Fig. 27.7).

ULTRA-Ex Projects (21)

- Hilo and Kailua-Kona, HI
- Los Angeles, CA
- Fresno/Clovis, CA
- Portland, OR and Vancouver, WA
- Tucson, AZ
- Albuquerque and Los Cruces, NM, and Phoenix, AZ (Southwest Gradient)
- New Orleans, LA
- Chicago, IL

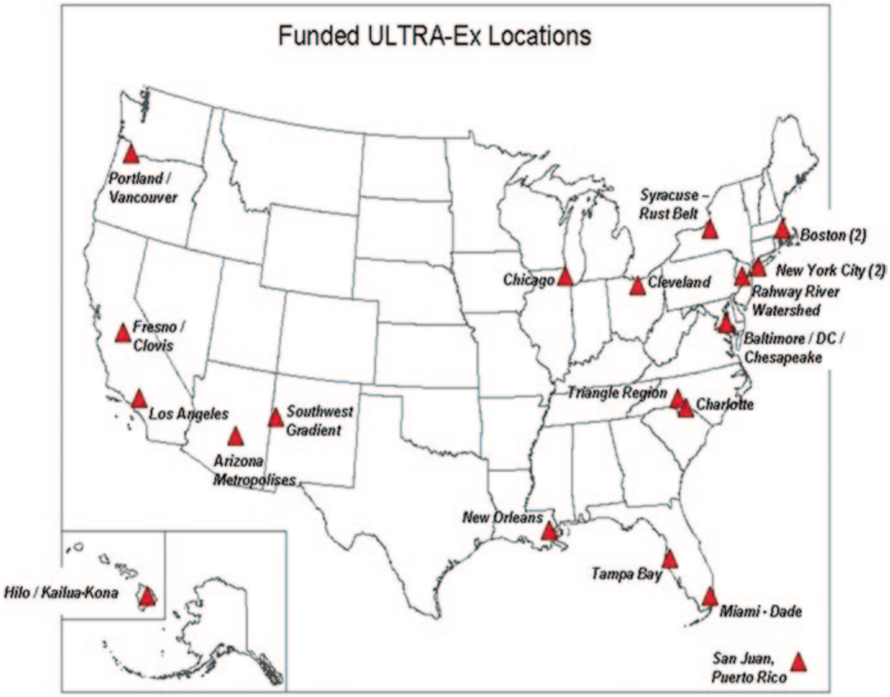

Fig. 27.7 21 ULTRA-Ex projects, located in diverse climatic, social, cultural, and economic landscapes

- Cleveland, OH
- San Juan, Puerto Rico
- Miami, FL
- Tampa Bay, FL
- Raleigh-Durham and Chapel Hill, NC (Triangle Region)
- Charlotte, NC
- Washington, D.C. and Baltimore, MD
- New Jersey Highlands, NJ (Rahway River Watershed)
- New York City, NY (2)
- Boston, MA (2)
- Syracuse, NY

It is hoped that a second solicitation for full ULTRAs will be made eventually. This call for proposals would not be limited to the existing 21 ULTRA-Ex projects, and some undetermined number of proposals would be funded on a funding cycle and level of funding similar to LTER sites. Fully funded ULTRAs would be selected based upon criteria similar to those for the ULTRA-Ex projects.

27.5 Conclusion

ULTRA projects have advanced scientific theory and practical knowledge about urban systems. This accomplishment is particularly important given the demographic trends for this century and a focus on adapting our cities to be more sustainable. In addition, ULTRA projects have two collateral effects that represent significant changes from the current state of academia and decision making. First, the establishment of ULTRA projects substantially legitimizes and recruits scientists and students to work on interdisciplinary topics, to focus on places where most humans live and will live, and to provide direct, practical benefits for decision making. Second, the ULTRAs provide decision makers with multi-scale, long-term, and systems-type knowledge about urban areas.

ULTRA projects can yield mutual benefits to the existing EFRs. Even one century after the establishment of the first Experimental Forest, there is still much to learn and apply from the EFRs to urban areas. This body of knowledge is related not only to comparing scientific understanding and methods of social–ecological systems in diverse wildland, rural, and urban contexts but also to the EFRs' culture of long-term research and addressing stakeholders' questions. At the same time, the explicit link between the ULTRAs and the EFRs can increase the public's knowledge about the Forest Service's investment in Experimental Forests and Ranges, the diverse types of ecosystems and conditions that exist in rural areas, and the scientific and practical benefits that the EFR network has provided for the past 100 years.

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