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FORUM

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Progress in the 21st century: a Roadmap for the *Ecological Society of Japan*

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Abstract The primary goal of the 60th anniversary symposium of the *Ecological Society of Japan* (ESJ) was to re-examine the role of the *Society*. The first of five lectures, "*Development of Long-term Ecological Research in Japan*," discussed the increasingly important role of long-term and networked research studies. Ecological research in Asia faces many challenges, because Asia features natural and anthropogenic landscapes with highly diverse ecosystems. "*Developing Strategies of the Ecological Society of Japan for Worldwide Societies of Ecology with Special Reference to Strategies for Asia*" emphasized the role of ESJ in promoting ecological research and outreach in Asia. Ecosystem sustainability is a key issue in both the theory and practice of ecosystem management. A framework concept of an environmental and biodiversity cycle was proposed in the session "*Linking Community and Ecosystem Dynamics*" for understanding the mechanisms driving the sustainability of ecosystems. Ecosystem services are essential aspects of land use and conservation planning and management. "*Integrating Models of Ecosystem Services and Land Use Changes*" reviewed recently-developed models that simulate patterns of land-use change and analyze its effects on ecosystem services and also recommended future directions for collaboration among researchers. "*Disaster Resilience and Coastal Ecology*" highlighted the contributions of ecologists to evaluating the resilience of damaged coastal ecosystems and provided sound proposals to local communities and governments for rehabilitation plans. The past achievements and future directions of ESJ were discussed by the panelists and the audience in "*Past and Future of the Ecological Society of Japan*."

Keywords Asia · Community and ecosystem dynamics · Disaster resilience · Land use change · Long-term ecological research

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Introduction

The *Ecological Society of Japan* (ESJ) was established in 1953 to promote research and education in all aspects of ecology. ESJ celebrated its 60th anniversary in 2013. How the society envisions itself has changed over time. In addition to promoting research in the basic field of ecology and related sciences, ESJ has come to play other roles. These include contributing to finding solutions to social and environmental problems, such as the loss of biodiversity, and addressing global climate change. These goals are often pursued by establishing close relationships with various types of international and domestic organization (governmental, industrial, and non-profit).

The 50th anniversary meeting of ESJ that was held in Tsukuba, Japan, in 2003 provided an opportunity to highlight the following three roles of ESJ: (1) to promote ecological research at large spatial and temporal scales; (2) to contribute not only to conservation of natural ecosystems but also to the recovery and rehabilitation of damaged or lost ecosystems; and (3) to promote international activities, especially within the East Asian region. The 50th anniversary meeting of ESJ prompted the establishment of two new ESJ committees, the *Committee of Large-Scale and Long-Term Ecology* and the *Committee of Ecosystem Management*, and promoted connections with the *East Asian Federation of Ecological Societies* (EAFES). In 2003, EAFES was established collaboratively by the ecological societies of China, Japan, and Korea to promote ecological science in East Asia.

A symposium titled "*Progress in the 21st Century: A Roadmap of the Ecological Society of Japan*" was held during the 60th annual meeting of ESJ in Shizuoka, Japan, on 6 March, 2013. This symposium was organized to evaluate the past activities and future roles of ESJ. The symposium consisted of five lectures and a general discussion. The themes of the five lectures were based on the achievements of the 50th anniversary meeting. The first two lectures mainly reviewed the achievements of ESJ over the past decades, whereas the last three focused on the current and future directions of the society's activities. However, the selected topics did not cover every challenge facing ESJ. This paper summarizes the symposium, following the sequence of the lectures and ending with the final panel discussion. The symposium consisted of two parts: (1) an overview of long-term ecological research (LTER) in Japan and the international role of ESJ; and (2) a review of recent ecological research.

The overview addressed two topics. The first topic introduced the history of LTER in Japan since the conclusion of the International Biological Program (IBP) of 1964–1974. LTER has long been recognized as providing important data and knowledge; LTER networks in the United States (US LTER) and internationally (ILTER) have been established to build a global network (Kim 2006). This section of the meeting described the relatively long gap between the establishment of LTER and the initiation of an effective LTER network in Japan. It also emphasized the current and future need for ecologists in Japan to participate in several new projects associated with LTER. The second topic described the international efforts of ESJ since the conclusion of the IBP. The section reviewed past and current strategies of the ESJ to promote worldwide research projects and to establish international organizations and societies designed to encourage ecological research.

The second part of the symposium was divided into three topics related to advances in the theory, modeling, and practices of ecosystem management. The first topic introduced one of the most important subjects in ecology today on a global scale: elucidating the links between community and ecosystem ecology. The discussion on the sustainability of ecosystems addressed a key issue for both the theory and practice of ecosystem management. The section provided a framework concept of an environmental and biodiversity cycle to provide a better understanding of ecosystem sustainability. The second topic reviewed recently-developed models that simulate the patterns and consequences of land-use and land-cover change. Ecosystem services are essential aspects of land use and conservation planning and management. The section described various models and emphasized that developing integrated models of ecosystem services and land-use changes is essential. The third topic addressed the Great East Japan Earthquake of 11 March, 2011, described the resilience of coastal ecosystems in light of this and other disasters, and integrated other topics related to coastal ecology. Scientific knowledge related to ecology helps people evaluate how catastrophic disturbances damage ecosystems and emphasizes ecosystem resilience. Such information allows ecologists to make sound proposals to local communities, stakeholders, and decision-makers for improving rehabilitation plans. Finally, a summary of the general discussion held at the symposium is given in the last part of this review, with emphasis on some proposals for future activities of ESJ.

History and the roles of ESJ

Development of long-term ecological research in Japan

Long-term ecological research is important because it elucidates (1) processes that occur slowly, (2) the effects of rare and episodic events, (3) processes with large fluctuations, and (4) processes with complicated interactions. Recently, LTER has also been expected to provide scientific findings to help solve global environmental issues. The foundations of LTER were laid in the early 1980s, when the IBP was completed (Table 1). The IBP established a basis for large-scale ecosystem studies and clarified factors involved in biological production as well as in matter and energy cycling in various types of ecosystem. The program also established a number of research sites with the potential to integrate more research and/or comparative studies. US scientists established the US-LTER network in 1980 to extend IBP activities and include discussions on the significance of long-term research (Franklin 1987). US-LTER initially established 17 domestic research sites, and then expanded into an international and global network upon the creation of the International LTER (ILTER) in 1993.

In contrast, the research sites established during the IBP in Japan were not directly integrated into a system similar to the US-LTER. Some of the sites were not

Table 1 History of long-term ecological studies and related issues since 1970

Year	Climatic change	Biodiversity	Ecosystem	Acts in Japan
1970				
1971				
1972				
1973				
1974			End of IBP	
1975				
1976				
1977				
1978				JIBP Synthesis
1979				
1980			US LTER, BCI plot	
1981				
1982				
1983				
1984				
1985				
1986				
1987			Permanent Plotter	
1988	IPCC			
1989				
1990			IGBP	
1991		DIVERSITAS I		Center of Ecological Research, Kyoto Univ.
1992	UNFCCC	CBD		
1993			ILTER	DIWPA
1994				
1995		Tree of Life		
1996				ILTER-EAP conference in Tsukuba
1997	Kyoto Protocol			
1998				US–Japan Young Scientists exchange
1999				WG of Long-Term Research in ESJ
2000				
2001		DIVERSITAS II, GBIF, IBOY	ESSP	Research Institute for Humanity and Nature
2002	GCP		WSSD, MDG	
2003			GLP	Monitoring sites 1000
2004		Barcode of Life		
2005		ImoSEB, MA report	GEOSS	Committee for long-term and large scale studies
2006	Stern Review			JaLTER
2007	IPCC AR4			
2008		GEO BON		
2009		APBON		JBON
2010		TEEB		
2011		IPBES		Data paper in Ecological Research
2012		Future Earth	NEON	

maintained, although a small number have been preserved through the personal efforts of individuals. In some cases, valuable data were lost. The IBP studies in Japan made outstanding contributions to documenting productivity and nutrient cycling in various ecosystems, and the results were found to be very useful internationally (Kira et al. 1978). However, the research foci of ecologists have shifted over time, and the IBP framework was not successfully implemented in subsequent decades. Thus, a rather long gap exists from the conception to the establishment of long-term ecological studies and an associated network in Japan.

Since the early 1990s, global environmental issues such as climate change and biodiversity loss have shifted the focus of many ecological studies. Site-based ecological research is important to these issues. The *International Geosphere–Biosphere Programme* (IGBP) and *DIVERSITAS*, both of which were established to promote international collaboration in studies involving biodiversity, commenced operations in 1990 and 1993, respectively. Long-term and networked studies seem to be very effective in answering questions related to these issues. For instance, the studies on Barro Colorado Island (BCI), Panama, which were initiated by the *Smithsonian Tropical Research Institute*, provided considerable new insight on biodiversity in tropical forests (Hubbell and Foster 1983). The institute also started to establish a network of studies in various regions of the tropics (Table 2).

In response to these research trends, some long-term study activities also emerged in Japan (Nakashizuka 1991) and a voluntary network was established among them. Members of the network have met several times and collaborated on a publication describing the importance of long-term and networked studies (Nakashizuka 2001). Also, they have operated an exchange

Table 2 Abbreviations and URLs of referenced organizations, projects, and networks

Name	Abbreviation	URL
Asia–Pacific Biodiversity Observation Network	AP-BON	http://www.esabii.org/ap-bon/index.html
Barcode of Life	Barcode of Life	http://www.barcodeoflife.org
Convention on Biological Diversity	CBD	http://www.cbd.int
DIVERSITAS	DIVERSITAS	http://www.diversitas-international.org/
DIVERSITAS in the Western Pacific and Asia	DIWPA	http://diwpa.ecology.kyoto-u.ac.jp/index.html
East Asian Federation of Ecological Societies	EAFES	http://www.e-eafes.org
Ecological Society of Japan	ESJ	http://www.esj.ne.jp
Earth System Science Partnership	ESSP	http://www.essp.org
Future Earth	FE	http://www.icsu.org/future-earth
Global Biodiversity Information Facility	GBIF	http://www.gbif.org
Global Carbon Project	GCP	http://www.globalcarbonproject.org
Group on Earth Observations Biodiversity Observation Network	GEO BON	http://www.earthobservations.org/geobon.shtml
Global Earth Observation System of Systems	GEOSS	http://www.epa.gov/geoss/
Global Land Project	GLP	http://www.globallandproject.org
International Biodiversity Observation Year	IBOY	
International Biological Program	IBP	http://www.nasonline.org/about-nas/history/archives/collections/ibp-1964-1974-1.html
International Council of Science	ICSU	http://www.icsu.org/
International Geosphere–Biosphere Programme	IGBP	http://www.essp.org/?id = 22
International Geophysical Year (IGY)"	IGY	http://www.nas.edu/history/igy/
International Human Dimensions Programme	IHDP	http://www.ihdp.unu.edu/
International Long-Term Ecological Research Network	ILTER	http://www.ilternet.edu/
International Mechanism of Scientific Expertise on Biodiversity	ImoSEB	
Intergovernmental Platform on Biodiversity & Ecosystem Services	IPBES	http://www.ipbes.net
Intergovernmental Panel on Climate Change	IPCC	http://www.ipcc.ch/index.htm
Japan Long-Term Ecological Research Network	JaLTER	http://www.jalter.org/
Millennium Development Goals	MDG	http://www.un.org/millenniumgoals/
National Ecological Observatory Network	NEON	http://www.neoninc.org/
Economics of Ecosystems and Biodiversity	TEEB	http://www.teebweb.org
Tree of Life web project	Tree of Life	http://tolweb.org/tree/
United Nations Framework on Climate Change	UFCCC	http://unfccc.int/2860.php
US Long-Term Ecological Research Network	US LTER	http://www.lternet.edu/
World Climate Research Programme	WCRP	http://www.wcrp-climate.org/
World Summit on Sustainable Development	WSSD	http://www.who.int/wssd/en/

program between US-LTER and young Japanese scientists. ESJ also created a working group to promote LTER in 1999 and in 2005 promoted the group into a committee. In 2003, the Japanese *Ministry of the Environment* began ecosystem monitoring activities in Japan (Monitoring Site 1000) and the ecologist group decided to collaborate with this effort. Also, the *Global Earth Observation System of Systems* (GEOSS) was established, and Japanese scientists played key roles in planning its activities. Based on new requirements and policies, LTER scientists were expected to make a significant contribution. Supported by these activities, Japan LTER (JaLTER) was officially established in 2006 and joined the ILTER network in 2007 (Enoki et al. 2007), 27 years after US-LTER was established. JaLTER has 20 Core and 36 Associate research sites (in 2012) and has become one of the most active ILTER networks.

The role of long-term and networked research studies has become increasingly important. The *Group on Earth Observations Biodiversity Observation Network* (GEO-BON) was established under GEOSS, with the ILTER sites serving as key observation points in this program. Some new issues are also emerging. In 2012, the US initiated another, even larger activity, the *National Ecological Observatory Network* (NEON), to provide answers to global environmental problems. Thus, the activities of LTER and NEON complement each other somewhat; LTER sites study processes to integrate findings from the bottom up, while NEON will assess large-scale change based on systematic monitoring. Another trend is to enlarge research projects and make them more multi-disciplinary. In 2011, the *International Council of Science* (ICSU) reformed the conventional framework of international science programs into the *Future Earth* framework. This program integrates natural sciences with social and human sciences. Japanese ecologists are expected to be involved with such international concepts and projects more actively than previously. In this case, the framework of the LTER network must be used to its full capacity, although some new perspectives and mechanisms must be added to enable integrated multi-disciplinary studies.

Developing strategies for ESJ related to worldwide societies of ecology with special reference to strategies for Asia

ESJ was established in 1953. The 1950s were a time when researchers studying environmental sciences engaged in intense international collaboration. In 1951, when Japan

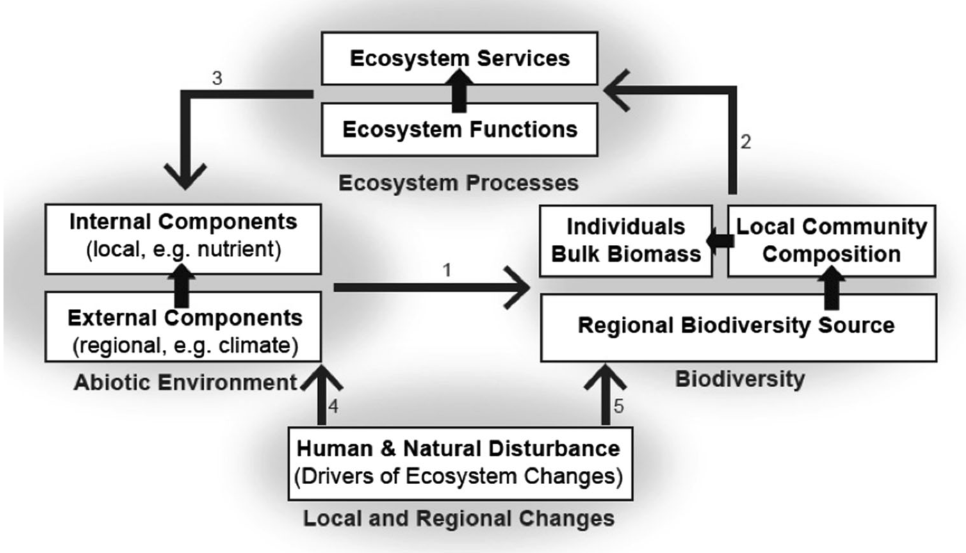

Fig. 1 Environment–biodiversity cycle. The abiotic environment consists of (1) internal components such as soil nutrients, which are rapidly modified by local ecosystem activity, and (2) external components such as climate, which may change slowly. Biodiversity has three important components: local species composition; bulk quantity, such as total biomass or forest size; and the regional pool of biodiversity. (3) Ecosystem processes include both ecosystem functions and services. Drivers of ecosystem changes appear at both local and regional scales

had not yet become independent (prior to the effective date of the San Francisco Treaty) researchers working in the environmental sciences proposed *The International Geophysical Year* (IGY), with a comprehensive series of global geophysical activities. During the final stage of the IGY in 1957 and 1958, 67 countries participated. Under the worldwide trend for international collaboration, ESJ initiated developmental strategies for the world starting in the 1960s. One of the main concerns for ESJ was biodiversity.

To promote the IBP, ESJ started to examine the foundation of the *Joint Usage Center* for freshwater biology, using Kyoto University's Otsu Hydrobiological Station (OHBS) as a basis (Center for Ecological Research 2011). This led the establishment of the *Center for Ecological Research* (CER), Kyoto University, by reorganizing the OHBS and the *Plant Ecological Research Station* in 1991 when *DIVERSITAS* was launched (Center for Ecological Research 2011). In 1992, the research program *SymBiosphere: Ecological Complexity for Promoting Biodiversity* proposed by CER was adopted by IUBS, SCOPE, and UNESCO (Kawanabe et al. 1993; Kawanabe 1996); this encouraged ESJ to take the lead in biodiversity research Japan (Kawanabe 1996). Thus, ESJ cultivated a closer connection to *DIVERSITAS*, launching *DIVERSITAS* in the Western Pacific and Asian regions (DIWPA) in 1993 (Center for Ecological Research 2011).

Why concentrate on the Western Pacific and Asia? In October 1992, Prof. Kawanabe and his colleagues held an international symposium at La Selva, Costa Rica, and discussed the most important regions of the world for biodiversity research where financial and manpower sources were limited (Kawanabe 1996). Interestingly, they identified the unique ecosystems of the Western Pacific and Asia as being most important, including the terrestrial Green Belt from Siberia to New Zealand and the marine Blue Belt along its eastern border (Kawanabe 1996). Places with high primary production were expected to have high biological diversity, so those researchers eventually decided to focus on the biodiversity in that region (Kawanabe 1996).

DIWPA has organized many international meetings, built capacity through an international field biology course, organized the *International Observation Year of Biodiversity* (DIWPA-IBOY) in 2001, published several books (nine volumes as of May 2013), and publishes newsletters (28 as of May 2013) (DIWPA Newsletter 1995, 2003, 2004).

In 2003, the *East Asian Federation of Ecological Societies* (EAFES) was formed through the collaboration of ecological societies in China, Japan (ESJ), and Korea to promote ecological science in East Asia. EAFES plans symposia, meetings, joint research projects, and other activities to contribute to the development ecological science and ecological societies in this region. The three national ecological societies take turns organizing the joint *EAFES Congress* at least once every 2 years; five congresses have been held thus far.

One of ESJ's important recent activities related to Asian biodiversity is the *Asia–Pacific Biodiversity Observation Network* (AP-BON), which was launched in

2009 and collaborates with GEO-BON. GEO-BON collects and analyzes data on the status of and trends in the world's biodiversity, with special attention paid to ecosystems, species, genes, and ecosystem services. AP-BON has organized several international workshops (Yahara et al. 2012) and published a book on biodiversity research in Asia (Nakano et al. 2012).

ESJ has been supporting the startup of *Future Earth* (Asian Conservation Ecology 2013), because implementation of a symbiotic society will strengthen the links between human beings and ecosystems. *Future Earth* will also concentrate on the links between human beings and biodiversity, one of the important challenges for ecologists.

Biodiversity is a global resource of tremendous value to the present and future well-being of humanity. However, anthropogenic threats to species and ecosystems have never been as serious as they are today. We hope ESJ will continue its activities in support of the sustainable use of biodiversity and ecosystems to create a symbiotic society.

Landscape ecology and ecosystem services

Linking community and ecosystem dynamics: the role of competition

A fundamental question in ecology today is the origin of ecosystem sustainability, although it has not often been addressed (e.g., Cropp and Gabric 2002). If the origin of life on Earth does not automatically imply the establishment of a sustainable ecosystem, there should be undiscovered mechanisms at the levels above the single individual and population in support of the long-term persistence of ecosystems. Elucidating this issue will not only contribute to establishing a fundamental theory of ecology but also provide conceptual and practical solutions for sustainable management of human-dominated ecosystems.

A conceptual framework that integrates the interactions among major components in ecosystems (Chapin et al. 2000, 2009; Miki 2009) has been developed in the last two decades to improve our understanding of the mechanisms producing sustainable ecosystems. Here, we present an environment–biodiversity cycle in a simplified ecosystem (Fig. 1) that describes (1) endogenous feedbacks among the abiotic environment, the biotic community (biodiversity), and ecosystem processes and (2) the modification of these endogenous feedbacks by human and natural disturbances. By addressing the role of competition, we first review three major questions that have been extensively investigated. Second, we recommend a few ideas for future research from the community ecology perspective.

The first question is: what determines the structure of a community and local biodiversity (see arrows 1 and 5 in Fig. 1)? Competition (and other ecological interactions) and disturbance have been identified as the determinants in population and community ecology (Connell 1978; Tilman 1980; Interlandi and Kilham 2001; Molino and Sabatier 2001). However, in other fields (e.g., biogeography and macroecology), species composition has been understood as an additive sum of individual species preferences and adaptations to local environments (Brown 1995; Gaston 2000; Pearson and Dawson 2003). The second question is: what are the patterns and mechanisms of the relationship between biodiversity and ecosystem function (see arrow 2 in Fig. 1). At a local scale, the relationship is characterized by (1) the selection effect, (2) functional complementarity and insurance, and (3) functional redundancy (Loreau et al. 2001; Hooper et al. 2005; Reich et al. 2012). Competition is responsible for all three components by determining (1) species abundance distribution, (2) niche differentiation, and (3) niche overlap. The third question is: what are the consequences of the feedback process between local components of the abiotic environment (e.g., soil nutrients), the entire community (e.g., total biomass of key players such as plants), and ecosystem functions (e.g., nutrient cycling) (see arrows 1, 2, and 3 in Fig. 1). The direction of feedback determines ecosystem resilience and the likelihood of state shifts among multiple steady states (Scheffer and Carpenter 2003; Folke et al. 2004; Chapin et al. 2009). Competition is sometimes, but not always, involved in the feedback loop (e.g., competition for resources and space among functional types, Berendse 1994; McCook 1999).

From a basis in community ecology, we propose three research directions for a better mechanistic understanding the environment–biodiversity cycle. The first direction would be integrating the processes involved in these three questions to help researchers understand the entire environment–biodiversity cycle. We should incorporate biodiversity into studies of ecological resilience (the third question) by considering the impact of local environmental conditions on local biodiversity (the first question) and the impact of local biodiversity on the local environment via ecosystem processes (the second question). For example, the strength and direction of local control by the community of the abiotic environment (through their ecosystem functions) is not only determined by dominant functional traits (e.g., of plants) but also modified by biodiversity and functional traits in other functional groups (e.g., soil decomposers) (Naeem et al. 2000; Duffy et al. 2007; Miki et al. 2010; Miki 2012). The second direction is to develop our understanding of large-scale community ecology concepts. The roles of competition and other ecological interactions in creating community structure variation and in changing the biodiversity gradient at large spatial scales still remain unclear, but 'global' community ecology is one of several emerging fields in global change biology (Araújo and Luoto 2007; Brook 2009; Gilman et al. 2010). As for the third direction, the development of a quantitative model based on community ecology is necessary; such a model could quantitatively predict the impacts of human activities (Drivers of ecosystem changes, MA 2005) on biodiversity and the impacts of biodiversity changes on ecosystem processes (e.g., Miki et al. 2013). For these new research questions and directions, large ecological datasets will be increasingly important. Therefore, long-term and large-scale ecological observations and experiments will play central roles in community ecology in the next 10 years.

Integrating models of ecosystem services and land use changes

Land-use and land-cover (LULC) change may affect ecosystem function. Ecologists often study and quantify the impacts of land-use changes on ecosystems and their functions. Numerous land-use models, including stochastic, optimization, dynamic process-based simulation, and empirical models, have been developed to simulate the patterns and consequences of LULC for various purposes. The models are classified into different categories. For instance, Parker et al. (2003) designated land-use models as Equation-based, Econometric, Statistical, System, Expert, and Evolutionary models as well as Cellular Automata and Agent-based Models and Hybrid Models.

The conversion of land use and its effects (CLUEs) is a hybrid land-use model that simulates land-use changes using empirically quantified relationships between land use and its driving factors in dynamic land-use modeling (Verburg et al. 2002; Verburg and Veldkamp 2004; Lin et al. 2007). In CLUEs land-use modeling, the allocation of each land-use type is based on a combination of empirical and spatial analyses along with dynamic modeling (Verburg et al. 2002; Lin et al. 2007). However, quantifying all of the potential interactions between the different land uses and drivers in a logistic regression model is difficult for three reasons: (1) the lack of a thorough understanding of all the factors involved; (2) insufficient information about the interactions; and (3) restrictions on the functional form of the logistic regression model (Lambin and Geist 2006; Lin et al. 2011). Artificial neural networks (ANNs) consider any nonlinear complex relationship between the drivers and land uses (Pijanowski et al. 2002, 2005; Dai et al. 2005) without additional information or functional forms and have been applied in land-use change modeling (e.g., Pijanowski et al. 2005; Almeida et al. 2008; Liu and Seto 2008).

The *Slope, Land use, Excluded land, Urban extent, Transportation, and Hillshading* (SLEUTH) model combines an urban growth model with the land-cover change model developed by Clarke (Clarke 1997; Lin et al. 2008), which generates multiple simulations of the growth of cities using Monte Carlo routines (Lin et al. 2008). SLEUTH is a bottom-up simulation model that uses adaptive cellular automata to simulate the growth and environmental changes of cities. Moreover, in urban growth module, urban dynamics are simulated using the growth rules of SLEUTH (Claggett et al. 2004). Agent-based modeling (ABM) is widely used to simulate land-use changes that result from variations in individual decisions and actions (Matthews et al. 2007; Parker et al. 2003; Robinson et al. 2007; Valbuena et al. 2010). Because ABM defines different decision-making units or agents, it can model the interactions between humans and natural systems (Valbuena et al. 2010) and simulate land-use changes. However, SLEUTH and ABM can be classified as bottom-up models. In addition to models designed to explore possible land-use change under plausible scenarios in the near future, policymakers determine the optimal land-use configurations in terms of costs and effects using various tools (Loonen et al. 2007; Lin et al. 2009). A land-use model based on a spatial pattern optimization could be used to complement and support landscape conservation design and planning (Duh and Brown 2005; Loonen et al. 2007; Lin et al. 2009).

Ecosystem services are the benefits that humans derive from ecosystems (MA 2005). The *Millennium Ecosystem Assessment Report* (2005) categorized ecosystem services into four groups: supporting, provisioning, regulating, and cultural services. Recently, the importance of research into ecosystem services has been widely recognized. The mapping of ecosystem services is regarded as a key element in having institutions and decision-making bodies recognize the value of ecosystem services (Daily and Matson 2008; Burkhard et al. 2009). In recent years, many scientists have developed approaches for mapping ecosystem services (e.g. Troy and Wilson 2006; Egoh et al. 2008; Naidoo et al. 2008; Burkhard et al. 2009; Nelson et al. 2009; Tallis and Polasky 2009).

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) and *Artificial Intelligence for Ecosystem Services* (ARIES) are Geographical Information System (GIS)-based ecosystem services tools (Vigerstol and Aukema 2011) used to map ecosystem services across landscapes. InVEST 2.1 beta version was developed by Tallis et al. (2011). It comprises a suite of models that use LULC patterns to estimate the levels and economic values of ecosystem services, biodiversity conservation, and the market values of commodities provided by the landscape (Nelson et al. 2009). InVEST models are spatially explicit, use maps as information sources, and produce maps as outputs (Tallis et al. 2011). ARIES (Villa et al. 2009) is a web-based tool used to map ecosystem services. It allows users to evaluate trade-offs among ecosystem services and to identify stakeholders who may benefit from services in a study area (Vigerstol and Aukema 2011). Moreover, ARIES identifies relationships between user input data and ecosystem service values using probabilistic Bayesian networks. To map beneficiaries, ARIES can often be run with a single spatial data layer or simple GIS operations rather than Bayesian networks (Bagstad et al. 2011). However, there is a dearth of spatially-explicit values of ecosystem services across landscapes that might inform land-use and management decisions (Balmford et al. 2002; MA 2005; Nelson et al. 2009), so further studies are needed.

Recently, a multi-disciplinary research community has identified the goods and services provided by ecosystems in sites scattered across the world (Nelson and Daily 2010). By understanding how changes in LULC and land management cause changes in ecosystem services across a landscape, researchers (e.g., Nelson and Daily 2010) can design and implement policy interventions to improve ecosystem service values and marketed economic returns on the landscape. However, LULC models have been widely used in modeling LULC changes. Ecosystem service modeling is just beginning to be applied in the policy arena (Nelson and Daily 2010). GIS is a potential tool that can be used to model, analyze, and map ecosystem services and LULC for land management and conservation planning. For instance, InVEST and ARIES are both GIS-based models. Thus, integrating models of land use and ecosystem services in a GIS-based platform provides essential information used in land-use and conservation planning and management; this method can simulate land-use changes and their effects on ecosystems and ecosystem services or functions.

Disaster resilience and coastal ecology

The coastal areas of northeastern Japan were heavily damaged by the 11 March, 2011, mega-earthquake and tsunami. We realized how vulnerable human society, even in highly-developed countries, is to catastrophic disasters that occur on time scales of hundreds to thousands of years. How can we, as ecologists, contribute to enhancing the resilience of damaged coastal ecosystems and help local societies recover after such a disaster? The major goals of natural science are to quantitatively assess and evaluate the impacts of such catastrophic events on ecosystems and to estimate the ecosystem resilience. Based on the scientific data collected after such disasters, we can then make sound proposals to local communities, stakeholders, and decision-makers to improve rehabilitation plans.

One of the difficulties in effectively assessing the impact of catastrophic events such as tsunamis is that quantitative data on ecosystems are not always available prior to the disturbances because they are unpredictable. Long-term monitoring data of biodiversity and ecosystems collected prior to such events, if they exist, allow evaluation of the impact through before/after comparisons (Whanpetch et al. 2010). A long-term ecosystem monitoring program, entitled *Monitoring Sites 1000*, covers three coastal sites on the Sanriku (northeastern Tohoku) coast that were heavily affected by the tsunami. By continuing the same type of monitoring after the tsunami, we could quantitatively examine its impact on these sites. The tsunami's impact was remarkably variable among habitat types. A tidal flat in Fukushima and two seagrass beds in Iwate were heavily impacted by the tsunami, with a large decrease in species diversity and in the abundance of major organisms, whereas the diversity and abundance of an algal community in Miyagi did not change greatly after the tsunami. The level of impact varied even within a single seagrass bed in areas with different depth gradients and topographical settings. Large differences within a small spatial scale were also reported in the impact assessment of the 2004 tsunami along the Andaman Sea coast of Thailand (Whanpetch et al. 2010). Similar tsunami impact assessments have been ongoing by various marine scientists and fisheries researchers who have been studying the areas since before the disaster happened (Urabe et al. 2013; Takami et al. 2013). Mate analysis incorporating these individual studies across a large spatial extent and diverse environmental gradients provide promising ways to understand general characteristics of how the tsunami's impacts and subsequent recovery processes varied.

A further challenge to ecologists is to develop a way to effectively use our science-based knowledge for decision making for and by coastal human communities, such as designing rehabilitation plans to maintain coastal biodiversity and effectively restoring marine resources. Some ongoing attempts include plans to develop marine protected areas (and their potential candidates), to enhance recovery of severely-damaged habitats using surviving local populations, and to establish new management plans for fisheries and aquaculture that are reasonably sustainable over the long run.

A recent highlight in ecology is that the ecosystem connectivity among different types of adjacent habitat, such as between forest and river or between terrestrial and marine ecosystems, is seen to play an important role in structuring the biological community and material flows in each system (Polis and Hurd 1996; Nakano and Murakami 2001). Incorporating the concept of connectivity can contribute to better rehabilitation planning in damaged coastal areas. In most coastal areas of Japan, including the Sanriku regions, natural connectivity among terrestrial, river, and marine ecosystems had been substantially lost since the mid-20th century with the expansion of industrial activities such as reclamation and the construction of ports and embankments along the coastline (Shikita and Koarai 1997). The tsunami damaged these man-made structures, which ironically led to the recovery of natural connectivity in some areas. Scientists, environmental administrators, and some local citizens are working together to incorporate these newly recovered ecosystem links into rehabilitation plans to enhance the resilience of coastal ecosystems and their services; for example, some guidelines established by the Ministry of the Environment illustrate this technique (2013). Our next challenge is to consider how we can incorporate these guidelines into actual rehabilitation plans at each local site. Discussion with local stakeholders, decision makers, and other interested persons is required for fairness in the development of coastal rehabilitation plans that consider the conservation of biodiversity and sustainable use of ecosystem services in damaged areas.

In conclusion, ecologists can contribute to enhancing the disaster resilience of areas affected by the tsunami in a variety of ways, ranging from a general understanding of the tsunami's impacts on marine ecosystems to the use of new science-based knowledge for rehabilitation activities at various levels (local, regional, and national). The achievements are worthwhile not only for increased resilience in disaster-damaged regions in northeastern Japan but also for other regions of the world where catastrophic events will occur in the future.

Past and future of ESJ; sketches of questionnaires and discussions during the 60th anniversary symposium

During the discussion session of the 60th anniversary symposium, the past achievements and future directions of ESJ were discussed by the panelists and audience. To facilitate this discussion, the organizing committee collected various opinions from ESJ members and used a web-based questionnaire distributed with the meeting announcement via the ESJ mailing lists to ensure that a diversity of perspectives were considered. Sixty-three ESJ members responded to the questionnaires between 19 December, 2012, and 4 March, 2013. The questionnaire asked the following four questions:

Q1. What major discoveries and significant progress have been made in ecology in Japan during the past decade?

Q2. What research area in ecology in Japan is expected to be emphasized in the coming decade?

Q3. What is the global role of the Ecological Society of Japan?

Q4. Do you believe national policies and the needs of the public affect your research currently?

The responses to the first question highlighted a wide diversity of opinions addressing many aspects of ecology in Japan. The organizing committee of the symposium used a few representative comments to facilitate discussion during the meeting. Some comments addressed long-term advances in ecological research (e.g., Enoki et al. 2007; Ohte et al. 2012), including the improved understanding of non-steady state phenomena. Progress made in the production and use of analytical tools for mega-ecological data was also emphasized (Cornwell et al. 2008; Ishihara et al. 2011). Also, some responders noted the rising popularity of ''biodiversity'' as a common keyword for the ecological community and general public during the last decade (Fujikura et al. 2010; Larigauderie et al. 2012; Vihervaara et al. 2013). Others commented on an abundance of project-based large-scale ecological research studies compared with fewer small-scale studies conducted by individuals (*DIVERSITAS*; IGBP; Kohyama et al. 2007).

During the symposium's discussion, some panelists mentioned that ecologists in Japan are dealing with a wider variety of ecological data, including the long-term monitoring of biogeophysical parameters as powerful indicators of environmental conditions and ecosystem functions (e.g. Ishihara et al. 2011; Iken et al. 2010; Yoshida et al. 2006). The other panelists noted that we have developed and applied various new analytical technologies to ecological research, such as molecular biology (Azuma et al. 2006; Okubo and Sugiyama 2009), remote sensing (Hiura 2005; Yamaji et al. 2008; Nagai et al. 2010), GIS (Ileva et al. 2009; Yoshida and Noguchi 2009), and numerical modeling (Sato et al. 2007; Katsuyama et al. 2009; Miki et al. 2010).

Regarding the future direction of ESJ, some responses to the questionnaire emphasized the need for further progress on biodiversity conservation, ecosystem management, and ecosystem rehabilitation with Asia-wide perspectives to contribute not only to ecological interests but also to societal needs (Nakano et al. 2012). Others pointed to basic and pure ecological studies, such as taxonomy, natural history, physiology, and the clarification of mechanisms within ecosystems, as important research topics. Some insisted that unique research themes that do more than simply copy those in the United States and Europe should be critical to ecological studies within the ESJ and also in the international research arena. The panelists also addressed the need to ensure that future ecological studies in Japan cover diverse research areas (i.e., basic and applied research and collaborative- and individual-based projects) with unique research questions, hypotheses, and topics. One panelist emphasized the need for ESJ and Japanese ecologists to be more engaged in international networks (e.g., Shibata and Bourgeron 2011) by sharing data and analytical tools to create new concepts and findings.

Contributions by the audience at the symposium included the needs to improve the educational system, establish core stations for integrated ecosystem–biodiversity–climate change research, help young scientists become involved in global research trends such as *Future Earth*, and appeal to multidisciplinary and cross-site research findings for the general public and society. The ESJ members provided suggestions, comments, and opinions on how national policies and the needs of the public have been affecting their research. Many challenges lie ahead for ecological research and outreach, especially in Asia, with its highly diverse ecosystems that include natural and human-modified landscapes. Useful tools are now available that improve the resolution and accuracy of data collected and analyzed by ecologists. The activities of the individual are of supreme importance both for the pure science of ecology and for the application of ecological principles. In addition, the importance of the roles of ESJ was recognized, as was the importance of the relationships between ESJ and the research studies of its members. We hope the symposium will be a landmark of interactive development among ESJ members, ESJ, and all people concerned.

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