will ultimately need to include this important and common type of interaction.

Brooker and Callaghan focus attention on important issues that will need to be resolved before we truly understand the nature and dynamics of plant communities. Their perspective on positive plant–plant interactions, however, also points to the need to consider how physical stress affects plant interactions and influence general attempts to understand plant community configurations across gradients of physical stress and natural disturbance, where stress and disturbance are independently and simultaneously manipulated, will be necessary to resolve these important issues.

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Transcending boundaries in biodiversity research

Neither species nor ecosystems recognize the borders of nations or the boundaries of scientific disciplines. Therefore, the development of effective research, assessment and management strategies for contending with the ecological consequences of global declines in biodiversity will require both international and trans-disciplinary efforts. The Biodiversity and Ecological Complexity workshop held in Kyoto, Japan last November represents the most recent in a series of such international, multi-disciplinary efforts for fostering exchange and collaboration among scientists studying declining biodiversity. Sponsored by Kyoto University’s Center for Ecological Research (CERKU) and the Japanese Ministry of Education, Science, Sports and Culture, the workshop brought together 20 speakers and more than 20 additional participants from Japan, other Western Pacific and Asian countries, Europe, North America, and Australia to review key issues in the ecological dimensions of biodiversity. Masahiko Higashi (CERKU), the conference’s principal organizer, assembled speakers to address key issues examined from both a theoretical and empirical perspective.

The importance of ecological heterogeneity

The multiplicity of roles ecological heterogeneity plays in the generation and maintenance of biodiversity was made clear by its recurrence as an important factor in many of the presentations. Higashi reviewed theoretical evidence for the importance of environmental heterogeneity in modes of speciation, while Simon Levin (Princeton University, NJ, USA), using similar theoretical approaches, showed the importance of spatial heterogeneity in co-existence among species.

Several different forms of ecological heterogeneity were discussed. Kansyu Momose (CERKU) discussed the importance of climatic variability (abiotic ecological heterogeneity) as a factor that accounts for the low degree of specialization among pollinators in Western Pacific dipterocarp forests. Noro Yamamura (CERKU) discussed how diverse strategies among plants for defense against herbivory (biotic ecological heterogeneity) leads to the evolution of diverse herbivore strategies for surmounting such defenses. Kansyu Moe (Kyoto University, Japan) presented a detailed example of such co-evolutionary processes between plant viruses and their hosts. Finally, Moritaka Nishihira (Tohoku University, Japan) showed the importance of coral reef-dwelling organisms which modify microhabitats (biotically induced habitat heterogeneity) as a key factor in maintaining coral diversity. In contrast to these presentations, however, David Burslem (University of Aberdeen, UK) showed that long-term coexistence among tree species in the Solomon Islands can be remarkably constant despite environmental heterogeneity. Species distributions are also associated with gradients in environmental heterogeneity. For example, Hiroshi Takeda (Kyoto University) showed that leaf-litter communities along a latitudinal gradient from subalpine/boreal forests in Japan to tropical forests in Thailand and Malaysia are organized by a gradient in shifting distributions of carbon and nitrogen from soils in the north to above-ground biomass in the south. Allen Herre (Smithsonian Tropical Research Institute, Panama) provided a picture of organization along a biotic gradient rather than an environmental gradient. Fig trees and their seemingly incomprehensibly complex nematode–wasp–mite–fungus–ant–bat communities reveal a strong pattern of organization along a biological gradient from small to large-fruited trees. In contrast, Richard Law (University of York, UK), argued that some patterns in diversity reflect the result of intrinsic assembly rules independent of the influence of the environment, and he provided a detailed example using microbial communities.

Linking species diversity and ecosystems

A critical issue in contemporary biodiversity research is to understand how biodiversity loss may impair the functioning and stability of ecosystems. Five presentations reviewed this issue.

Michel Loreau (Ecole Normale Superieure, Paris, France) provided models for plant production in terrestrial ecosystems which, based on local nutrient depletion zones, predicted the well known asymmetric relationship observed between plant production and species diversity. Using a different approach, Shigeo Yachi (Ecole Normale Superieure) demonstrated that when production responses of plants to environmental heterogeneity varies among species, variability in production decreases, while overall levels of production can increase. Shahid Naem used still another approach, combining models and microbial microcosm experiments to demonstrate that when the numbers of species per functional group increases,
The human dimension

HUMAN WELLBEING IS INTimately CONNECTED TO Ecosystem functioning, but the human dimension of biodiversity issues remains unclear. Several presentations provided insights into this dimension.

Although aquatic ecosystems represent only a minor component of the biosphere, from the standpoint of human needs they are perhaps the most critical. Jotaro Urabe (CERKU) noted that over 40 million people rely on Japan’s Lake Biwa alone for fresh water. Urabe showed, however, that the quality of Lake Biwa water is strongly regulated by the community of organisms in the lake. Similarly, Zen’ichiro Kawabata (Ehime University, Japan) provided evidence that pH buffering capacities of aquatic ecosystems may be a function of the level of diversity of organisms found in the water.

Measure of biodiversity may also serve as indicators of environmental quality. Roger Kitching (Griffith University, Brisbane, Australia) demonstrated that macro-biodiversity could serve as reliable indicators for “rapid” biodiversity assessments of habitat disturbance. Finally, Katsuyoshi Fujii (Kyoto University, Japan) provided a unique portrait of human cultural linkages with biological diversity with his studies on the Bodi of Ethiopia.

Whither biodiversity research?

Given the enormous scale of the issues, what directions should biodiversity research take? Takoya Abe (CERKU) and Eitaro Wada (CERKU) presented biodiversity initiatives in the region, in particular DIWPA (The International Network for Diversitas in Western Pacific and Asia) and CERKU’s DIVER (Diversity and Ecosystem Relationships). Wada noted that these programs can trace their roots back as far as 1996. This overview of BIP (1965) on through MAB, WCRP, IUOB, Diversitas and UCTE, and most recently BDP. Such programs are rapidly becoming the primary means for international evaluations of large scale environmental issues.

Such large-scale efforts may be an unfamiliar direction for ecology and evolution, which have traditionally emphasized the primacy of individual effort. Other disciplines of biology, however, have discovered the necessity of collaborating to address large-scale issues (for example, 150 researchers from 12 nations co-authored a recent paper describing the genome sequence of a single species of non-pathogenic bacteria). Western nations have begun such large efforts such as BODEPTH in Europe and the Ecotron in England. With DIWAS in the Western Pacific and the Symbiotron (a device like the Ecotron) under planning at CERKU, the Eastern nations are moving in a similar direction.

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