

stream patterns in autotrophic and detrital respiration, standing stock of C in fine and coarse woody debris, total C inputs, and other ecosystem properties. Landscape position is not so easily scaled for wetlands. Geographic patterns of wetlands range from the disconnected bogs of glaciated terrains to the highly connected wetlands along low-gradient rivers on the Coastal Plain of the southeastern United States. Johnston and Naiman suggested scaling landscape position in relation to the balance between streamflow and rainfall as water and nutrient sources. Rainfall-fed wetlands tend to have lower productivity than wetlands deriving most of their water from more nutrient-rich surface and subsurface sources.

This collection of talks offered a broad spectrum of insights into effects of geomorphology on ecosystem properties, although no examples came for steep, high-relief mountain landscapes where geomorphic effects might be most pronounced. Emphasis varied greatly—landform effect on microclimate and soil properties is strong in high latitudes; influence of landscape position on water and nutrient flow was highlighted in desert, wetland, and river environments. Perhaps the richest set of examples of important geomorphology–ecosystem interactions came from the low-relief, shortgrass prairie environment, which at first glance appears simple, but actually involves a complex overlay of landform effects on wind, water, and animal transfers of soil, carbon, and nutrients.

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SCALE OF MEASUREMENT IN ECOLOGY

Avian Community Ecology: The Importance of Scale. A symposium organized by Brian A. Maurer. Cooper Ornithological Society Annual Meeting, University of California, Davis, CA, September 1986.

Brian Maurer (Brigham Young University) introduced this symposium by defining "scale" as a progressive graduated series along some physical (mass, space), temporal, velocity (rate, speed, frequency), or allometric dimension. He noted that our simplis-

tic theories do not presently account for processes that operate on many scales simultaneously, and that we need to begin to incorporate such considerations into community analyses. The success and stimulating nature of this afternoon symposium could be evidenced by the high level of attendance (close to 200) from the beginning to the end, and by the nature of conversations during breaks after the symposium took place.

In his overview of the problem of scale in avian ecology, John Wiens (Colorado State University) reiterated his published warnings that the answers to ecological questions will vary with scale of measurement. Later, James Karr (Smithsonian Tropical Research Institute) provided information from his tropical understory bird "community" that attested to this fact; the richness and temporal variability associated with his bird species counts were strongly scale-dependent. So, which scale of measurement is correct? Wiens made several suggestions about how some questions clearly dictate the necessary scale of measurement, and William Calder (University of Arizona) outlined how we will need to consider such questions from the organism's perspective because of the relationship between the relative "patchiness" of an environment and the body size of an organism.

One of Wiens' earlier contentions was that processes operating at one scale of resolution cannot be blindly extrapolated to explain patterns at another scale of resolution because of the scale-dependent nature of patterns and processes. Wiens concluded here, however, that epistemological interdependencies between scales mean that we are going to *need* to use processes at one scale to answer questions about patterns at another. The challenge for field ecologists was clear.

Using data from their long-term study, which comes as close as any to meeting the above-stated challenge, Tom Sherry (and co-author R. T. Holmes, Dartmouth College) argued that conditions are more-or-less limiting most of the time for the birds at Hubbard Brook, and that release from competition for food due to insect outbreaks might actually be the rare events (a mirror image of Wiens' "ecological crunch" hypothesis). The population sizes of birds appear to be products of both local-scale events and events far removed in space and time, necessitating an

integration of multiple-scale effects simultaneously to gain an understanding of the population dynamics of forest bird communities.

In a thought-provoking experimental study, Barry Noon (and co-authors S. Droege and K. Purcell, Humboldt State University and the Patuxent Wildlife Research Center) introduced a difficult applied problem: How does one determine an appropriate scale of manipulation to use for testing questions about community structure? In their own study, herbicide-induced removal of the understory vegetation from a 20-ha plot produced no changes in the numbers or the nesting success of birds on the plot relative to a control plot. Extrapolation of results from small-scale perturbations to large-scale operations will be difficult at best.

Frances James (Florida State University) stimulated more discussion immediately following and long after her presentation than any other participant, I would guess. If I'm not mistaken, her main thesis was that communities as functional units do not exist. If no more than two or three species occur the year around with, say, Red-cockaded Woodpeckers, then where's the community? Nobody argued that communities were functional units, but there was rebuttal to the line of reasoning that interactions among species were therefore unimportant. She further suggested an autecological "envirogram" approach to studying selected species, but the utility of such an approach was also questioned. In short, she added a lot to the symposium. The relevance of scale in this particular instance was not entirely clear to me, but I believe her point was that the local conditions that individuals face vary tremendously from one individual to another, and therefore large-scale community parameters will bear little relevance to the individual.

For an interesting twist, Tom Strong (and co-author C. E. Bock, University of Colorado) showed that the relationship between geographical extent in distribution and abundance of a species is independent of scale of measurement. From this they concluded that the abundance of a widespread species is not entirely a product of local conditions, and that our attempts to understand community-level patterns will necessarily be confounded. Their data are considerably open to alternative interpretation, however.

Brian Maurer concluded with a discussion

of how most models used in community ecology include linear, "averaging" variables (like r) that hide much of the small-scale variation in time and space. The small-scale variation is important, however, in determining the population dynamics of a species. A hierarchical approach that deals with processes on different time scales may be a viable alternative for the study of community structure.

In summary, no scale of study is inherently "best" for field ecologists; the simultaneous consideration of multiple answers from different scales may provide insights that would otherwise be difficult to attain. The real challenge for field ecologists will be to demonstrate how a pattern or process at one level might have consequences at another level of organization. Recognizable patterns at the community level are not necessarily the result of population- or community-level processes. Another recurrent theme throughout the symposium was that scale should be studied as a topic in its own right, and not simply recognized as important, period. This symposium provided a prelibation of the excitement that should continue to surround community ecology for some time to come.

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MICROBIAL ECOLOGY

Fourth International Symposium on Microbial Ecology. Ljubljana, Yugoslavia, August 1986.

The Symposium attracted 760 participants from 40 countries, providing a unique opportunity for microbial ecologists of all ages from countries throughout the world to meet and exchange information relating to their shared interests.

The program featured 20 morning sessions of invited speakers on selected focal topics that included extreme environments; trends in microbiological theory; unusual microorganisms; anaerobic interactions; ecology of fermented foods; human pathogens in the environment; and microbial activity and influence in the gastrointestinal tract. There also were sessions on more traditional subjects such as marine microbiology; cycling of