conceptual approaches of insect biological control: (1) classical biological control, an approach in which non-native biological control agents are introduced for permanent establishment to provide long-term control of a specific host; (2) inundative biological control, a method whereby mass-produced strains of fungi are applied for immediate control; and (3) conservation biological control, a strategy in which agricultural and adjacent environments are manipulated to enhance resident populations of microbial biological control agents.

In summary, *The ecology of fungal entomopathogens* is an excellent reference and timely update for insect mycologists and fungal ecologists alike that will challenge this research community to delve more deeply into the hidden lives of insect pathogenic fungi.

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Making sense of a complex world

Schmitz, Oswald. 2010. **Resolving ecosystem complexity.** Princeton University Press, Princeton, New Jersey. $65.00 (cloth), ISBN: 978-0-691-12848-1 (alk. paper); $35.00 (paper), ISBN: 978-0-691-12849-8 (alk. paper); $35.00 (e-Book), ISBN 978-1-4008-3417-4.

Key words: complexity; food webs; landscape of fear; trophic dynamics.

Ecosystems are the epitome of complex systems. Despite having innumerable actors engaged in a bewildering array of interactions, patterns are evident to even casual observers. More careful analysis reveals predictable processes that may be transient and contingent on species composition and site history. A central focus of ecological research is to make sense of these patterns and to characterize the processes that underlie them. One ultimate goal of ecological research is to use this information on pattern and process to forecast future conditions, at least in the short term, so as to determine sustainable levels of interaction between humans and non-humans. This is a tall order, and one that is continually bedeviled by the complexity of ecosystems. In this short (142 pages of text and figures), readable, and engaging book, Os Schmitz provides a framework for understanding the complexity of ecosystems in light of ecological and evolutionary contingency.

This is a "big-picture" book. Rather than building an intellectual edifice piece by piece from many small observations—Schmitz uses the analogy of a jigsaw puzzle being completed by fitting pieces together and assembling small subsections—*Resolving ecosystem complexity* starts with a set of a priori rules and a sense of how the world works. These a priori rules generate a model of the world and not every detail (or puzzle piece) is needed to understand how the model works. At the same time, Schmitz recognizes that taking this second, "strategic" path can lead to many blind alleys, especially if the a priori world-view is inconsistent or wrong. But even if many of the pieces are neither needed nor places in the overall puzzle, the big picture that emerges by the end of *Resolving ecosystem complexity* is ultimately satisfying, just like the feeling one gets from looking at a successful impressionistic painting.

The fundamental axiom of ecology that Schmitz identifies is that ecosystems are made of species that consume resources and that in turn are consumed. This simple truth, so obvious that it is rarely remembered, much less mentioned, drives virtually all ecological patterns and processes. Most importantly for this book, looking at the world through trophic-colored glasses allows Schmitz to make straightforward links between population and community ecology on the one hand (through studies of single-species resource consumption, predator-prey interactions, and food web structure and dynamics) and ecosystem ecology on the other (through studies of movement of energy and nutrients through food webs, both producer- and detritus-based). Although certainly not a new observation—important antecedents include Stephen A. Forbes' 1887 paper "The lake as a microcosm" (*Bulletin of the Scientific Association*, pp. 77–87), Raymond L. Lindeman's [1942] "The trophic-dynamic aspect of ecology" (*Ecology* 23:399–418), and Donald L. DeAngelis's [1992] *Dynamics of nutrient cycling and food webs* (Chapman and Hall, New York)—it bears repeating. The increasing specialization by ecologists on small parts of the ecological universe and the concomitant proliferation of journals, blogs, and wikis dedicated to each piece of the ecological jigsaw puzzle make it all too easy to ignore or forget fundamental ecological principles and similarly easy to overlook observations and results that can unify subfields and provide substantive scientific advances.

By linking temporal and spatial contingency, evolutionary dynamics of consumer-resource interactions and food webs, and flows of matter and energy through ecosystems, Schmitz creates a compelling argument that it is indeed possible, in principle, to develop a predictive understanding of ecosystem complexity. But Schmitz has taken this idea one very important step further. He has spent nearly two decades experimentally testing these ideas and the hypotheses they raise in a grassland meadow in northeastern Connecticut. Contemporary ecologists increasingly argue that manipulative experimental studies are inadequate to address large-scale ecological questions and environmental issues. In contrast, Schmitz shows us clearly that only experiments, unlike correlations drawn from observations, can provide strong and compelling evidence for cause and effect. His own work further demonstrates that small-scale studies of spiders, grasshoppers, and plants in a small grassland meadow can be used to accurately forecast and manage how wolves, deer and moose, and aspen and spruce interact in a "landscape of fear." Such scaling from the plot to the landscape, made possible by strategically testing general ideas in specific systems, is what will define ecology not only as a predictive science but also as a useful one.

Two additional ideas emerge in *Resolving ecosystem complexity*. The first is the concept of a habitat domain, which

considers species' habitat use not only in terms of choice of microhabitat occupied but also by measuring the extent of spatial movement within the chosen microhabitat. The intersection of how consumers find food (e.g., actively searching or sit-and-wait predators) and how potential prey avoid being eaten plays out in the habitat domain, and incorporates both effects of traits and idiosyncrasies of individual species. This idea leads to testable predictions at both population/community and ecosystem levels; subsequent manipulations of the relative abundance of species (or functional types) within habitat domains immediately leads to changes in, for example, plant species composition and in measurable ecosystem properties (such as primary production, decomposition, and nutrient mineralization).

Second, Schmitz extends G. Evelyn Hutchinson's metaphor of the ecological theater and the evolutionary play. In its original conception, the time-scales of ecological dynamics (fast) and evolutionary change (slow) were completely separate and non-overlapping. Here, Schmitz emphasizes that the time-scale of the play also can be fast, occurring in evolutionary-ecological time. Although the focus here is on phenotypic variation and phenotypic plasticity, thus freeing individuals from the fixed (Hutchinsonian) roles prescribed by their evolutionary history, more could be made of the observation that species can evolve very rapidly—indeed, in ecological time—in predator-prey systems.

As Schmitz rightly concludes, there is yet much to be done to develop a predictive mechanistic understanding of contingency in ecological systems. We need many more detailed natural history observations and careful manipulative experiments that are clearly linked to overarching synthetic theories. In *Resolving ecosystem complexity*, Os Schmitz has shown how productive this approach can be. This book would be a great starting point for undergraduates considering careers in ecology and is a goldmine for graduate students looking for dissertation topics. But most importantly, this book reminds all of us that we can indeed understand the complexity of ecological systems.

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Spotlight

Recent Publications of Interest

Burrows, Anne M., and Leanne T. Nash, editors. 2010. **The evolution of exudativory in primates.** Developments in primatology: Progress and prospects. Springer, New York. xxi + 303 p. $179.00 (cloth), ISBN: 978-1-4419-6660-5 (acid-free paper). Did you know many primates feed by scraping plant surfaces for underlying exudate? This book, the result of a symposium held at the 2008 Congress of the International Primatological Society, elaborates on this topic by including chapters on many diverse fields such as ecology, morphology, nutrition, and conservation. Targeted at upper-level undergraduate and graduate-level primatology courses, it attempts to synthesize our current knowledge of this unique dietary niche with input from leading researchers in the field of primatology.

Zimmer, Carl. 2010. **The tangled bank: an introduction to evolution.** Roberts and Company, Greenwood Village, Colorado. vii + 385 p. $59.95, ISBN: 978-0-9815194-7-0. Zimmer is a science writer and had four "scientific advisors" in producing this text. The topics include evidence for evolution, mechanisms of evolution, speciation, adaptive radiation and extinction, interactions between species, sexual reproduction, evolutionary medicine, and behavior. Each chapter begins with a word picture describing the work of an evolutionary biologist and includes a rich array of color photographs and diagrams.