per hectare. These estimates are conservative, however, because there are no reliable data on belowground NPP in mangrove forests. Isotope studies reviewed by Robertson et al. illustrate that dependence of nearshore fisheries on mangrove-derived carbon varies greatly with location and hydrodynamic regime.

The importance of herbivory in mangrove carbon cycling, also reviewed briefly by Robertson et al., has received experimental attention only in the last five years. With the exception of fisheries dynamics (reviewed by A. I. Robertson and S. J. M. Blaber), population and community ecology of animal communities associated with mangroves has received scant attention. Recent studies of the mangrove benthos (reviewed by D. M. Alongi and A. Sasekumar) should address this historical lacuna and greatly improve the precision of mangrove ecosystem models.

Nutrient cycling in coastal wetlands is understood much better in temperate-zone salt marshes than in mangrove ecosystems, and nutrient cycling dynamics in the latter have been extrapolated from studies of the former. Alongi, Boto, and Robertson comprehensively summarize all available information on nitrogen and phosphorus cycling in mangroves. Their chapter presents a detailed nitrogen budget for Hinchinbrook Island, the only mangrove swamp for which a complete nitrogen budget has been constructed. Alongi et al. illustrate clear differences between salt marshes and mangroves in the process controlling nitrogen cycling, but generalizations depend on similarly detailed studies in other mangrove forests.

Mangrove forests occur in regions where annual population growth ranges from 1.3% to 3.8%, and development pressure on these forests is intense. For example, mangroves are used for charcoal, timber, honey, and ethanol, and they support lucrative fisheries. Yet, in his concluding remarks, Robertson states that scientific knowledge has not advanced the cause of sustainable management of most mangrove forests. The reasons are hauntingly familiar: lack of basic scientific information, overemphasis on curiosity-driven research, and a lack of willingness of scientists to place their results into a management framework. The AIMS researchers are attempting to bridge the gap between basic research and ecosystem management, and this book serves as an example for those interested in building such bridges.

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CLIMBING INTO THE BIG PICTURE


Scientific advancements are often marked with a restless tendency to stray from the core issues of a discipline and probe the boundaries for expansion. In biology, such forays often originate in the needs of disciplines at higher scales, which seek the reductionist view for the purpose of organizing higher-scale phenomena around generalized patterns or processes. This pattern can be evoked to describe the recent birth of molecular systematics and the older birth of physiological ecology.

Scaling Physiological Processes, an edited volume by J. R. Ehleringer and C. B. Field, reflects one such pattern, in this case an expansion of plant physiological ecology to meet the needs of ecosystem ecology in seeking a mechanistic understanding of biogeochemical cycles and their role in global processes. Plant physiological ecology is that discipline concerned with the functional determinants of plant growth and persistence. Traditionally, studies in the field have focused on carbon-dioxide and water-vapor exchange across leaf surfaces. Reflecting the discipline as a whole, this book describes the means by which such gaseous exchanges can be aggregated from the single-leaf to the global scale. The articles were originally presented at a workshop on the topic of biological scaling in Snowbird, Utah, in December 1990.

This seminal work represents the first synthetic formulation of approaches to bring plant ecophysiology into the larger arena of earth systems sciences. It is groundbreaking in this respect. The book successfully accomplishes the task of defining the process of aggregating patterns at one scale to feed the inputs of higher scales. It provides a thorough review of the concepts and approaches that ultimately lead to successful scaling studies. However, when it comes to actually defining new scaling paradigms, the book takes more the tack of cobbling together existing ecological theories than creating a new, tight conceptual framework.

The book is divided into five parts that do not appear to fit the same logical scale (leaf to globe) espoused in the title. Rather, the grouping of chapters wanders, reflecting more the strengths of the contributors than an editorial strategy designed to define the leaf-to-globe hierarchical approach.

The strength of the book falls in a series of six chapters grouped within the section titled “Leaf to ecosystem level integration.” These chapters lay down the leaf-to-canopy and leaf-to-ecosystem approaches that have been so successfully developed by the individuals (J. Norman, D. Baldocchi, P. Jarvis, J. Reynolds, and S. Running) who have been at the core of scaling for many years.

For those readers interested in an overview of the factors that matter most in leaf-to-ecosystem scaling, they need look no further than these chapters. They provide beautiful lessons in some of the modeling shortcuts required to match the input of one scale with the output of another. Examples include J. Norman’s exploitation of the correlating re-
rationship between absorbed solar radiation and canopy carbon dioxide assimilation. D. Baldocchi's exploitation of eddy transfers within canopies to measure canopy trace-gas exchange, and S. Running and R. Hunt's exploration of phenom-
enology as a means of matching scale inputs and outputs. J. Reynolds, D. Hilbert, and P. Kemp provide infor-
mative discussions of the compromises involved in developing eco-
system models; the differences among mechanistic, empirical, and phenomenological models; and the potential problems with emergent properties in working among different scales.

What is missing from this section, however, is a clear compara-
tive discourse that brings to light the relationship of the mechanistic approaches adopted by those con-
cerned with describing instantaneous canopy-level fluxes, to the more phenomenological approach adopted by those concerned with integration over longer time scales. For example, the approach described by Norman and Baldocchi focuses on mesoscale processes such as those that occur in the canopy, with less regard to how one aggregates such units (e.g., separate forest stands) to describe eco-
system-level processes. Running and Hunt, on the other hand, jump di-
rectly from the leaf to the ecosys-
tem, essentially skipping all levels in between. One can glean these differ-
ces by reading the chapters and deriving one's own comparative analysis. However, given the germi-
inal nature of this book, a compara-
tive structure to this section would have laid the foundation for future integrations among these ap-
proaches. Also missing is consider-
ation of those models so useful in scaling across time, for example, CENTURY. In fact, temporal scaling is underrepresented throughout the book.

The reader will also find interest-
ing the section entitled "Functional units in ecology." Both F. Bazzaz and F. Chapin provide timely syn-
thetic reviews of ecological para-
digms concerning the role of indi-
vidual plants and species in influencing higher-scale phenomena, such as competition and community dynamics, and the response of plant growth to resource availability and its influence on ecosystem-level carbon, nutrient, and water fluxes.

J. Clark provides an excellent in-
tegrative chapter that truly reflects the theme of the book, discussing specific quantitative approaches to aggregating species differences in growth rate into community-level processes. This chapter is one of the few that take on the issue of emerg-
ent properties as a complication to moving among scales. This issue appears to be one of the keys to developing a broad framework of scaling, but it tends to be underrep-
resented in the book. One of the novel proposals to come from this section on leaf-to-ecosystem-level integration is the grouping of spe-
cies into form-function categories as a means of organizing vegetation into functional units large enough to be used in the description of eco-
system-level processes.

One disappointing aspect of the book stems from the section on glo-
al and regional processes. The prob-
lem is not so much what is present, but rather what is missing. Chapters by P. Vitousek, P. Tans, P. Jarvis, and R. Dewar provide solid foundations for understanding aspects of scaling at this level. But they hang together loosely without a central theme.

Vitousek provides a strong con-
tribution on the broad strategies used in scaling up from ecophysiology to ecosystems and down from the glo-
bal system to ecosystems. This chap-
ter includes recognition, but no dis-
cussion, of the possible nonadditive effects resulting from the interac-
tions among ecosystems as they in-
fluence regional processes. Once
again, the importance of emergent properties to scaling studies is brought to light but is not devel-
oped in any depth.

Tans provides a specific pitch for the establishment of better empiri-
ical validation of spatial patterns in the global carbon cycle. His pro-
posal for a system of continental sampling sites for improved insight into terrestrial sources and sinks of the global carbon cycle underscores a principal empirical limitation to the global scaling database. Jarvis and Dewar provide a thorough re-
view of the global carbon cycle and

the principal factors causing distur-
bance to this cycle.

Missing from this section, how-
ever, is a clear elucidation of inter-
actions and synergisms above the ecosystem level. The importance of such a perspective is noted in the second paragraph of the chapter by M. Caldwell, P. A. Matson, C. Weissman, and J. Gamon: "scaling represents the transcending concepts that link processes at different levels of space and time" (p. 223). The elucidation of such transcending principles would appear to be the key for the maturation of scaling as a central component of earth system studies. It is the emergent properties of scale and definition of the con-
nections between scales that would appear to determine how units such as ecosystems can be integrated into the global scale, rather than simply aggregated as mathematical sums. The lateral transfer of mass, momentu,

m, and energy, the processes that connect ecosystems into a glo-
bal framework, are ignored. The dis-
cussion also omits three-dimen-
sional atmospheric transport mod-
els, the tools with which to study such connections.

This book represents the first syn-
thesis of physiological-based scal-
ling, and as such it should be consid-
ered a success. It effectively lays the foundation on which the construc-
tion of a unique framework can oc-
cur. Admittedly, it lacks depth in some aspects, and coverage of some topics is missing. This shortcoming was likely due as much to limita-
tions to the size of the workshop from which it was derived, and length limitations on the publica-
tion, as to an oversight in prepara-
tion.

As a result, the book should not be considered comprehensive. It is written for those with previous train-
ing in ecology and plant physiology. This book will be especially useful as an introduction to scaling prin-
ciples and could easily be used as the reference base for senior or gradu-
ate seminars.

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