BOOK REVIEW

P. R. Van Gardingen, G. M. Foody, and P. J. Curran (eds.): 1997, *Scaling-Up from Cell to Landscape*, Society for Experimental Biology, Seminar Series 63, Cambridge University Press, Cambridge, 386 pp.

The term ‘scaling-up’ or ‘upscaling’ can refer either to the process of taking observations made at a series of discrete points and transforming this information into larger scale averages, or to the process of taking models that were originally developed for application to a single point and applying the models to larger spatial domains. Although this might sound simple, upscaling is often quite difficult. When data are scaled up, spatial variability in the phenomenon being measured combined with inadequate sampling can lead to significant errors in large-scale averages or fields. With regard to models, point process models are generally not valid when applied to larger areas. This can be a result of nonlinearities in underlying processes combined with spatial heterogeneity, or due to interactions between adjacent patches that lead to system-scale properties that cannot be captured by the original model. Upscaling is an important problem in a wide range of physical and social sciences that are involved in research pertaining to environmental change (including climatic change).

The book being reviewed here, *Scaling-Up from Cell to Landscape*, presents an excellent overview of the problems of upscaling involving land plants and their role in the carbon cycle, surface climate, and surface hydrology. Both the writing and the figures are of uniformly high quality. The 18 papers in the book fall into the following categories: (i) four overview papers; (ii) four papers dealing with the use of remotely-sensed data; (iii) two papers dealing with the aggregation of point data obtained on the ground; and (iv) eight papers dealing with upscaling of process models (either mathematical or conceptual models). Rather than comment upon every paper in this fine volume, I shall instead make a few comments about selected papers in each of the above categories.

In the overview category, G. R. Squire and G. J. Gibson discuss the role of scale in linking scientific research with the needs of policymakers. They provide an enlightening discussion, from the field of landuse and animal husbandry, of an example whereby an attempt to build a system model by integrating the reductionist understanding of small-scale processes resulted in a model that could not make predictions that were of any use for policy. The problem, as they see it, is that scientists frequently switch from the scales of interest to policymakers to the scales

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of interest to them. Those interested in developing or using so-called 'integrated' assessment models for climate change policy might do well to carefully consider the lessons highlighted in this chapter.

With regard to the use of remotely-sensed data, P. M. Atkinson discusses the issue of relating measurements made on the ground to measurements made from satellites, when the area involved in the former is much less than the latter or involves incomplete sampling of the area seen by the satellite. C. E. Woodcock and others discuss the use of remotely-sensed data in developing parameterizations for use in environmental process models that are to be applied on a grid of points distributed over some area. The problem here is that the correct way to translate remotely-sensed images into model parameter values depends on the scale (and hence resolution) of the image. Recalibration of the transfer function is needed when using regional-scale images to develop regional-scale, distributed parameters. A third paper, by M. J. Barnsley and others, addresses the issue of creating global land cover datasets from satellite imagery. The scaling issues addressed are (i) What classification schemes should be adopted, given that some pixels will be mixtures of different land cover types? (ii) How can land cover maps be validated? and (iii) How can these maps be converted into the scales appropriate for use by mesoscale and global-scale atmospheric models? Several different schemes are discussed.

With regard to upscaling of point data, a paper by J. Weyers and others discusses scaling from the subleaf to the leaf scale when observing stomatal behaviour, while D. Atkinson and R. Fogel discuss the problems in extrapolating sampled measurements of root volume and processes to the ecosystem scale. With regard to stomatal behaviour, there are known instances where a change in relative humidity or in light can cause changes in stomatal conductance that are the same throughout a leaf, and other instances where independent behaviour on different sub-leaf patches is observed. The prevalence of both kinds of behaviour in the field is unknown but is obviously important in modelling the response of plants to changes in atmospheric CO_2 and to climate (at least in the short term, when direct effects might be most important).

This brings us to the largest collection of papers, dealing with upscaling of point process models. The topics covered are: (i) scaling of photosynthesis and transpiration from leaves to the canopy, (ii) explaining and predicting plant community properties based on the attributes of the component species; (iii) aggregating surface-air heat and moisture fluxes up to the GCM grid scale; (iv) simulating regional effects of climatic change on crop production, given that data and sites used for the parameterization and validation of crop models are apparently not representative of overall regional conditions in most cases; and (v) scaling hydrological processes from the landscape slope element scale to the watershed scale. Of particular interest to your reviewer is a paper by B. Kruijt and others that explains how the photosynthetic response of individual leaves to changes in environmental conditions can be scaled to that of the entire canopy by invoking the hypothesis that the vertical distribution of nitrogen within the canopy adjusts itself so as to maximize the total canopy net photosynthesis. This hypothesis leads to a very simple scaling scheme that works very well compared to a detailed, bottom-up simulation of total canopy photosynthesis.

In short, *Scaling-Up from Cell to Landscape* is an excellent collection of papers spanning a range of scaling issues that arise concerning land plants and their interaction with the surrounding environment. I would recommend it to researchers involved in other areas of environmental research who wish to gain an appreciation of upscaling issues in this field. Although I am not a botanist, I would expect that botanists will also find this to be a useful and convenient reference on scaling issues in botany.

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