ANALYZING AND MODELLING GRASSLAND BIOMES

Grasslands, Systems Analysis, and Man (International Biological Programme No. 19.), edited by A. I. Breymeyer and G. M. Van Dyne. Cambridge University Press, New York, 1980, 950 p., illus., $140.00 (77-28249).

Grassland Simulation Model (Ecological Studies. No. 26.) by G. S. Innis. Springer-Verlag, New York, 1978, 298 p., illus., $24.80.

At the end of the International Biological Program, hasty judgments of IBP were published before the main work was published. Now, however, massive detailed results are emerging. Two books on the grassland biome are reviewed here. In IBP 19, edited by Breymeyer and Van Dyne, Part I on processes and productivity has chapters on the abiotic system, autotrophic system, small herbivores, large herbivores, invertebrate predators, vertebrate predators, and the decomposer system (A. I. Breymeyer, W. T. Hinds, G. M. Van Dyne, J. S. Singh, M. J. Irlich, P. G. Rissa, R. E. Redmann, J. K. Marshall, L. Andrezejewska, G. Gyllenberg, N. R. Brockington, Z. Scacs, J. Busk, C. A. Rilde, L. D. Hanis, G. B. Bowman, D. Coleman, A. Sasson, M. C. Dash, Y. Dommergues, H. W. Hunt, E. A. Paul, R. Schaefer, B. Uleblora and R. I. Zlotin). Part II on systems synthesis has chapters on nutrient cycling, comparative studies of ecosystem function, total system simulation, and trophic structure and relationships (F. E. Clark, C. V. Cole, R. A. Bowman, N. I. Bazilevich, and A. A. Tilly a nova, G. Innis, I. Noy-Mier, M. Gorson, A. I. Breymeyer and E. Van Dyne).

Part III on system utilization has chapters on management, impacts on grasslands, simulation of grazed systems, and reflections and projections. Some of it concerns scientific history, documentation of experiments in international scientific communication, and experience with large-scale project organization (K. J. Hutchinson, K. L. King, N. G. Seligman, G. W. Arnold and G. M. Van Dyne).

The Innis book presents the most complex and last generated overall model of the U.S. Grassland IBP. The books are a compendium of detailed data on grassland ecosystems and the way the parts and processes interrelate. The chapters have 37 authors and coauthors from fourteen countries with most phenomena considered with world-wide comparisons. Relationships of two or three variables are usually expressed with equations that fit observed data graphs and have mechanistic rationales. Thus, the parts of grassland ecosystems are modeled with many variations. Understanding of the autecology and biology of subsystems seems to have been advanced considerably. In the two volumes there are approximately 51 seasonal graphs of grassland properties, 74 graphs relating one property as a function of another factor, 33 diagrams that summarize budgets of organic matter or nutrients, and 39 qualitative sketches of models of the main blocks within the ecosystem.

Good reviews of literature are given for many topics such as sugar translocation and storage in various plants, above- and below-ground partition, transpiration and vegetation cover, species distribution of C_3–C_4 metabolism, water potential relations to photosynthesis, temperature optima, percent plants consumed by herbivores, age-weight relations, models of others, percentage intake in growth compared to fat, soil enzyme activity, and cycles of nitrogen, phosphorus, and sulfur.

A sample of the many contributions to grassland science are the following: Frequency of abiotic phenomena was eight to nine times higher than that of dependent biotic units. The dead leaf area indexes were higher than for live areas. Permissable defoliation or grazing was determined by carbohydrate reserves. Tables of productivity have efficiency of net production 0.13–3.8% on a weight basis; herbivores were 0.1–0.7% of plants and consumed higher percentages of plants than in forests. Each species of large herbivores has a characteristic signature of use of grass, forbs, and shrubs. Predators are in proportion to herbivores and saprophages, and herbivores are in proportion to plant production. Cultivation reduces biomass and diversity of grassland invertebrates and may allow epidemics. Small predators are in the soil litter interface and increase with carbon/nitrogen ratio. Abiotic release of carbon dioxide comes from carbonate-rich soil horizons; potassium in plants sharply declines with tissue age. Grassy swamps are nutrient sinks. Up to 50% decomposition may be abiotic. Consumers control production. Making models with more detail did not improve accuracy. The books are rich in discussion of such modeling issues. The mathematician's translation of simple prey-predator model to Forrester diagrams (on p. 23 of Innis volume) conserves organisms but not energy or matter.

Some aspects may be criticized: The role of air velocity in chambers on CO_2 release from soil was not analyzed, and the figures on this may be much too small. Opportunities for overview perspective were missed by using net production rather than grass production and total respiration. A driving dream was building one model that would work on any grassland in any continent, and this helped add more model complexity, whereas nature's way may be to substitute a few items that are important, relegating much of the observed diversity to contingency gene pools. Optimization as a separate economic model may not be as realistic as a self-optimizing model of the grassland and economic relations together.

As in the AEC rainforest project a decade earlier, much of the time and resources were spent just getting the data, coordinating the different authors, and putting the documentation into usable form. Full theoretical use of data and synthetic overview models were left unfinished as funding and publication deadlines passed. Unity of presentation had to be sacrificed so the contributions and creativity of many authors could be expressed. Only fifteen pages of IBP are quantitative simulated models that synthesize. Most of the Innis volume also concerns parts.

IBP was offered in part to understand and foster the biological production of ecosystems as related to humanity. However, boundaries were drawn around the grassland with humans left outside. Then, the grassland ecosystem was divided up into subsystems such as soil, herbivores, plants, etc. Models were developed for these, the parts of which were evaluated in the field measurements. The work was organized, therefore, at two size scales smaller than the system of ecosystem and man where the emphasis had been advertised. The idea was that each subsystem model might then be strung together to simulate the whole. The behavior of the whole ecosystem was to emerge from the combination of the component models; then human impacts were to be applied. Since the parts' models were in great detail, the synthetic combinations were cumbersome, costly, and too complex for easy understanding, and thus not very amenable to representation or to have confidence in.

In summary and synthesis sections of IBP 19, only simple overview sketches, aggregated grazing models, and budget diagrams are given for nutrients and organic matter. There are no representations of the complex synthetic models of the whole grassland, which were extensively studied as the main purpose of IBP. In Ecological Studies 26, the report on the complex total system model, ELM, includes component models and equations overview sketches, comparisons of submodel and total model simulations with time series data, a critique discussion by Woodmansee, and extensive discussions of the steps and thoughts in evolving the project and its models. However, the only representation of the whole model relationships is a sketch of submodel boxes.

In many places in these books, authors refer apologetically to the complex models with reservations about their meaning. Even if the complex models were not what the authors had hoped, they should be given so that new science can build on the experience. If not dealing with complexity, the books represent the state of the science. Ecosystem science is being inhibited because people are not reading each other's models and are having difficulty visualizing their own complex ones. Editors discourage full representations of models in program form or as bulky sets of equations because of the difficulty in comprehension. Even in the detailed reviews of models in this book, ecosystem structures are not compared. Energy-language diagramming would help. Unfortunately, the books do not have all the information in a form for translating the ELM into a complete diagram.

An underlying question is whether complex large models of ecosystems are less useful because of limitations of modeling complexity, and whether there are integrative principles and features of ecosystem organization in real systems that do not get included when submodels are strung together. The books do not deal with ecosystem level organization and structure.

The alternative concept is that models should not get more complex because the size of the ecosystem is enlarged, but appropriate aggregations of detail should leave all models the same size regardless of the size of the system. In this way, important features are not lost in details that are not important at the larger scale.

In the era before modeling, detailed descriptive, quantitative, and experimental research left scientists believing that they understood the systems they studied because the qualitative theories they carried seem to explain relations. What formal quantitative modeling did was show that expression of these ideas in simulation rarely coincided with expectations. In other words, scientists not doing modeling are kidding themselves about their understanding, and those who do know they have a long way to go. A paper without a model to demonstrate consistency of ideas and data offered may soon come to be regarded as second rate.

Although the IBP did not address the scale of size and time that was promised and required to understand the basic science of man and nature, it was nonetheless a marvelous contribution to biology and small-scale ecology.

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HISTORY OF MARIHUANA

Marihuana: The First Twelve Thousand Years, by Ernest L. Abel. Plenum Press, New York, 1980, 289 p., $17.95 (80-15606).

It is refreshing to find, in the recent plethora of books on *Cannabis,* one that looks in such an equanimical way on the relationship of this ancient cultivated plant with human affairs. Against a historical background of thorough research, Abel follows the historic and economic significance of marihuana from the early years of the ancient world; the era of its importance to maritime needs of Europe and its introduction to the New World; its emergence as a medicine and narcotic in the Old World; to its acceptance in the Americas as a drug.

I have found all of the chapters equal in their reliability, matter-of-fact synthesis, and expert handling of a complete knowledge of the pertinent literature, epitomized in the carefully chosen bibliography of 293 entries. Personally, however, I rate the chapter entitled "Epilogue" a most original and succinct ending to an outstanding book.

The range of interests covers a broad spectrum. The book should long be of value to historians, sociologists, economic botanists, pharmacologists, lawmakers, and legal experts. Its message might be expressed in a nutshell by quoting sentences from its first and last chapters: "Of all the plants men have ever grown, none have been praised and denounced as often as marihuana . . . undoubtedly a herb that has been many things to many people. . . . Whatever marihuana's past, its future will inevitably be that of decriminalization and eventual legalization. . . . Whether . . . the world faces a real threat to its social and economic stability, to progress and to morality . . . as a result of the liberalization of marihuana . . . is left to the future. If the past is any example, instability, lack of progress and immorality will or will not occur regardless of whatever happens where marihuana is concerned."

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ANATOMY TEXT

Human Anatomy, (Laboratory Textbook) by Kent van de Graaff. William C. Brown Company, Dubuque, Iowa, 1981, 322 p., illus., $12.95 (80-65740).

As the title indicates, this textbook is designed to augment work in the laboratory. It is written systemically and for paramedical students. With this textbook, no other in anatomy is necessary.

The text is divided into five units with appropriate chapters under each unit. These units are: (1) Organization of the Human Body; (2) Body Support and Movement; (3) Control Systems of the Human Body; (4) Maintenance of the Human Body; and (5) Continuity of the Species.

Each chapter starts with a list of learning objectives, followed by a list of materials needed to study this particular system, and student instructions immediately after. Then comes an introduction and descriptive material about the system being studied. Clinical considerations have been added to maintain interest. The text is well illustrated.

Outlines of laboratory reports are also provided, and the text is structurally arranged so that punched pages may be removed from this spiral-wire bound book and later filed in a 3-ring notebook.

If I were the student using this text, it would take some time for me to become accustomed to having the legends placed above the illustrations. The use of figures for labels, requiring glancing down constantly to obtain the actual name of the structure labeled, can become annoying after a while, but perhaps what would be most frustrating is the inadequate space in the many tables the student is expected to fill in. For example, on page 192, how could anyone describe the function of the pituitary in a space 1 cm high and 6½ cm wide?

Another problem with tables is the use of so many that students may memorize them rather than visualizing and understanding the anatomy. I also am concerned that the descriptions are not detailed enough for the