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Reconsidering the Ecosystem Concept

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Moran, Emilio F., ed. *The Ecosystem Concept in Anthropology*. Boulder, Co.: Westview Press, 1984. xiv + 320 pp. including index. $28.50 cloth.

Sir Arthur Tansley (1935) is given credit for the term ecosystem. Tansley, a knowledgeable geologist and field botanist, gifted teacher, student of Freud, prolific author on botany and occasionally psychology, and activist in the founding of the Nature Conservancy, focused his diverse research talents on the interactions of plant associations with climate, soils, and animals. He drew attention especially to natural-physical interrelationships, and argued that the ecosystem was analogous to physical systems: it was in their nature to develop toward a dynamic equilibrium. He also provided a term useful for the subject of this review, *anthropogenic* ecosystem, by which he meant to recognize the influence of humans on natural processes.

Tansley was a versatile and productive scholar. The concept he identified has had a deep but somewhat protean impact on the biological and certain social sciences. It is sometimes defined as an aid to holism, useful for keeping attention on multiple parts and linkages, sometimes as an actual, spatial sample of flora and fauna plus their physical context, sometimes as an analytic model based, for example, on trophic levels and food chains, and sometimes as an organized network with emergent, generalized "system" properties like homeostasis. For reasons which will become apparent, I prefer to avoid the last of these definitions, with its emphasis on equilibrium and cybernetics. Moran, paraphrasing Evans, states that it is "an elegant concept because of its comprehensiveness" (p. 4), but we might also ask if it remains a telling scientific construct *in spite* of its wide purchase. The breadth admirable in Tansley's biography may be a liability in the idea he named, which should, after all, discipline and direct thought and contain this sprawling and slippery list of associations. This is one of the issues arising in Moran's important edited volume, *The Ecosystem Concept in Anthropology*.

Widespread application of the ecosystem concept in anthropology commenced with the expan-

sion of cultural ecology in the late 1960s and early 1970s. Geertz's influential 1963 book, *Agricultural Involution,* began with an "ecosystem" perspective, and the approach gained further credibility with publications by Netting (1968), Vayda (ed., 1969), Rappaport (1968), and others. Moran (p. xiv) notes that its popularity was due to the endorsement which the biological concept gave to holistic studies of humans in their natural and physical environment, a long-term concern of anthropologists. Some additional reasons hint at the attractiveness that the ecosystem concept held for anthropology.

For one, the ecosystem perspective was elaborated in terms of structure, function, and equilibrium. Recognizing some fuzziness on terms, there was considerable conceptual similarity between this ecosystem formulation and still influential approaches developed somewhat earlier in sociocultural anthropology. Compare titles of two important volumes, one in biology, *Ecosystem Structure and Function* (J. Weins, ed. 1972), and one in anthropology, *Structure and Function in Primitive Society* (A.R. Radcliffe-Brown 1952). There was promise here of common organization and processes in natural and social systems. The potential structural-functional similarities seemed to lie deeper than their mutual association with an organismic analogy.

The possibility of common principles suggests another kind of attractiveness to the ecosystem concept. Again, for illustration, compare the generalizations offered in an ecological classic, *Perspectives in Ecological Theory* (R. Margalef 1968), with those of *Evolution and Culture* (M.D. Sahlins and E.R. Service, eds. 1960). Margalef developed the principle of exploitation, "A more mature system always exploits a less mature system. . . " (1968:37). Sahlins and Service promoted much the same idea in the Law of Cultural Dominance, which states that "that cultural system which more effectively exploits the energy resources of a given environment will tend to spread in that environment at the expense of less effective systems" (1960:75). Especially in the works of Eugene Odum (1953, and later editions) and Howard Odum (1971), anthropologists found general principles which seemed able to explain various currents of sociocultural evolution. Succession, energy-flow, diversity, stability, productivity, and the apparent regularities linking them inspired some highly original fieldwork.

There is another, more personal observation to make here. Many anthropology majors in the late 1960s and early 1970s were affected by the ecology movement and excited by the prospect of being advocates and analysts of the human ecosystem. It helped that ecology sounded a preservationist theme for habitats and species just as the urgency to promote similar ideas on behalf of the world's non-industrial peoples became a prominent issue. Professors on different parts of the campus were using the same terms, developing the same general ideas, and encouraging peripatetic, interdisciplinary class schedules. For a while, concepts, principles, and action resonated. In the present volume only Bennett professes clear dedication to this activist vision.

The Assessment

The ecosystem concept has had two decades of influence on human ecology. This suggested to Emilio Moran that it was time for a "reassessment" in order to "determine when, and if, the concept is still relevant and productive for anthropology" (p. xiii). Moran organized a 1982 AAAS symposium for anthropologists and ecologists, later invited some additional papers, and has edited the results for this book. It contains six papers on the historical background of the ecosystem concept in ecology or various subdisciplines of anthropology, and seven which address some of the shortcomings evident in earlier applications. The list of authors includes many of the people prominent in ecological anthropology over the last 20 years; their con-

tributions stress contemporary fieldwork. It is a constructive, loyalist critique worth the attention of ecological anthropologists *and* those wary of this approach.

In his introductory discussion, Moran identifies the deficiencies of the ecosystem concept as the following: (a) too much emphasis on energy flow (p. xiii); (b) too heavy a reliance on functionalist analysis (p. xiii); (c) neglect of historical and evolutionary factors (p. xiii); (d) neglect of the role of individual decision-making (p. xiii); and (e) vagueness about boundary definitions (p. xiv) and a tendency to use the ecosystem as a spatial rather than analytic construct (p. xv). There is a matching list of benefits. To its credit, the ecosystem concept has: served as a heuristic tool reducing the gap between the biological and social sciences (pp. xiv-xv); stimulated expansion of ecological/adaptation approaches in anthropology (p. xiv); promoted quantitative methodologies (p. xv); provided a framework for hypothesis testing (p. xv); and, by directing attention to "complex links of mutual causality" (p. 13), reduced the "polemic" (p. 3) between environmental and cultural determinisms (see also Gross, pp. 253-55). Clearly the subject has broad ramifications.

What Is a Concept?

This list appears to represent problems and successes that have come to attention in the practice of ecological anthropology studies. It is hard to judge if it is exhaustive, or whether its entries can be reduced to fewer and more basic issues of method and theory. The entries appear disconnected because a critical point goes undiscussed: What is a concept? What kind of scientific work do we mean it to do? Neither the volume title nor the semantic practice of individual authors suggests that they mean ecosystem theory, model, or hypothesis. Rigler (1975:15) avers that "When ecologists use the word 'concept' they use it, not as a synonym for 'theory,' but as a substitute for it." The same appears true here, but the implicit negative definition gives us little guidance about expectations.

The consistent usage provides a clue, and one that guides this review: concepts are not theories or hypotheses. A concept is a statement which isolates and systematically defines relationships or processes felt to be especially worthy of analytic attention. Niche, surplus, and ecosystem are concepts. Developing and refining appropriate concepts are important steps in analysis, but to be useful in research which seeks explanation a concept must be joined to a theoretical stance or exploratory hypotheses. A theory or hypothesis, be it explicit or not, well or poorly formulated, appropriate or inappropriate, is necessary. As a result, a critical evaluation of research guided by a concept must distinguish those flaws which arise from the concept itself and those due to the theory or hypotheses joined with it.

With some exceptions this kind of distillation is missing from the Moran volume. As a result it sometimes is hard to decide to what extent the listed shortcomings (or successes) of human ecology can be attributed to the ecosystem concept *per se*. Since at least some (functionalism, problems with boundaries, organismic analogies) predate the explicit use of the ecosystem concept or characterize areas of anthropology not affected by it, it is plausible that they derive at least partially from theoretical or methodological sources unrelated to ecology. Thus, while these papers explore deficiencies and exemplify successes of human ecology research, the motivating premise of the collection—that the ecosystem concept is culpable or praiseworthy—cannot easily be evaluated. More importantly, it is difficult to judge if remedies applied to the concept itself fully address the source of the problem, hence how likely they are to be effective.

This essay will attempt to complement papers in the Moran book by suggesting that some of the cure for these shortcomings lies in theory. It will also attempt to complement the topical coverage.

The volume's authors cover subjects related primarily to criticisms (c), (d), and (e); I will add a discussion related to (a) and (b).

Background and Methodology Papers

Several contributions to this book do not address explicitly criticisms of older ecosystem studies. Before proceeding to that topic, these papers on background and methodology deserve attention.

Golly, the lone ecologist, gives a succinct history of the ecosystem concept in ecology, and outlines current research issues. He provides the biographical facts on Tansley cited earlier, and makes some fascinating observations on the role of ideological factors in shaping differing Western and Soviet perceptions of ecosystems. Jochim describes the heuristic impact of the ecological approach on archaeology. He discusses several questions in European prehistory and notes the interpretive benefits gained by placing them in a holistic, ecosystem framework. Little and his co-workers describe their ecosystem research on the Turkana, East African pastoralists. This sophisticated multidisciplinary study draws on the experience gained by ecologists and human biologists in I.B.P. research, and it integrates the biome and human adaptability components which were separated in the earlier I.B.P. work. It is a persuasive example of the advantages of an ecosystem orientation.

Two papers deal primarily with methodology. Gross evaluates the relative merits of three different approaches to field study: comparative, cross-sectional, and longitudinal. He argues that the critique of ecological approaches has been disproportionate, and he advances the point emphasized in this review: the ecosystem concept "cannot substitute for theory that is coherent and that can yield testable hypotheses" (p. 254). Finally, Connant uses East African examples to demonstrate the potential of remote sensing for discovering large-scale human impacts on the environment. The ability to repeat samples of large areas undergoing change is a particularly attractive aspect of this technique.

The Energy Flow Emphasis

Aware that there is some ambiguity about the target of the critique (Is it the concept or its theoretical context?), we now can examine each of the listed deficiencies, in order. The first is energy flow, and although Moran (pp. 15-16) notes the charge of an energy flow preoccupation, none of the papers is devoted to reviewing this subject (see Adams 1978; Harrison 1982; Nydon and Thomas 1982).

Energy flow methods have stimulated some outstanding research, lasting studies influential even outside anthropology. Rappaport's (1968) *Pigs for the Ancestors* and Thomas's (1973) *Human Adaptation to a High Andean Energy Flow System* are exemplary. Energy flow studies also stimulated a premature critique, based apparently on fears that anthropology was about to be engulfed by a "calorific obsession." (The phrase is traced to Brookfield [1972:46], although it is unclear that he meant it as a slogan to be brandished against energy flow studies.) This vivid choice of words hinting at pyroneurosis has probably proven more powerful in dissuading people from developing this line of research than the substance of the criticisms. Even the most cited critical review, that by Vayda and McCay (1975), is aimed more at advancing an alternative perspective than at finding faults in extant energy flow studies or unavoidable problems in the methodology.

The early work delineated flows of energy and materials and established their magnitudes. The effects on these flows of physical-chemical inputs (e.g., sunlight) and of direct energy expenditures (e.g., weeding of crops) received study. This research did not give sufficient attention to the multiple human decisions implied in the branching flows of energy, materials, and efforts. Standardized means of representing a system of flows and cycles and reliable, replicable techniques borrowed

from time allocation and work physiology facilitated comparative analysis and quantitative simulations. The work was pioneering and generally normative. It tended to be descriptive, and it had an impact much greater than might be expected, given the modest number of studies completed. If theory was a significant component, it usually focused on adaptation (Thomas) or cybernetics (Rappaport).

The influence and practice of energy flow studies appear to have waned sharply (no recent fieldwork is reported in this volume or in Harrison [1982]; but see Dufour [1984]). This is unfortunate. As an example from economic theory will show, the concepts and methods of energy flow remain a promising area for research activity.

Beginning with Piero Sraffa, neo-Ricardian economists have made an incisive critique of the marginalist foundations and formalist methodologies of neoclassical economics. The ensuing debate has encompassed a reappraisal of the classical economists (especially Smith and Ricardo) and generated new perspectives on production and distribution. The implications of this realignment of ideas and problems extend to anthropology. Gudeman, whose interpretation I am following, states that "For anthropology the task which follows . . . is to locate and specify culturally different patterns of distribution and to determine the forces which underlie them" (1978:349).

Gudeman discusses how this might be accomplished. First, for Sraffa, distribution (to rent, profits, wages, subsistence, etc.) is figured in commodity terms, a method that "must tantalize anthropologists" (1978:356), because it provides "a new mode of calculating surplus, and this without reference to money" (1978:360). The method thus avoids the hoary problem of calculating "price equivalents" in societies without an internally dominant market to adjust prices. It makes a theoretical virtue of what is left over, actual quantities of materials and effort. The advantages do appear tantalizing from the energy flow perspective, because the latter places emphasis on time allocation, effort, energy, and materials.

Second, Sraffa's method recognizes the role of labor in production by focusing on the use of commodities to produce commodities. Gudeman notes the novelty of this position: "Perhaps Sraffa has taken his predecessors one step further by emphasizing neither the relations between persons and objects (Adam Smith) nor between persons and persons (Marx) but between objects themselves!" (1978:360). But, Gudeman also resolves the apparent paradox—that an analysis which directs attention to objects can be uniquely revealing about the human and cultural aspect of their transformations—again in terms that appear to complement an energy flow approach.

Finally, Sraffa "assumes that the economy is a circular process in which consumption feeds back into production" (1978:360). The same process is represented in energy flow studies as links between "production," "consumption," and "expenditure," some of which gets applied in creating more production (Thomas 1973). Gudeman's examples leave little doubt that the terms employed (e.g., labor units, net and gross product, subsistence consumed) and observations entailed in this economic approach are like those of an energy flow methodology. It also may be that an energy/materials flow diagram, extended to differentiate social entities besides the usual and normative individuals or households, could provide a model of distribution like that he envisions. Adapted to neo-Ricardian theory, energy flow methods could help to rigorously quantify and trace the partitioning of production which for Gudeman is the heart of "cultural economics" (1978:371).

Discomfort with economic anthropology helped to motivate the early growth of human ecology studies. The economic anthropologists were muddying themselves, their subject, and bystanders with the formalist-substantivist dispute just as ecology seemed to be offering consensus on lucid and far-reaching concepts and principles. Vayda

(1967) was one of the first to publicly wash his hands of economic anthropology in the clearer and less turbulent waters of ecology. At present, an updated synthesis of neo-Ricardian theory with energy flow concepts and methodology might be to the advantage of both economic and ecological anthropology. Although sketchy, the above discussion is sufficient to show the kind of possibility that merits attention in any full evaluation of energy flow studies. It would be a pleasing historical turn if discomfort with the theoretical limits of this type of ecosystem ecology led it back to economics.

Functionalist Analysis

Functionalist explanation is prominent among the criticisms of ecosystem studies.[1] Its widespread use in human ecology is not surprising given anthropological precedents and the influence of organismic and cybernetic analogies on the ecosystem concept. Less evident is what should or can be done about it. For a while it appeared that replacing the word function with adaptation (culture with population, etc.) would insulate human ecology from this particular disquiet. But substitution of biological for social terms has not eliminated the problem. Human ecologists generally acknowledge the difficulties with functional explanation but leave the details to worry philosophers or inspire the critics of ecological anthropology. The volume under review exemplifies this. Morgan raises the issue, but none of the contributors attempts to resolve it.

The problem admittedly is difficult, but again it may help to distinguish what we can hope to accomplish with concepts from what must be accomplished with theory. As before, the source is economic theory, but in this case Marx rather than Ricardo. In his book *Karl Marx's Theory of History: A Defence,* Gerald Cohen filters Marx through the "standards of clarity and rigour which distinguish twentieth-century analytical philosophy" (1978:ix). Historical materialism emerges as a *functionalist* theory of society and history. Given this, in order to make his defense complete, Cohen must address the reservations expressed by social scientists and philosophers about functional explanation—that "distinctive explanatory procedure in which reference to the effects of a phenomenon contributes to explaining it" (1978:250). With hesitation, because of brash disregard for the length, precision, and analytical finesse with which Cohen makes his case, I will collapse his argument to these observations:

1. Attribution of a function (or benefit) is not the same as providing a functional explanation;
2. Given a *consequence law,* functional explanations are logically reliable and confirmable; and
3. Neo-Darwinian and Marxist theory provide the requisite consequence laws for their respective subject matters.

A consequence law in this formulation must specify theoretically how an effect or utility of a feature can account for its existence.

If we make the generous assumption that Cohen is correct, by the standards of analytical philosophy, and usefully so, for the standard subjects of anthropology, then there seem to be two lessons here: (1) buttressing functionalist analysis must be done at the level of theory (no amount of tinkering with the ecosystem concept will provide a consequence law); and (2) either Darwinian evolutionary or Marxist economic theory can produce satisfactory functional explanations. Either then may be an appropriate complement to the ecosystem concept. Ellen (1982) begins to explore general similarities between Marxist theory and human ecology.

As in the energy-flow discussion, this is the barest outline of a proposal. But it does suggest that resolution of a persistent problem in ecosystem studies may be possible if we clearly acknowledge the contribution of theory, and the special potential of economic theory for study of anthropogenic ecosystems.

Historical/Evolutionary Factors

A current debate in ecology (Engelberg and Boyarsky 1979; Patten and Odum 1981) asks this question: Are ecosystems cybernetic systems? That is, do they "contain informational links whose function is to steer or regulate the system" (Engelberg and Boyarsky 1979:317)? The cybernetic analogue is pervasive in ecosystem ecology, as is the use of general systems theory. Although Golly outlines a pro-cybernetic argument (pp. 44-45), I find the observations of those answering in the negative to be more persuasive. The informational circuits for regulating feedback in the designed systems of control engineers are not apparent in the structure or function of natural ecosystems, even though the latter exhibit more or less regular behavior (see Engelberg and Boyarsky 1979).

Equally important is the theoretical argument: Current neo-Darwinian theory can account for cybernetic, homeostatic design at the level of individuals but it does not predict like design of functional relationships at the level of communities and ecosystems. Tansley was clear about the theoretical source of his view that ecosystems move naturally to a dynamic equilibrium: "There is in fact a kind of natural selection of incipient systems. . . " (1935:300). Margalef was candid about his own support for a similar view: "Perhaps in the depths of his psyche, the ecologist may be grateful to cybernetics for throwing a tenuous mantle of respectability over the discredited method of reasoning by analogy" (1968:16). But these are just the points in doubt in evolutionary theory (Smith, pp. 53-59; Rindos 1984) and also questionable as analogy.

Resolution of this ecological debate will be of interest to anthropologists, but not necessarily decisive for the study of anthropogenic ecosystems. To develop their argument that ecosystems are noncybernetic. Engelberg and Boyarsky (1979) contrast them with social entities, ranging from the family to the European Economic Community, which they claim *are* cybernetic. Thus, as humans become components of ecosystems, intent, symbolic capacity, and trafficking in information directed to the management of energy, materials, and other people introduce networks of causality that can be regulating *at the system level.* From an anthropological perspective, uncertainty that natural systems are cybernetic only sharpens the need to analyze how and to what extent "socionatural systems" (Bennett, p. 302) may be cybernetic, and different because of that quality. Flannery (1972) and Rappaport (1968) are among those emphasizing that information flows are integral to analysis of human ecosystems.

If ecosystems are equilibrium systems on the physical model, as Tansley believed, then their analysis can end when that equilibrium has been characterized and explained. Deviation is short-lived and attributed to incidental, exogenous variables. Anthropologists, influenced by functionalism, have been receptive to a similar ahistorical orientation. In both ecology and anthropology cybernetic views reinforced diachronic blindness; in both, historical emphases are growing in importance. Although Golly (p. 47) suggests that historical analysis need enter ecosystem studies only when humans are components, other ecologists would disagree (references in Winterhalder 1980).

The question of how to make human ecosystem studies more historical is discussed extensively in the Moran volume. One proposed solution couples the ecosystem concept to historical demography, following Boserup or others (Moran, pp. 17-18; papers by Adams and Kasakoff; Netting). The quality and insight of Netting's (1981) work in the Alps suggest that this is an attractive option.

The attempt by Adams and Kasakoff to engage history by delineating periodic temporal boundaries appears to be less promising. They recommend to human ecologists the *Annales* school of historical analysis, especially work by the French historian Braudel. By the cited epigraph (p. 205), Braudel organizes his facts and explanations by dealing with "long-term equilibriums and disequilibriums."

In other passages of this paper there is reference to "cycles," and vaguely defined but increasing durations of time assigned the names "event," "conjuncture," and the "Long Run," with an extension of the latter identified as "history which stands still." Long Runs are analogized to "stages" of cultural evolution (all, pp. 209-10). These terms appear to be arbitrary categories, primarily used to organize descriptive historical accounts. It is not clear that they can make a contribution to human ecology. Adams and Kasakoff present important methodological lessons in their discussion of historical demographic research in New England, but they make a weak case for adopting the *Annales* approach.

As an alternative to energy flow analysis, Vayda and McCay (1975) suggested in 1975 that ecologists study hazards, large-scale perturbations which presented people with clear adaptive problems. Lees and Bates amend this approach by their focus on "events," observed at the micro-historical scale and with an emphasis on individual-level action. The choice of this more prosaic term is meant to (1) direct attention away from catastrophes and toward the day-to-day disturbances and coping behavior, (2) circumvent the equilibrium connotation of "perturbation," and (3) imply that any impact can be either a problem or an opportunity for particular persons. Lees and Bates cite some impressive studies as exemplifying their approach, but they provide limited theoretical guidance for recognizing or studying events.

In Cohen's (1978) analysis, functionalist statements become explanatorily reliable when they are given the same logical form as precedence (causal) statements, but this also sets them into an inherently temporal framework. It is not accidental that synchronic field studies generate the greatest misgivings about functionalism, nor that the Darwinist and Marxist theories that Cohen cites are preeminently historical. The emphasis on history in these papers is an important one, for both ecology and anthropology.

Individual-Level Decision-Making

Ecosystem analysis has led human ecology to neglect the active decision-making role of individuals (papers by Lees and Bates; Gross; Bennett). The critique by Smith confronts this problem most directly. Smith is the non-loyalist in the group: ". . . at best, the ecosystem concept offers a macro-scale descriptive framework for human ecology with little explanatory utility for anthropology" (pp. 51-52).

Smith observes that in biology there are "two ecologies" (p. 52), ecosystem ecology and evolutionary ecology. He argues that anthropological studies have too uncritically embraced the former, with its problematic load of cybernetics, homeostasis, and ecosystem thermodynamics, while remaining uncognizant of the latter, with its more secure basis in neo-Darwinism and individual level analysis. As a consequence, human ecologists have occasionally adopted cybernetic theories which imply goal-directedness at the system level, a "top-down" functionalism (p. 55). In place of ecosystem ecology, Smith advocates evolutionary ecology, "bottom-up" theory rooted in the use of micro-ecological (or micro-economic) optimality models for analyzing foraging strategy decisions, life history traits, spatial organization, and community structure.

Smith's critique is adroit. Yet his reasoning touches less on the ecosystem concept (which we should not expect to have explanatory utility) than on the thermodynamic functionalism often associated with it. Separated from the latter, the concept remains useful, even for Smith's framework, and it may be essential where the power of that framework does not reach.

The topic is a difficult one, but a few observations are pertinent. It is worth noting that even in biology there is debate about the extent to which evolutionary ecology models will be able to generate a "bottom-up" picture of community structure and function (Salt, ed. 1984) that can supplant ecosystem studies. In anthropogenic systems the

problem of the sufficiency of bottom-up explanation becomes more acute. Information, energy, and material flows can be regulated to meet the goals of individuals, groups, and institutions. Consider the optimizing behavior of powerful individuals or a dominant class. Either can control information in a society for the purpose of maintaining a self-serving homeostasis in the whole of the anthropogenic ecosystem. Engineers design cybernetic qualities into their machine control circuits; the conscious or unconscious engineering of individual or class domination may function "top-down" to the same effect.

Second, there is a good case for viewing the evolutionary ecology and ecosystem perspectives as complementary. For instance, optimization analysis of subsistence decisions could be matched to energy flow studies. Optimization analysis would gain by being able to trace the material, system-level consequences of present decisions to see how they affect future options and choices (Schelling 1978). Energy flow studies would gain by greater attention to the fact that flow networks gain their form from the actions of individuals choosing among ecological alternatives.

Finally, there are questions which by their very nature must engage analytic units larger than individuals. Lees and Bates discuss Sahelian desertification and the oil crisis, and Bennett describes the development and promulgation of environmental regulation of fisheries and surface mining. These cases entangle analysis in history, large institutions, development, multidisciplinary research, and in many instances simulation methodologies. They raise and answer questions which cannot fully be solved by extrapolating from micro-economic or micro-ecological analysis focused on individuals.

Renewed emphasis in these papers on the role of individual choice and goals is redressing an imbalance toward assumptions of system-level functionalism in ecological anthropology. What we lack is a clear sense of the circumstances and ways in which these different levels of analysis fit together.

Boundaries and Space

Pictorial representations of the ecosystem concept depict boundaries as points for assessing input and output. Boundaries establish the measurements that can isolate from a series of linkages the transformations occurring within a few of them. The conceptual boundary enhances analytic control but it also emphasizes relationships beyond the unit being studied. In practice, ecologists typically seek systems (e.g., lake, watershed) where such boundary flows are more obvious, fewer in number, and diminished in magnitude, hence more readily controlled. With a few exceptions, I suspect that emphasis on actual isolation of local ecosystem units was never so great for ecologists as it has been for the anthropologists borrowing the concept. The latter brought to the idea the preexisting ethnographic notion of a self-sufficient, closed corporate community. The issues raised by the identification of real and analytical boundaries are significant, and are the focus of several papers in Moran's book.

Ellen draws on his work in the Moluccas to present a comprehensive analysis of empirical and theoretical boundaries in human ecology. Ellen differentiates geomorphological, biogeographical, and cultural domains, and then explores how these lead to observed asymmetries in the relationships (e.g., exchange, political control) among locations. By tracing the geographical orientation of these asymmetries, he finds centers, peripheries, and structural foci. These give him a working definition of "graded boundaries," which are operational, relative, and recognized to be permeable. By changing scales or type of interaction, he can show how these various networks nest together. Ellen argues that the drawing of boundaries is critical because it will determine how one locates cause and effect.

Moran's paper attributes problems in Amazo-

nian development, and the extended debates about human ecology in the Amazon, to confusion arising from application of data at levels of analysis for which they are not appropriate. For instance, soil maps at scales of 1:500,000 cannot depict the spatial variability relevant for field choice; they imply homogeneity that does not exist for the farmer. Recognition of these points requires detailed study, sensitive to fine-grained variability, and Moran can draw on his extensive fieldwork on Amazonian ecology and soils to provide this. Noting the distinction between micro- and macro-economics and ecology, Moran suggests differentiating micro- and macro-ecological scales of study.

Of these two approaches to boundaries, Ellen's is the more inductive and operational orientation. It stresses openness on the numbers and types of units extant in a particular location or study. Moran's micro-macro differentiation has greater potential for generalization, and ties into the source theories for the concepts. Ellen and Moran agree on a related point: ecosystem boundaries should be analytically, not spatially, construed.

Robert McC. Netting's paper, "Reflections on an Alpine Village as Ecosystem," is a candid, thoughtful, and too brief epilogue to his (1981) book, *Balancing on an Alp*. On boundaries he states, "I may well have been guilty of the ecosystematic fallacy" (p. 225), and then analyzes how anthropologists and their subjects can unwittingly conspire to portray a village as an isolated, self-sufficient unit. Netting recounts how money, trade, cultigens, labor, marriage partners, and genes pass through the "porous" membrane which links the geographically isolated Torbel with the world. The spatial permeability of the Torbel ecosystem is evident in part because of the temporal depth of Netting's work.

Bennett concludes the volume with a growl of impatience about a different kind of boundedness. Human ecologists are too preoccupied with "archaistic studies of odds and ends of humanity," with a "scientizing mode of thought" uncontaminated with politics, and with concepts which have little bearing on the "competitive and individualistic" economy which dominates the world, threatening their relevance and everyone's lives (pp. 289-290). Socionatural systems face a trade-off between sustaining current prosperity and the health and livelihood of posterity. Consumers and institutions are making the short-term and shortsighted choice for present wealth. Bennett argues that we should study how human systems "absorb" nature and how behavior can be modified to "create a mass culture more concerned with posterity than with self-gratification in the here and now" (p. 291). Regulatory or developmental interactions with nature are the appropriate context for this analysis (see also Lees and Bates). Although he does not directly address the issue here, Bennett's approach is one quite skeptical of ecosystem theory (Bennett 1976).

Conclusions

The conceptual analogies and general principles that brought ecological system concepts and anthropology together left them with similar problems: whether applied to human or natural communities, structural-functionalism reified systems and made them appear overly homeostatic. Enthusiasm for quick insights from general principles has diminished as definitional problems go unresolved and counterexamples accumulate. The conservationist political climate which nurtured the early growth of human ecology is less in evidence, and even successful studies invariably make us aware of our limitations. The papers in this volume are about the hard work of developing holistic human ecology studies after that initial heady promise of the ecosystem concept has faded. They stress that the advantages of the idea are evident, and at least some of the shortcomings soluble.

I have argued that ecosystem is a concept like niche or surplus: alone it explains nothing. A task of human ecology well advanced by this volume is

to distance the ecosystem framework from an uncritical association with explanations offered by cybernetics. Although Lees and Bates state several times (pp. 134, 135, 146) that self-regulation is "inherent" in the concept, this is only historically the case. In natural systems cybernetic approaches may be quite inappropriate; in socionatural sytems we may learn much by combining noncybernetic sources of theory with an ecosystem view.

A second task is to sharpen the concept itself, analytically or methodologically, by giving greater and more refined attention to problems of individual choice, history, boundaries, scale, and methodology. In this area the articles in this book demonstrate significant advances.

A third task is theoretical and largely is missing from these papers. The ecosystem concept is the subject but theory is sometimes the implicit issue. With the exception of Smith, there is little sense of the theory that might replace cybernetics. In taking up the subjects of energy flow and functionalist analysis, I have suggested that economic theory offers an important complement to the evolutionary focus. Both Darwin and Marx are explicitly historical; they provide functionalist explanation which is justifiably skeptical of equilibrium as the quintessential system property.

The biologists have given us a curious concept, at once anthropomorphized and mechanistic. The ecosystem concept has been fixed to *humanly designed objects,* the computers and machines engineered to have equilibrium and cybernetic qualities. There is an important tension between the holism assigned the concept and the limitations of its most developed theoretical formulation. The former derives from inclusiveness of parts and relationships, the latter from the analogues used to explain function. The subject matter encompassed is broad and unruly, but the explanation offered reductionist and physical. According to Golly, the term ecosystem "expresses nature in physical mechanical terms, de-emphasizing the biological-evolutionary aspect, and it links directly to computer science and information theory" (p. 43).

I suggest that we cede the ecosystem concept its untidy and varied associations. As in this volume, human ecologists can seek to discipline their studies by giving the concept careful analytic refinement. As well we need to direct more careful attention to the theory which we choose to associate with it. The latter must reach to sources less physical than those cited by Golly, and those less exclusively analogical with the biological or system sciences. Neo-Darwinian evolutionary and neo-Ricardian or Marxist economic theory are promising, perhaps complementary in this respect. The one is organic and best developed in the area of individual-level behavior; the other socioeconomic and better able to address systematic relationships among groups and institutions. This may locate our ecosystem studies closer to their proper emphasis on the anthropogenic, and perhaps as well more surely within the holistic spirit exemplified by Tansley.

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NOTES

1. Cohen (1978:283-284) separates "functionalism" from functional explanation. The former he associates with Malinowski and Radcliffe-Brown and with three theses:

(i) All components of social life are strongly interconnected, an inseparable whole.

(ii) All function to reinforce and support themselves

and the whole.

(iii) Each is explained by its contribution to the whole, as defined in (ii). If we substitute "an ecosystem" for social life in the first proposition, it is evident that a similar functionalism has sometimes been associated with ecosystem analysis. So defined, strict functionalism is rarely defended in either social or ecosystem studies today.

Functional explanation need not entail any of these theses. It appears unavoidable in either the biological or social sciences. As a consequence, my discussion is limited to this more restricted and pressing issue.

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