NEW DIRECTIONS IN ECOLOGY AND ECOLOGICAL ANTHROPOLOGY

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In this essay we consider four criticisms of ecological anthropology: its overemphasis on energy, its inability to *explain* cultural phenomena, its preoccupation with static equilibria, and its lack of clarity about the appropriate units of analysis. Recognizing that some of these criticisms may not be justified, we nevertheless point to parallel concerns in ecology. Further, we ask whether new directions indicated by some ecologists might be appropriate paths for future work in ecological anthropology. A central theme is the desirability of focusing on environmental problems and how people respond to them.

The kind of environmental problems we are especially concerned with here are those constituting hazards to the lives of the organisms experiencing them. In other words, we are particularly concerned with problems that carry the risk of morbidity or mortality, the risk of losing an "existential game" in which success consists simply in staying in the game (82, 85; cf 80, cited in 78).

Our focus upon hazards and responses to them emerges partly from consideration of neo-Darwinian selection theory. As Colinvaux (22, p. 499) notes: "Selection . . . chooses from among individuals those which are best adapted to avoid the hazards of life at that time and place." Our focus reflects also the new concern of biologists such as Slobodkin (81, 82, 85) with the actual processes of responding to hazards or environmental perturbations rather than with formal alterations in hypothetical genetic systems. Related also is the emerging view among medical scientists that health is a "continuing property, potentially measurable by the individual's ability to rally from insults, whether chemical, physical, infectious, psychological, or social" (7, 8; cf 78). At least some and perhaps all of the insults referred to in the preceding quotation can be subsumed in our category of hazards; even social and psychological insults may evoke physiological "stress" and disease (60, 79) as well as psychological and behavioral adaptive strategies (99).

A further influence on us has been the recent proliferation of research and thinking on problems of human response to "natural hazards" in geography (19,

20, 64, 98). However, unlike many of the geographers, we do not restrict our notion of "hazards" to extreme geophysical events such as floods, frosts, droughts, hurricanes, and tornadoes. Burton & Hewitt (19) have already warned against classifying geophysical hazards according to their climatic, meteorological, geological, or geomorphic origin rather than in terms of magnitude, extent, frequency, and other "hazard characteristics." In line with this, we would also warn against classifying separately such nongeophysical events as predation by warfare, plundering or raiding (20a, 55, 56), exactions of tribute and taxes (37, 48), or acts of religious persecution (27). These also constitute hazards for some people and are comparable, as Barton's work (10) suggests, to natural hazards in terms of hazard characteristics and people's responses to them.

The nature of environmental problems and hazards and the responses to them will be discussed further as part of our attempt to clarify what some limitations of ecological anthropology have been and in what directions they might be overcome. Suffice it to say at this point that any event or property of the environment which poses a threat to the health and ultimately the survival of organisms, including people, may be regarded a hazard for them, and that responding adaptively to such hazards involves in our view—as in Bateson's (11, 12) and Slobodkin's (82)—not only deploying resources to cope with the immediate problem but also leaving reserves for future contingencies.

A convenient framework for indicating promising new directions in ecological inquiry and how these relate to a focus upon hazards and responses is provided by consideration of criticisms that have been or can be made of past work in ecological anthropology. We will consider particularly the approaches set forth in articles by Rappaport and Vayda (74, 91a, 95). These are the approaches that critics have labeled "new ecology" (66), "newer ecology" (59), and "new functionalism," "neo-functionalism," or "neo-functional ecology" (2, 3, 33). The label of "cultural ecology" is also sometimes applied (e.g. 5, 27), but Vayda & Rappaport (95) and Flannery (31) have rejected this as a designation for their chosen areas of inquiry and have applied it to other approaches [including Steward's (88) and Harris's (41)] which they have criticized. To facilitate exposition, we will forgo these scholastic distinctions and speak simply of "ecological anthropology" in the pages to follow. [For a survey and assessment of the various ecological approaches in anthropology, consult Anderson's recent article (6).]

Four main criticisms of ecological anthropology may be usefully considered here. One is that its point of view has been equilibrium centered—that its focus has been upon the discovery and elucidation of self-regulating, homeostatic, or "negative feedback" processes by which some kind of balance between human populations and their environments is maintained and that it has thereby ignored nonhomeostatic changes, system disruptions, and "unbalanced" relations between people and their environments (1, 5, 27, 39). A second criticism is that showing how traits or institutions like potlatching or warfare work in relation to environmental problems does not constitute an acceptable explanation of those traits or institutions (33, 39). A third criticism is that ecological anthropologists

tend to concentrate their inquiries upon the production and consumption of food energy to a degree that amounts to a "calorific obsession" (18, p. 46) and the sin of "nutritional reductionism" (26, p. 45).

A fourth criticism is that the units analyzed are either ill chosen or ill defined. This important criticism has not been made very explicit in appraisals of ecological anthropology, but it is implied by Friedman's strictures against making a priori reductions of "relatively autonomous phenomena" such as populations to a single phenomenon like a "homeostatic eco-system" (33, p. 466). More explicit criticisms along similar lines have been made by nonanthropologists (e.g. 28, 46, 47, 86) about the way in which some sociologists and political scientists use constructs like "social system" and "political system."

Questions can be raised about the extent to which these four criticisms are justified. Several recent analyses in ecological anthropology have been explicitly concerned with disruptions of systems and with positive as well as negative feedback processes (e.g. 31, 58, 75, 92, 93). Moreover, the ecological anthropologists have said clearly that they are not trying to explain traits or institutions but are trying simply to show how they work (24, 91, 95). And they themselves (e.g. 31, 95) have criticized Steward (88) and his followers for neglecting environmental phenomena other than food resources. The fact that the criticisms persist in spite of this might be regarded as reason enough for considering them again here. Better reasons, however, are that similar criticisms are being voiced about work in biological ecology and that new developments in ecology in response to these criticisms may suggest possible parallel developments in ecological anthropology.

It will be convenient to consider first the criticism related to the "calorific obsession" and then to consider the remaining criticisms. Something like the calorific obsession has been operating among biologists too. Making the basic assumptions that all living organisms compete ultimately for energy and therefore that adapted organisms will be energetically efficient ones, biologists have spent much time, effort, and money in studying the transformation of energy by plants and animals and in measuring and simulating flows of energy through ecosystems (see 68, part 1; attempts to include man in the study of these systems are presented in 25, 51, 67, 69, 73, 89). Some biologists, however, are now questioning the assumptions underlying much of this work. Slobodkin, for example, distinguishes effectiveness from energetic efficiency:

> . . . an animal may be effective at hiding or effective at searching for food in the sense that it does these acts well and in the way that is appropriate to whatever environmental problems it may face. The energetic cost or lack of energetic cost associated with these acts may prove of interest if energy is, as a matter of fact, limiting. The conditions under which energy is limiting can also be specified, but there is not any formal necessity for a connection between effectiveness and efficiency. Effectiveness may or may not involve optimization or maximization of some function relating to energy (83, p. 294).

Similar points are made repeatedly by Colinvaux in his introductory textbook, as, for example, on p. 233:

> It is a mistake to believe that animals and plants have all evolved primarily as efficient converters of energy. The pressures of natural selection are pressures for survival, and survival may sometimes be more concerned with the efficient use of nutrients, ensuring that individuals mate, safe overwintering, or swift growth and dispersal, than with the efficient use, or even collection, of energy (22).

The implication of this for research is that studying the efficiency of energy capture and use by an individual organism or population can be valuable for understanding the strategies employed by that unit if, as Slobodkin says, energy is limiting. If it is not, and if other problems such as floods or water shortages or predation are threats to the survival of an organism, then the effectiveness of the organism's response to those problems and not the energy expended in making the responses is the important subject matter.

These implications have as much pertinence in ecological anthropology as in biology. In the case of people for whom energy and its translation into food and fuel calories do appear to be major limiting factors, energy flow studies can be expected to contribute significantly to our understanding of how the existential game is played. A careful study by Thomas (89) among the Quechua Indians of the Nuñoa District of the high puna of the southern Peruvian Andes provides confirmation of this, for Thomas found among the people a variety of tactics and strategies contributing to efficient use of the limited energy available. Among the sociotechnological adaptations here are: 1. exploiting a spatially dispersed, multiple resource base of energetically efficient crops and domestic animals; 2. interzonal trading whereby surplus resources produced in Nuñoa are exchanged for high energy foods from lower regions; 3. assigning much of the labor of herding to children, for whom it is energetically less expensive than it is for adults; and 4. restricting daily activities to sedentary tasks as much as possible. As reported in a recent article (103), the Quechua Indians also make energetically efficient use of sheep, llama, and cattle dung for fuel and fertilizer.

Other studies of responses to shortages of calories have been made by anthropologists among such people as sisal workers in northeastern Brazil (38) and Quechuan migrants to low-altitude Peruvian towns where, because of poverty and the impossibility of continuing with adjustments practicable in the puna, the people became perhaps even more subject to the hazards of limited energy availability than they formerly were in their high-altitude homelands (34). If ecological anthropologists want to make their energy-flow studies relevant to our questions about playing the existential game, the research opportunities certainly exist: shortages of calories, sometimes escalating to widespread famines (as happened recently in Ethiopia, Bangladesh, Afghanistan, and the Sahel), are major hazards for many people in the modern world. [For examples of studies of responses to famines in recent years and in the nineteenth century, see (13, 61, 63, 71, 105).]

But what about cases in which the energy available is not a limiting factor for the people? The !Kung Bushmen studied by Lee (57) and the Tsembaga Marings studied by Rappaport (72, 73) might be examples, and so might members of the

upper classes of many modern nations. Research on energetic efficiency among such people can provide answers to some questions but not to those that are most critical for assessing their health or adaptedness. It cannot, in other words, answer questions about how effectively the hazards actually confronting people in their environments—for example, water shortages in the case of the Bushmen and malaria-transmitting anopheles mosquitoes in the case of the Marings—are dealt with.

To consider the parallels between ecology and ecological anthropology in the other criticisms and in their implications for new directions, we may note first that in ecology, as in ecological anthropology, the tools of systems analysis have generated much enthusiasm and led to sophisticated models of the structure, function, and dynamics of natural communities and ecosystems (62, 96a, 97a). However, some ecologists have come to the conclusion that these mathematical models cannot account for certain biological processes, the specificity of which places their description and predictability beyond the capacity of models that derive from classical physics and are now used in ecology. Because of the *specificity* and *opportunism* of evolution, such models cannot, for example, predict what new "trick" will be produced by an organism in response to an environmental problem. Thus Slobodkin (81), giving the example of a species of rotifer that has developed the "trick" of making itself inedible by enlarging its spines in the presence of a certain predator, notes that no mathematical theory could be expected to have predicted anything like that.

Similar conclusions can be reached with respect to the analysis of feedback systems and processes in ecological anthropology. Such analysis may (as noted in 23, 24, 95) show how a trait functions under some conditions for a particular group of people—for example, shoulder-blade divination when game is becoming scarce among the Naskapi Indians (65). But the analysis cannot be expected to predict the specific tricks, traits, processes, or institutions—like shoulder-blade divination—that people will evolve in coping with social or environmental problems (94, Chap. 1).

These considerations do not necessarily mean, however, that no predictive generalizations about responses to hazards can be developed in ecology and ecological anthropology. As one of us has suggested elsewhere, it still should be possible to elucidate general features of hazards and responses and to develop generalizations in terms of such variables as the magnitude, duration, and novelty of hazards, the magnitude and reversibility of responses to them, the temporal order in which responses of different magnitudes occur, and the persistence or nonpersistence of response processes (93, 94).

A framework for attempting this has been provided by Barton (10, Chap. 2), who presents a "typology of collective stress situations," based upon the criteria of magnitude, speed of onset, duration, and relative novelty. A good example of the kinds of studies needed for developing generalizations about the temporal properties of responses in relation to the temporal properties of hazards is Waddell's analysis of how the Fringe Enga people of the New Guinea highlands cope with recurrent, and sometimes severe, plant-killing frosts (96).

Waddell is explicitly concerned with the temporal ordering of responses and their articulation with the timing, recurrence, and severity of frosts. He posits the existence of a series of interrelated responses, ranging from the agricultural practice of "mounding" to migrations of varying degrees of permanence. Thus, whereas some observers have viewed massive migrations here as a "disorganized fleeing of starving victims," Waddell's focus upon how people actually cope with hazards leads to the conclusion that such migrations are the culmination of a structured set of responses to severe frost (96).

For criticism of equilibrium concepts in ecology, we may turn to a recent article by Holling:

> An equilibrium centered view is essentially static and provides little insight into the transient behavior of systems that are not near the equilibrium. Natural, undisturbed systems are likely to be continually in a transient state; they will be equally so under the influence of man. As man's numbers and economic demands increase, his use of resources shifts equilibrium states and moves populations away from equilibria. The present concerns for pollution and endangered species are specific signals that the well-being of the world is not adequately described by concentrating on equilibria and conditions near them (44, p. 2).

We regard as cogent some parallel criticisms that anthropologists are beginning to make about an equilibrium centered view—for example, with respect to the size of primitive, prehistoric, or "pre-modern" human populations, which has often been thought (e.g. 14–16, 42) to have been maintained in finely adjusted equilibrium. Arguments and evidence are now emerging in support of an alternative view whereby the size of these populations is regarded as having fluctuated widely in most cases and the members of the populations are seen as having had to cope recurrently with the ups and downs of fertility and mortality (4, 30, 54).

Rejection of an equilibrium centered view does not, however, imply abandoning the study of the processes by which some properties of systems or organisms are kept unchanged even as other properties are changing. Thus, Holling & Goldberg (45), who say that the "key insight" of the ecological approach is that ecological systems are not in a delicately balanced state and that "natural systems were subjected to traumas and shocks imposed by climatic changes and other geophysical processes" long before man appeared on the scene, also say that the ecological systems that have survived are "those that have evolved tactics to keep the domain of stability, or resilience, broad enough to absorb the consequences of change." In other words, resilience itself may be a system property that as a result of evolutionary selection is maintained by various processes. Holling's examples (44) of forest insect and other animal populations that fluctuate widely and are able to survive periodic climatic extremes that would be fatal to a population in a finely adjusted equilibrium underscore the need to keep distinct the notion of equilibrium and the notion of the maintenance of system properties like resilience.

The maintenance of such properties has been described as "homeostasis" by

Slobodkin (82, 84), Vayda (93), Bateson (11), and others. We regard this term as appropriate and will continue to use it here, although we recognize that there is a tendency among some anthropologists (e.g. 1, 27) to confuse it with concepts of static equilibria and unchanging systems—concepts inconsistent with the new directions indicated in the arguments of Holling and Slobodkin. Slobodkin in particular emphasizes that some properties of homeostatic systems must at times change so as to maintain other properties that are important for staying in the existential game—properties such as what Holling calls resilience and what might be described as remaining flexible enough to change in response to whatever hazards or perturbations come along (cf 12, 82, 84, 85). The Quechua Indians of the Peruvian altiplano can be referred to again in this context. They appear to employ a wide variety of adaptations to hazards of their high-altitude environment—hazards such as energy scarcity, cold, and low oxygen tension. Some of the adaptations were summarized earlier. In addition, the people use other behavioral responses such as coca-chewing (e.g. 40) and various physiological responses, including changes in the respiratory and cardiovascular systems in response to hypoxia (17b, 33a). Bateson (11) and Slobodkin (82, 85) have suggested that certain interrelations of behavioral, physiological, and genetic means of responding to such hazards as confront the Quechua Indians may be important for homeostasis. More specifically, they suggest that the development of mechanisms at one level in response to persistent environmental problems frees mechanisms at another level to deal with other possibly more transitory hazards. This warrants more investigation and can be regarded as indicating further directions in which predictive generalizations can be sought. [For another discussion of interrelations of behavioral, physiological, and genetic adaptations, see (50).]

Before we can give any other example of changes that might contribute to homeostasis, we must deal with the question of what units or systems are to be looked at as undergoing change and/or maintaining their properties. Some of the quotations that we have given from Holling's articles suggest that ecological systems are natural entities, units of adaptation with survival strategies like those of their component living organisms. This reflects a fairly common view among ecologists. Even before the advent of systems analysis in ecology, some natural historians were inclined to see natural communities as engaged in lawful processes directed towards achieving a "climax" community with superior social organization. With systems analysis the focus was shifted to ecosystems as the appropriate units of analysis. Ecosystems came to be viewed as self-regulating and self-determining systems with goals such as maximizing energetic efficiency or productivity, the efficiency of nutrient cycling, biomass, or, through an increase in species diversity and food web complexity, maximizing organization ("information" content) and stability.

Some ecologists now reject such ideas; the reader is referred to Colinvaux (22, pp. 549–72) for specific empirical and theoretical objections to each of the goals mentioned above. The important general objection stated by him is that "nowhere can we find discrete ecosystems let alone ecosystems with the self-

organizing properties implied by the concept of the climax society'' (22, p. 549). The ecosystem is an analytic, not a biological, entity. Natural selection acts not upon it but rather upon individual living things. Interactions observed in complex ecosystems need not be regarded as expressing self-organizing properties of the systems themselves; instead they can be understood as the consequences of the various and variable adaptive strategies of individual organisms living together in restricted spaces.

In biology there has been controversy not only about whether natural selection can choose between ecosystems but also about whether it can choose between populations. The emerging resolution, based upon both theory and empirical observations, seems to be that selection works primarily and most importantly upon individual organisms or closely related genetic kin (3, 39a, 87, 100, 101).

This resolution still leaves the problem of accounting for the properties of the larger units—populations, communities, and ecosystems. Indeed, according to Orians (70), ''perhaps the greatest challenge'' for ecologists is the ''development of theories about the properties of communities on the basis of selection for the attributes of their component individuals'' (70, p. 1239). By focusing on how individual organisms respond to hazards and problems, biologists can hope to come closer toward meeting this challenge, insofar as the attributes of individuals favored by selection must include the ability to survive the hazards of particular times and places [for recent attempts to respond to the challenge see Force (32) and Barash (9)].

The counterpart of this challenge for social scientists is what Homans refers to as their central problem: ''How does the behavior of individuals create the characteristics of groups?'' As Homans notes, this is the question posed long ago by Hobbes when he asked why there is not a war of all against all (46, p. 813; 47, p. 106; cf 21).

If we focus on how individuals respond to hazards and problems and on the ways in which the nature of their responses (including any patterns of aggregation and disaggregation that these may produce) are related to characteristics of the hazards and problems they face, we may move closer towards answering this question too. For, as Boissevain (17, p. 549) notes for ego-centered networks, forms of social organization are often used by people to solve problems, just as according to some sociobiologists (52, 53) social systems of interaction among nonhuman organisms are used by them to cope with their problems. Important here is the notion of *processes* of response, including processes whereby the unit of action may shift from individuals to various forms (and degrees of inclusiveness) of groups and perhaps back to individuals, in accord with the magnitude, persistence, and other characteristics of the hazards in question. We are suggesting, in other words, that an individual-oriented ecological anthropology may help us to understand processes of group formation and dissolution, as well as the processes whereby, for example, quasi-groups or coalitions become structured groups over time (17, p. 551; cf 17a). The transi-

ence of organized group activity and composition among hunters and gatherers can be interpreted in relation not only to interpersonal difficulties but also to temporal properties of environmental problems (57a, 104). Similarly, the formation, persistence, and dissolution of a large extended family among some Navahos studied by Downs (29) can be understood as responses to the changing nature of water supplies; a persistent drought finally resulted in the dissolution of the extended family into nuclear families, and even the breakdown of some nuclear families. Variations in the scope, content, and persistence of networks of neighbors in British rural communities may be related to the mobility of families, the size of the parish, and whether alternative sources of casual labor and occasional aid exist for coping with their problems (102). Some kinds of social organization, such as segmentary lineage systems (48, 77), appear to be effective in coordinating the size of the responding unit with the dimensions of the problems the people face. The rapidity with which guerilla and underground activist groups dissolve and reappear may represent effective strategies within the environments of concentrated and coordinated state power (35, 36). Rapidly forming, transient, and problem-specific groups characterized as a new "adhocracy" (12a; 90, Chap. 7) may represent especially effective strategies in the modern world insofar as the number, novelty, complexity, and unpredictability of the problems faced by individuals and by the business and political organizations to which they belong may be greater than ever before and may preclude effective collective responses by members of permanent social units.

The above examples give only glimpses of possible relationships between processes of group formation and dissolution and environmental problems or hazards. Much finer and more specific analysis is of course necessary for any given case.

An approach focusing on how individuals respond to hazards may also lead us to note instances where cultural loss may be individual gain. For example, consider a recent study by Diener (27). The main question that he tries to answer is why Hutterite culture has persisted for four centuries despite the periodic loss of much of the Hutterite population through death from acts of persecution or through conversion to other beliefs. We would, however, ask also how individual Hutterites survived persecution, and we would then see (from Diener's own description) that (*a*) some did not survive; (*b*) some responded by moving to the economic and political frontiers of Europe and later North America; but (*c*) many others responded by giving up their Hutterite culture—they "despaired and abandoned their faith" (27, p. 613). This may be coping in what some would regard a minimal and perhaps ignoble sense, but it does bring to our attention all those people who remain in the existential game because they give up their participation in particular cultures. Their actions are, in other words, homeostatic insofar as they constitute changes in some properties of a responding unit so as to maintain the unit itself.

One other reason for focusing on how individuals respond to hazards and problems may be noted: the fact that the hazardousness of particular events may

vary significantly for different individuals in a population. For example, frequent cyclone-induced coastal flooding in Bangladesh is hazardous for migrant laborers who, being landless and poor, have few alternatives to working as hired fishermen or farming the extensive "char" fields made fertile by deposition from flooding. Mortality is, in fact, higher for them when floods occur than it is for local villagers, since the latter can more readily escape to high points in the villages or marketplaces and can climb the trees near their homes. At the same time, the flooding appears to be a benefit rather than a problem for large landowners who can use their resources and influence to circumvent government regulations and can thus annex newly formed "char" lands (49). Similarly, plant-killing frosts may be beneficial for Florida citrus growers who profit from the increased prices available for the surviving crops, given market scarcity, as well as from shorter harvest times and consequently lower labor expenditures (97); migrant farmworkers, however, suffer because of the reduced wages and unemployment that the frosts bring.

We do not wish to belabor this topic. The important point is that in studying the responses of people to hazards or other problems, we begin to ask who is affected by the hazards and who is responding; whether individuals respond by cooperating in groups of various kinds or by leaving groups; whether enduring, widespread, and/or severe environmental hazards result in the transformation of the responding units; and perhaps whether such features of human social life as loyalty, solidarity, friendliness, and sanctity may sometimes be important either as incentives for group action that may be advantageous for members of the group or as inhibitors of ill-timed individual responses (e.g. premature withdrawal from the group) (cf 43; 76, p. 204).

In the context of our discussion of criticisms of ecological anthropology, we have made various suggestions about research and theory. In conclusion, it may be noted that our focus on environmental problems and on how people respond to them calls for the following:

1. Paying attention to many possible hazards or problems in addition to those related to energy utilization.

2. Investigating possible relationships between such characteristics of hazards as their magnitude, duration, and novelty, and the temporal and other properties of people's responses.

3. Abandoning an equilibrium centered view and asking instead about change in relation to homeostasis.

4. Studying how hazards are responded to not only by groups but also by individuals.

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