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ECOLOGICAL ANTHROPOLOGY

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INTRODUCTION

Ecological anthropology may be defined as the study of the relations among the population dynamics, social organization, and culture of human populations and the environments in which they live. It includes comparative research as well as analyses of specific populations from both synchronic and diachronic perspectives. In many cases, systems of production constitute important links among population dynamics, social organization, culture, and environment. Defined as such, ecological anthropology provides a materialist examination of the range of human activity and thus bears an affinity to other materialistic approaches in the social and biological sciences.

Review articles can be critical or encyclopedic; this one adopts the former approach. It presents the development of ecological anthropology, not as a smooth accumulation of information and insights, but as a series of stages. Each stage is a reaction to the previous one rather than merely an addition to it. The first stage is characterized by the work of Julian Steward and Leslie White, the second is termed neofunctionalism and neoevolutionism, and the third one is called processual ecological anthropology. In all three cases, this article discusses the theoretical assumptions and methodological approaches, and examines a few representative studies. It reviews the links to biological ecology and analyzes the mechanisms of change. It is in these areas that processual ecological anthropology is particularly strong. It thus adopts a more historical approach than the positivist slant of recent texts in the field (123, 194, 205).

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This article focuses primarily on work in social anthropology. It contains relatively little archaeology. The treatment of demography is brief; for other studies of demographic anthropology, see (181, 229, 340). The primary focus is on social, economic, and political activity and ideology; there is only brief treatment of what has been termed "biosocial ecology" (321). The relation between environments and human physiology, nutrition, disease and the like, though part of human ecology, is not discussed in this article, although some work (166a, 236, 249) in ecological anthropology examines these topics.

THE FIRST STAGE OF ECOLOGICAL ANTHROPOLOGY: JULIAN STEWARD AND LESLIE WHITE

Ecological anthropology owes its existence to a number of swings on intellectual pendulums. Stated briefly, it emerged from the reaction to the incautious cultural evolutionism associated with Morgan, Tylor, and others in the nineteenth century. In this period, a number of writers developed models of cultural evolution. The specific details of the models and some aspects of the conceptualization of culture varied, but the writers shared the assumption that all cultures could be placed in a small number of stages and that cultures tended to move through these stages in a relatively fixed sequence. Morgan, one important figure in this school, established a set of seven evolutionary stages which Marx and Engels encountered and utilized.

The cultural evolutionistic approaches were overcome by the data which they attempted to order; the reaction to them led to the institutionalization of anthropology as an academic discipline. The increasingly detailed evidence of complex culture and social organization among allegedly primitive groups made it difficult to relegate them to more backward, earlier stages. The reaction to cultural evolutionism took different forms on opposite sides of the Atlantic and thus broke a relatively high degree of intellectual consensus. Anthropologists in America, led by Boas at Columbia University, questioned the unilinearity of the evolutionary schemes and the assumption of progress inherent in evolution. They accepted the interest in cultural process and change, but looked more prudently for details of each case of culture change, examining whether traits were diffused or independently invented and how they were reworked by each culture that adopted them. The school that they formed has been aptly named historical particularism. The British anthropologists faced a different issue which the cultural evolutionists had not resolved, the nature of the forces that united the different elements of a given culture or stage of cultures. Focusing on societies rather than cultures, they found that the diverse elements served certain functions,

although different authors did not agree on the nature of these functions. They also observed that the elements formed coherent structures. The influence of British social anthropology, itself changed somewhat over the decades, has begun to be felt in ecological anthropology only recently (36a); the history of ecological anthropology for many years remained primarily American.

Ecological anthropology emerged from the Boasian school of historical particularism (136, 223). It can be seen as having passed through two stages and now entering a third. The term "stage" is used to refer to a set of works that share theoretical approaches, modes of explanation, and choices of research problems. The term also suggests that the stages follow one another chronologically and that each is an intellectual outgrowth of the one that preceded it. The first stage ran from about 1930 to 1960, and the second from about 1960 to the early 1970s. These dates cannot be exact, since many writers continue to employ earlier approaches after new ones have been introduced. In addition, some researchers have shifted from one stage to the next, but others have remained with the previous ones. The stages thus refer to analytical frameworks rather than to specific periods in time or the writings of specific individuals.

As an intellectual endeavor, contemporary ecological anthropology can be clearly attributed to two individuals: Julian Steward and Leslie White. These men shared a strong Boasian training; Steward at Berkeley and White at Chicago were both taught by students of Boas, who had founded these departments (Alfred Kroeber and Robert Lowie, Fay Cooper Cole and Edward Sapir, respectively.) It is an apparent paradox that Steward, who received more contact with individuals outside this Boasian circle in his graduate student days, made the less definitive break with historical particularism.

Steward's work in ecological anthropology was motivated by a consistent set of intellectual concerns (177). His contact at Berkeley with the noted geographer Carl Sauer led him to examine the effect of environment on culture. This interest characterizes his early postdoctoral work in the Great Basin and his later more comparative work elsewhere. (Sauer also influenced Daryll Forde, one of the more ecologically oriented British social anthropologists.) His "method of cultural ecology" (292, 294) demonstrates his materialist emphasis. This method entails the study of the relation between certain features of the environment and certain traits of the culture possessed by the sets of people living in that environment. Within the environment, Steward emphasized the quality, quantity, and distribution of resources. The aspects of culture that he examined most closely were technology, economic arrangements, social organization, and demography, although he included other aspects as well. Steward stressed the fact that the

environment influenced only certain elements of a culture, which he termed the "culture core"; other elements of culture were subject to the autonomous processes of culture history which the more strict Boasians discussed. Steward was particularly interested in finding what he termed "regularities," or similarities between cultures that recur in historically separate or distinct areas or traditions, and which may be explained as a result of similar environmental features. These regularities are analytically similar to the individual lines of change which he examined in his approach of multilinear evolution. By introducing the concept of "level of sociocultural integration," he began efforts to integrate the study of small-scale "tribal" isolates with that of complex society and large sociopolitical units.

His method permitted both synchronic analyses of static equilibria and diachronic analyses of both long-term and short-term evolutionary processes (196). His early (289) work on prehistoric societies of the American Southwest demonstrates his interest in a specific area. His later evolutionary work was more ambitious and comparative; a change may be noted (40) in the shifts from the ambiguous categorizations of the *Handbook of South American Indians* (291) to the strongly evolutionist analysis of irrigation civilizations (290) to the later, more cautious works such as the controlled comparison of two Indian groups in North and South America (197) and a general review of cultural evolution (293, 295).

Leslie White's relation to the Boasian tradition was somewhat different. Like Steward, he wrote a historical particularist dissertation, but he made a sharp break with that approach soon after. He taught at Buffalo, where he visited the Iroquois and read Morgan's work. A trip to the Soviet Union in 1929 impressed him with Marxism, and he found that the works of those two figures were closely associated. He became virtually obsessed with the extreme rejection of cultural evolutionism that was current them and dedicated much of his intellectual career to efforts to restore it to respectability within anthropology.

White shared Steward's emphasis on culture as the unit of analysis and his interest in cultural evolution; his partitioning of culture into technological, social, and ideological components gave him a materialist stance generally similar to Steward's. White was more concerned with the broad details of evolution than with specific adaptations, however, and he also directed relatively little attention to the influence of environment on particular cultures. Instead he emphasized levels of energy use as the determinant of cultural evolution (328), a point which has continued to hold importance for anthropology (2a). Although his proposed science of culturology never achieved the fame that he had hoped for, his stress on the consistency of cultural evolution has had a broad influence.

Despite their similarities, there were several fundamental differences between these two founders of ecological anthropology. White was unwilling to admit the utility of other theoretical frameworks, but Steward specifically designated the areas where other approaches, such as historical particularism, could complement his own work. In both synchronic and diachronic studies, White was much less interested in adaptation of groups to specific environments than Steward was. Finally, although the distinction is not as rigid as some critics have made it out to be, White's models of cultural evolution were unilinear and monocausal, whereas Steward admitted a number of different lines of cultural development and a number of different causal factors. These differences posed a problem that was simultaneously intellectual and sociological; not only did many anthropologists wish to resolve the theoretical disagreements between the two, but they sought to avoid factionalism in specific institutional settings such as academic departments.

THE SECOND STAGE OF ECOLOGICAL ANTHROPOLOGY: NEOEVOLUTIONISM AND NEOFUNCTIONALISM

The attempts to address the similarities and differences of Steward and White mark the second stage of ecological anthropology. Boldly oversimplifying, one could argue that there are two main trends in this second stage: the neoevolutionists, who claimed that Steward and White were both correct, and the neofunctionalists, who argued that they were both wrong.

Neoevolutionism

The neoevolutionists, drawing inspiration from the centennial of Darwin's publication, *The Origin of Species,* established a series of evolutionary stages and used the notions of specific and general evolution (266a) to accommodate Steward's method of cultural ecology to White's work on unilineal evolution. The term neoevolutionism serves to distinguish their writings from those of earlier evolutionists such as Tylor and Morgan. General evolution, which tends to be unilinear, included features from Steward's work (level of integration) as well as from White's (energy use per capita per year). Elman Service (276), for example, dedicated his *Primitive Social Organization: An Evolutionary Approach* to Steward and White. General evolution strongly resembles the long discarded view in biology that evolution is progressive and leads toward new and better forms in succeeding periods. Much of this work has involved the establishment of a small number of evolutionary stages. These formulations also show the influence

of Polanyi's (230) notion of three types of economies, based on reciprocity, redistribution, and market exchange. Some work examines cases of apparent cultural regression or movement from a higher to a lower stage of cultural evolution. The debate (19, 46, 118, 173) on the ability of the humid tropical forest to support large complex societies reflects this discussion. By marking out cases of regression as exceptional, it serves to reinforce the general orthogenetic tone of neoevolutionism. The more multilinear specific evolution relies closely on Steward's writings. Adopting techniques from general systems theory, archaeologists and social anthropologists in the neoevolutionist school have collaborated in the study of the origins of agriculture and the emergence of the state. In the latter, for example, there has been considerable debate on several topics: whether the existence of social stratification preceded or followed the origins of the state (101, 207), the analytical power of certain causal theories of state formation (39, 277), the universality of patterns of pristine state formation (278), and the utility of the distinction between pristine or primary and secondary states (338). Several review articles on this subject have appeared recently (95, 144, 336).

Neofunctionalism

The neofunctionalist school represents a second line of resolution of Steward and White. It is associated with Marvin Harris and the early work of Andrew Vayda and Roy Rappaport; like the first line of resolution, it was concentrated for a number of years at Columbia and Michigan universities. The term neofunctionalism is used because the followers of this approach see the social organization and culture of specific populations as functional adaptations which permit the populations to exploit their environments successfully without exceeding their carrying capacity. This approach differs from other functionalist approaches in the social sciences in that the unit which is maintained is a population rather than a social order. It also differs from the treatment of adaptation in biological ecology by treating populations rather than individuals as the units which adapt to environments. It forms a school, although there are differences between individuals in it (Harris's greater concern with causality, Vayda and Rappaport's with system functioning), and some members have shifted their theoretical position in recent years.

In general, neofunctionalists explain specific aspects of social organization and culture in terms of the functions which they serve in adapting local populations to their environments. A close parallel might be noted between White's technological, social, and ideological components of culture and Harris's division of sociocultural adaptations into ecological patterns (including technoenvironmental and demographic aspects), social structure,

and ideology (129), which reappear, in slightly modified form, as infrastructure, structure, and superstructure (131), with a strong similarity evident to the Marxist concept of mode of production and its components of forces of production, relations of production, and superstructure. However, it would be more accurate to agree with the members of the neofunctionalist school and dwell on the sharp discontinuity between their work and that of Steward and White instead of the similarities. They adopt local populations rather than cultures as their units of analysis. They examine the interaction between environments and populations rather than treating the environment as a passive background which shapes culture but is not influenced by it, and their methodology is more explicit, rigorous, and quantitative than that of earlier writers. They are concerned to adopt concepts from biological ecology, although they often use these concepts in a naive or outdated fashion because of the weak historical, institutional, and interpersonal links between anthropology and biological ecology. Specific terms which were borrowed include adaptation, niche, and carrying capacity (11, 121, 122, 183, 243, 339), although there were numerous problems with all three cases (35, 137, 175, 182, 216, 296). [For more thoughtful treatment of the concept of adaptation, see Alland (4) and Vayda (310); there are also a few cases (106, 175) of appropriate use of the niche concept.] Their uncritical use of Wynne-Edwards' notions of group selection is another example of this problematic borrowing; examples (205) of the uncritical use of this concept can be found more than 10 years after a devastating attack on it had been published (331). Like the neoevolutionists, this school is influenced by systems theory, both generally, in its choice of homeostatic equilibrium models, and specifically, in its concern with energy flow in ecosystems (72).

Neoevolutionism and Neofunctionalism Compared

The neofunctionalist and neoevolutionist schools tend to follow certain trends within biological ecology. They focus on regularities in ecosystem-level process. In this approach, human populations are believed to function within ecosystems as other populations do, and the interaction of different human populations is like the interaction of different species within ecosystems (313). This approach leads to an emphasis (237) on energy and nutrient cycling. They also adopt a view of ecosystems as relatively tightly integrated, and they accept a series of concepts that are associated with the notion of "succession," or the orderly and regular replacement of species in a disturbed ecosystem over time as it goes from a "pioneer" to a "climax" stage. More "mature" ecosystems are supposed to be more complex, diverse, stable, and efficient. [Rappaport's (236) comparison between Tsem-

baga society and Polynesian kingdoms, for example, follows this view.] It is not surprising that several of the most frequently cited ecology texts are the different editions of E.P. Odum's *Fundamentals of Ecology* (209).

The neofunctionalists and neoevolutionists have examined the mechanisms which link social structure and culture to the environment. They follow biological ecologists in emphasizing survival and reproduction as the goals of organisms (165), and they therefore emphasize population pressure as one of the principal mechanisms of change (124). Unlike biologists, they do not have a principle like natural selection which generates these goals, and instead tend to fall back on implicit and poorly operationalized concepts of adaptation. Systems should tend toward homeostatic equilibrium (238, 239), with populations at or close to carrying capacity; population growth above these limits induces change. The carrying capacity reflects environmental variables and technology, and may be influenced by the presence of other neighboring groups of trade partners, political enemies, and the like. Population pressure, however, does not translate immediately into human motivation, and some ecological anthropologists, seeking to explain change, have had to appeal rather generally to notions of human desires for survival or to the gradual replacement of less efficient systems of production by more efficient ones (5). In a more recent discussion, Harris (131) lists the desires for food, sex, and love and affection and a tendency toward the expenditure of the minimum amount of effort necessary as universal human constraints from which social and cultural systems can be built, although this recapitulation of Malinowski is difficult to use in concrete cases. Values and preferences are explained by being reduced to the ecological functions they serve, as in treatments of factors which influence the levels of effort and efficiency of tropical forest hunters (249, 281) or in the female infanticide-male warfare complex (70, 145, 200). This lack of an ability to account for motivation and values in a more direct way has attracted a great deal of criticism, and may account in part for the rift between ecological anthropologists and their opponents (24). Such a lack, however, has been addressed in the third stage of ecological anthropology, as will be discussed later.

The neoevolutionists and neofunctionalists, although they examine populations of different sizes in different time scales, share a great deal. They accepted the issues which Steward and White had outlined as worthy of investigation, although they took different approaches in their study. They both added a strong systems orientation to an earlier materialism, although the neofunctionalists emphasized negative feedback mechanisms linking energy use, food production, and population size, and the neoevolutionists stressed positive feedback mechanisms among the same variables. They developed strong interpersonal and institutional links; the departments at

Columbia and Michigan universities had representatives of both for many years. Some individuals work in both approaches. Furthermore, the concern of the neoevolutionists to define stages (141) in general cultural evolution (e.g. "bands," "tribes") dovetails with the efforts of the neofunctionalists to establish basic production types (e.g. "hunting and gathering," "swidden agriculture"); in some cases, as in the ones listed, evolutionary stages and production types can be correlated (63, 73, 287).

Early neofunctionalist analysis (228, 297) of the Northwest Coast groups showed that the apparently exotic custom of the potlatch served adaptive functions by encouraging the redistribution of food from groups with a temporary surplus to those with a temporary deficit. Part of the appeal of this analysis (71, 162, 211) derived from the ability to challenge Boas on his own ground, since the cultures of that area were among the ones he studied most intensively. In addition, it began a tendency, still quite strong, within neofunctional ecological anthropology, to define one of its tasks as the explication of ethnographic riddles (130). In this line of work, an ecological anthropologist picks a custom or practice which would seem to demonstrate the extreme intercultural variability of human behavior and the lack of fit between culture and environment; the supposedly impractical cultural elements are shown to possess positive adaptive value. The second such riddle was the sacred cattle of India (127, 128, 208). Other examples have appeared, the most currently famous of which is Aztec cannibalism and its purported nutritional significance (125, 222, 231: see also 143, 253). The adoption of riddle explication as a goal would seem to be justified by the following logic: if apparently impractical behavior can be explained on ecological grounds, then less impractical behavior must surely also be explicable in the same manner. Although the discussion of such riddles has attracted a fair amount of attention within strictly anthropological circles and others as well (134), it has often not led to a more thorough attempt to explain the less bizarre behavior that makes up much of the subject matter of ecological anthropology (6). Instead it has led to the proposal of alternative solutions to the riddles (67–69) with little possibility of empirically testing them.

The neofunctionalist school has brought certain benefits, particularly the generation of detailed descriptions of food-producing systems (5, 153, 199, 256), a greater concern for recording environmental and demographic data (200), the suggestion of the systematic nature of the interactions between the environment on the one hand and social organization and culture on the other, and the demonstration of certain weak points in the work of Steward and White. There are several problems which have emerged from it, some of which also apply to the neoevolutionists: (*a*) Functionalist fallacy. The neofunctionalists are simply incorrect in attempting to argue

that human populations remain at or below carrying capacity, since they miss the cases of populations which cause significant damage to their environments (178, 187). The idea of a relatively fixed carrying capacity has remained in the literature, despite the publication of strong critiques of it. Even when the damage is minimal or unmeasurable, they possess the frequently criticized flaws of functionalism: the inability to distinguish between functional alternatives, logical circularity, and false attribution of purposiveness (245). (*b*) Ecological reductionism. Many of the writers of this school tend to assume that particular aspects of social organization and culture serve specific functions in adapting local populations to their environment (242). They (99, 117, 138) thus tend to present social organization and culture as unstructured sets of practices and beliefs rather than as possessing internal coherence. Leeds's (167, 168) discussions of the Yaruro Indians in Venezuela are an exception to this common pattern. (*c*) Energetics. Energy need not be the limiting factor in restricting population growth or social complexity. Although biological ecologists have recognized this fact for many years, ecological anthropologists have became aware of it only recently (207, 311). These issues are interrelated; energy flow is a simple way to consider local populations in the context of ecosystems (283). Thomas's (301) discussion of energy flow in a highland Andean district, for instance, argues that energy is a limiting factor despite the fact that local people are involved in producing commodities for export whose prices on the world market shift greatly; government policies also strongly affect their access to factors of production. It is therefore difficult to argue that their adaptations are constrained primarily by local environmental factors or their access to energy. The presentation of arguments that energy is not limiting in many human populations has led to minor refinements in several cases: protein is substituted for calories as the limiting dietary factor or energy, though not limiting, is critical; by producing energy as efficiently as possible, time is conserved to address the scarcity or excess of other limiting factors, so that populations still must behave in much the same manner as if energy were limiting. This latter approach raises a common problem in ecological anthropology; writers claim that populations or individuals maximize several variables simultaneously, but they do not address the issues of trade-offs between the variables and choice between several optima (132). (*d*) The local population as unit of study. Local populations are difficult to bound (193) and tend to be involved in wider networks of social, economic, and political relations (275a). The nature of population-level processes is unclear, and there has been a neglect of both supralocal processes and internal differentiation (227, 260). [See, however, some works by Harris (131) and Vayda (309) which examine larger units.] (*e*) Timescale. The assumptions about local populations being in homeostatic equi-

librium are difficult to assess because they require a long time scale. The work also tends to present a sharp disjuncture between synchronic equilibrium and long-term macroevolution corresponding to the separation between the neofunctionalists and the neoevolutionists. Mechanisms of short-term cultural evolution are also often lacking. [See, however, Leeds's (169) treatment of microinvention.]

THE THIRD STAGE OF ECOLOGICAL ANTHROPOLOGY: PROCESSUAL APPROACHES

In contrast to the work of Steward and White and the neoevolutionary and neofunctionalist schools, a third set of approaches in ecological anthropology has begun to emerge in recent years. The research that is being carried out cannot be characterized as strongly as in the two previous stages as sharing a large number of assumptions, but it does question the neofunctionalist approach along the lines indicated above. This work will be called "processual" ecological anthropology. The use of the term "process" has been used earlier by other writers (16, 158, 171, 186) to refer to the importance of diachronic studies in ecological anthropology and to the need to examine mechanisms of change. However, the term "processual ecological anthropology" to describe current developments in the field does appear to be new. Important trends are (*a*) the examination of the relation of demographic variables and production systems, stimulated in part by Boserup's work (31); (*b*) the response of populations to environmental stress (268, 311, 312); (*c*) the formation and consolidation of adaptive strategies (22–24, 27, 37, 38) which follow Barth's early work on the use of the concept of the niche (11); and (*d*) new work in Marxism, including the emerging interest of anthropologists in political economy and structural Marxism. The studies are called processual because they seek to overcome the split in the second stage of ecological anthropology between excessively short and long time scales (15, 84–86). More concretely, they examine shifts and changes in individual and group activities, and they focus on the mechanisms by which behavior and external constraints influence each other. These points indicate the importance of the incorporation of decision-making models into ecological anthropology. Like the neofunctionalist and neoevolutionist ecological anthropology, processual ecological anthropology examines the interaction of populations and environments (57) rather than treating the latter as a passive background to the former. There are strong parallels between processual ecological anthropology and current work in biological ecology; the nature of these resemblances is the subject of some analyses which seek to link anthropology and biology in a more rigorous manner than has previously been the case.

It should be noted that work characteristic of Steward in the two previous stages continues to the present. His method of cultural ecology, for instance, is exemplified in several studies (26, 303) including some of Netting's work among agriculturalists in Nigeria (201–203) and Switzerland (204); see also (197). Strong echoes of Steward's search for "regularities" can be noted in Wolf's *Peasant Wars of the Twentieth Century* (334) and elsewhere (116). Similarly, neofunctionalist studies are still being carried out. Bolton's (30) recent analysis of guinea pig production and consumption in one village in highland Peru, for instance, suggests that although guinea pigs contribute less than one-twentieth of the protein in the local diet, "the ritual cycle . . . serves to distribute protein, making it available at times when it will be maximally beneficial for the maintenance of health in the population" (p. 249) based on informants' statements on ritual guinea pig consumption, with little direct observation on diet, and simulation models rather than observation of guinea pig flock dynamics. Neoevolutionary work also continues to the present (53, 158, 174).

Actor-Based Models and Processual Ecological Anthropology

A major influence on the processual ecological anthropology is the actor-based models which have received general interest in social anthropology. The literature on these models is large and diverse; one particular focus, decision-making models, will be emphasized here. The actor-based models form part of a general shift in postwar anthropology in both Britain and the United States from social structure to social process, from treating populations as uniform to examining diversity and variability within them, and from normative and jural aspects to behavioral aspects of social relations. Firth's (92–94) distinction between social structure and social organization is a major point of departure. He underscored the importance of variability in decision making and individual behavior, and demonstrated that many social systems contain options among which individuals must choose.

The actor-based models have several advantages: they account for a wider range of social organization than previous models do; they permit a more precise analysis of the parameters of behavior and the variation of behavior within populations; they admit more readily an examination of conflict and competition; and they offer the potential of examining change through an analysis of the processes which generate economic, political, and social relations. One important aspect of actor-based models is decision-making models, which may be loosely divided into two types: cognitive or naturalistic models and microeconomic models. These types are not necessarily opposed, as attempts at synthesis (47a, 147) show; they remain, however, largely distinct. The former, borrowing from cognitive anthropology, attempt to depict actual psychological processes of decision

making by locating the cognized alternatives and the procedures for choosing among them. Quinn (234, p. 42) distinguishes within these among "information processing models," "retrodictive models," and "models of cultural principles." These types all tend to be employed to analyze contexts in which individuals must select among a small number of alternatives, often on the basis of consideration of social status. Postmarital residence and adoption are common topics. These models offer useful links between studies of native systems of classification and actual behavior; such ethnosemantic models have been developed for the planting decisions of Brazilian sharecroppers (154–156) and the marketing decisions of West African fish vendors (108). These models often are applied to situations in which alternatives are finite and may be distinguished by discrete rather than continuous variables. The parameters which affect the choices tend to be few in number, and the outcomes of choices are certain, or nearly so.

The microeconomic models resemble economic models of choice making. Actors operating under a set of constraints allocate scarce resources to a hierarchical series of ends or goals. Many such models assume that actors attempt to maximize some valued state, although some authors have proposed more complex models of optimizations such as "satisficing," minimax strategies, and hierarchies of strategies (18, 274). In this fashion they avoid the rigidities often attributed to models of rational actors (139). There is a larger concern with the *outcome* of the decision and less emphasis on the *process* of decision making. These models are applied to situations with greater uncertainty and ambiguity, where the range of alternatives and the outcomes of choices are less well defined. The alternatives may be distinguished by continuous as well as discrete variables, and many parameters may influence them. Barth's (12) efforts at generative models of social organization are an example of such work. Borrowing from game theory, he attempts to explain political organization among Pathans as a structure which had emerged from a large number of individual decisions made by actors operating under different constraints. Ortiz's (220, 221) studies of planting and marketing decisions by small-scale farmers in Colombia are another example. Although these models can be criticized for taking the goals and constraints as givens and failing to examine the patterns of resource distribution, they have been of considerable use in anthropology as in political science and economics.

The potential links between ecological anthropology and actor-based models are strong, but they have not been utilized extensively. Ecological anthropology, particularly in its first two historical stages, emphasized the importance of environmental factors in shaping collective patterns of behavior. The neglect of the examination of individuals which this focus has often produced may be explained in part by the repudiation of the examination

of individual actors by early ecological anthropologists (327) and in part from the neofunctionalist and neoevolutionist emphasis on systems in which aggregates and aggregate variables were accorded more importance than individuals. Conversely, actor-based models have tended to treat environmental variables as part of a relatively static set of external constraints to which individuals respond and adapt. This tendency is particularly strong in studies which focus on small areas in short periods of time. They have thus omitted some of the concerns of ecological anthropology. Despite the lack of effort in this direction, ecological anthropology can offer actor-based models a richer understanding of the dynamic that operates within the system of constraints; and actor-based models can permit ecological anthropology to examine the proximate factors which influence the behavior of individuals and of aggregates. The integration of the two is particularly favorable to the processual studies in ecological anthropology; the ecosystem and decisions made by individual actors affect each other reciprocally.

The microeconomic models of decision making are preferable to the cognitive ones in this synthesis, although the latter may also be of use in certain well-defined areas of behavior (9, 10, 57a, 109). In general, the alternatives are often characterized by continuous rather than discrete variables, by many parameters which influence the selection among them, and by uncertainty as to the outcomes. A concern for the interaction of actors with ecosystems would lead to a primary focus on the outcomes of decisions.

Processual Ecological Anthropology, Biological Ecology, and Evolution

The emphasis on individual decision making also corresponds to recent developments in biological ecology, with its stress on natural selection on the level of individual organisms as a principle which organizes populations and communities (176, 185, 245). The links between microeconomic and ecological models have been drawn to show parallels between consumer choice and foraging strategies, investment behavior and life-history strategies, locations of firms and refuging behavior, market behavior and predator-prey interactions, and the like (146, 241). In addition, the criticisms that the neofunctionalists and neoevolutionists have established a rigid separation between synchronic studies of homeostatic equilibria and diachronic studies of long-term evolution directly parallel the criticism that earlier work in ecology, typified by Odum and others, fails to synthesize adequately energy-flow studies and studies of ecosystem succession. The efforts of these ecologists to link the two through ecosystem-level processes such as ecosystem strategies and maturity have run into serious difficulties. Major research projects along these lines in the International Biological Program did

not generate as powerful results as were expected, and system modeling and simulation has also been relatively unrewarding. Both biological and human ecology have shifted from system-level statics and dynamics to utilizing individual action as a basis for emergent higher-level processes (252). Many biologists have begun to challenge the order and regularity of the sequence of successional stages. The links among diversity, stability, and ecosystem maturity are also questioned (58, 75, 157); the stability of some ecosystems has been shown to rely on climatic stability rather than on mechanisms internal to the ecosystem. The role of external stresses and catastrophes in influencing ecosystem structure and function has also attracted considerable attention (41, 65, 218, 224), paralleling the interest in the response of populations to environmental stress in ecological anthropology. The links with demography and biological ecology have led in many cases to increased efforts to define and operationalize variables, to include new methodological procedures for assessment of environmental variables, and to apply tests of statistical inference with greater rigor (166a). Furthermore, these parallels between cultural and biological ecology have generallly been proposed (245) more cautiously than was the case with the neofunctionalists. Rather than claiming that natural selection forces organisms to behave as if they operated with the same rational calculus that human actors are presumed to use, it can be suggested that these homologous optimization models facilitate the examination of the ways in which human action affects ecosystems and environmental constraints influence human decision making. They also allow interdisciplinary research efforts to proceed more easily. The questioning of the neofunctionalist approach has led to an ability to study productive activities (83, 166b, 332), settlement patterns (166, 324), and the like without attempting to show how they maintain human populations in equilibrium with their environments. In this way the processual approach and Stewardian cultural ecology may be seen to share some approaches. (The "principle of alternating generations" also links them.) Some research (207) on hunting typifies this work. Hunting behavior in traditional settings has been compared to the predictions of hypotheses on optimal foraging strategies in biological ecology. In some cases the hunters deviate from these predictions, because the most prestigious or culturally desirable meat is not always the most efficient or least risky to catch in energetic terms (80), or because fear of observation by members of other social groups constrains patterns of movement (179, 180).

Components of Processual Ecological Anthropology

DEMOGRAPHY Demographic decision-making models are closely tied to the specific trends in processual ecological anthropology mentioned earlier

in this section. They bear on the recent work in demography and anthropology which has contributed to processual ecological anthropology. Neofunctionalist work emphasized negative feedback mechanisms which maintained populations at static levels: neoevolutionists looked at the broad details of human demographic history, and often missed the details of particular cases.

A seminal work in this field is Boserup's *The Conditions of Agricultural Growth* (31). Her well-known hypotheses reverse Malthusian descriptions of human demography to suggest that population pressure causes rather than follows agricultural intensification; people shift from more efficient extensive systems to less efficient intensive ones only when driven by the necessity of feeding more individuals. The general outlines of her argument and the details of her sequence of stages in agricultural intensification have attracted a great deal of attention. Many authors have pointed out the shortcomings of her excessively simple scheme, and indicate that other factors can also influence the sequences of agricultural intensification; these include market systems, political pressures, and environmental variables. Boserup's work and studies by Spooner (286) and others (14, 17, 25, 37, 61, 113, 124, 126, 190, 203, 307, 325) stimulated by it may be classified as processual, for several reasons. The effort to assess the links between population pressure and agricultural intensification have led to diachronic studies (190) in which changes in single groups are traced through time; research in other areas for which little historical reconstruction is possible has been carried out by examining the covariation of population density and agricultural intensity (34a), with the assumption that current distribution of associations resembles past sequences. The studies often rest on an implicit decision-making model in which actors actually allocate scarce resources (labor) in order to achieve goals (food production). The mechanisms of change are seen in the connection between population and resources, linked through systems of agricultural production and the necessity to feed local populations. Individual decisions have cumulative consequences which lead to broader change; shortening of fallow periods may lead to a shift from communal tenure to private property, for instance. Other work links demographic and ideological change (20).

ENVIRONMENTAL PROBLEMS Vayda & McCay (311, 312) argue that the literature on the response to environmental problems is an important shift away from the strong focus on energetics and from the assumption of stable equilibrium; as they show, it also permits an examination of individual as well as population responses to environmental forces. Waddell's (314) work on the response of the Fringe Enga in highland New Guinea describes three types of responses to three levels of frost intensity and duration, with

larger (though still subpopulation) sets of individuals acting in cases of more severe potential or actual damage to crops. Earlier work by Vayda (308, 309) and others (120) on the nature of warfare and the choice of different forms of attack rather than other responses to certain situations similarly makes the point that the nature of the response can be correlated with the scale of the problem. Other works show that responses can vary on individual as well as collective levels to natural stresses such as storms (17), droughts (171, 212, 232, 243), famine (159, 219), and earthquakes (210). Laughlin's (163, 164) well-documented analysis of the responses of the So in East Africa to periodic crop failures is another good example of use of decision-making models and the analysis of environmental problems. Britan & Denich (33) address similar issues in Newfoundland and Yugoslavia in cases of secular rather than cyclical change. Some efforts (209a) have been made to quantify environmental hazards.

ADAPTIVE STRATEGIES The notion of adaptive strategy follows closely from that of decision making. The idea of adaptive strategy suggests that individuals, by repeatedly opting for certain activities rather than others, construct alternatives which others may then choose or imitate. It is also congruent with the emphasis on strategies and fitness in evolutionary biology (304). A focus on adaptive strategies leads to an examination of the manner in which a larger number of choices made by individuals can influence the wider setting (27, 47a, 178, 278a, 300, 323, 330). Rutz's (258) analysis of household decision making in a Fijian valley, for instance, shows the unplanned village-level consequences of interaction between households and their resolution of competition over different types of land. McCay (186) examines two types of adaptive strategies among Fogo Islanders as responses to a period of decline in the nearby fisheries. Individuals and households may adopt "diversification" and "intensification" responses, and the latter in particular led to outside intervention by governmental agencies, which made the environmental problems more severe. The concept of adaptive strategy, however, is often more elusive than one might suspect, as suggested by definitions such as Bennett's (22, p. 14): "the patterns formed by the many separate adjustments that people devise in order to obtain and use resources and to solve the immediate problems confronting them." The issues of the consciousness of the adaptive strategies and the ease with which they may be adopted are often not wholly confronted; the same work by Bennett on a region in the Canadian Great Plains recognizes four strategies (rancher, farmer, Hutterite, Indian) but does not fully examine the consequences of the fact that it is easier for farmers and ranchers to shift between those two strategies than to adopt the Hutterite or Indian one.

MARXISM It is at this juncture that the contributions of Marxism become evident. The important role of Marxism in the two earlier stages of ecological anthropology makes its contributions in the third stage appropriate. If adaptive strategies are seen as the outcome of decision making, or repeated allocation of scarce resources to a hierarchy of goals under conditions of constraint, then it is necessary to examine the pattern of resource distribution and the source of the goals and constraints. This is precisely the contribution of recent work in Marxism, including much structural Marxism (29, 103, 111) and the new political economy. In particular, a reconsideration of the notion of mode of production questioned the rigid sequence of succession of modes and the determination of the superstructure by the base (140, 172, 215), paralleling a rejection of neoevolutionism and neofunctionalism. Dependency theory raised similar issues on the relation of economics and politics and suggested the importance of an examination of world systems. This work is compatible with the emerging interest in political economy within anthropology (1, 36, 49, 114, 119, 151, 180, 213, 250, 269, 273), the concern for a historical materialist perspective (59), and an emphasis on the links between local populations and wider systems (31a, 36a, 259), including regional studies (16), studies of complex society (334), and a world-systems perspective (217). This work thus contrasts with the neofunctionalist ecological anthropology, which often adopted the local population as its unit of analysis. For a structural Marxist critique and reply, see (102) and (240). Each social formation may be seen as having a characteristic set of forces and relations of production and an associated superstructure. This social formation is pushed toward transformation by conflicts within the base, between the base and superstructure, and between the social formation and its wider natural and social setting. Any social formation is a transformation of the ones that preceded it. This criticism is similar to the one made by Sahlins, that ecological anthropology reduces culture to "protein and profit" (266, p. 45), that it misses the fact that activity and ideology form a coherent structured whole of meaning and its expression. This criticism also attacks the lack of satisfactory treatment of the mechanisms which generate human behavior on the part of many neofunctionalists and neoevolutionists.

Social Organization, Culture, and Process

One analyst (235, p. 34) of social conditions in Argentina, in attempting to explain living conditions to a junior colleague, pointed out the necessity for weighing the relative influence of geographical and institutional factors. The choice between environmental factors on the one hand and social and cultural ones on the other is not so simple, since the nature of their relations goes beyond the old debate between determinism and possibilism (36a).

[This debate continues to resurface, as may be seen, for instance, in the discussion of similarities and differences between blacks and East Indians in the Caribbean (66, 83, 100).] Environmental factors interact with social and cultural ones, and neither operates independently.

The neofunctionalists claim that the basic facts of technology, environment, and demography determine social structure and culture (131), and an extreme culturalist point of view, such as that of Sahlins, would argue that culture must be seen on its own terms. A useful place to compare the two approaches and to incorporate the Marxist contributions is the Pacific, an area where Sahlins and many of Harris's associates have worked. The contrast between Melanesia and Polynesia is an instructive one. In the period before European contact, the two areas shared a generally similar technology, including tools (dibble sticks, bamboo knives, stone axes) and crops [taro, yams, breadfruit, banana, coconut (8)]. There is considerable variety of environments in the Pacific, ranging from high volcanic islands to low coral atolls, from areas with high rainfall to others with low rainfall, but Melanesia and Polynesia each possess this wide range of habitats (34, 302). Population densities at the time of contact are harder to establish, but they varied in both areas from the order of one to two individuals per square kilometer to densities a hundred times larger. However, the cultures and social structures were quite different, since the areas were settled in separate migrations (326). The differences between the two areas stand out. The sharpest is the contrast between the Polynesian chief and the Melanesian big man drawn by Sahlins (264); the relative orderliness of chiefly succession in Polynesia, the ability of the chief to command his followers, and the success of linking smaller chiefdoms into larger kingdoms (112) are all quite distinct from the more individualized careers of the big men, the uncertainty of their rule, and the difficulties of establishing larger political units in Melanesia. The postcontact histories are also different; states formed in parts of Polynesia and cargo cults arose only in Melanesia. The two different systems also are connected with different ideologies, the famed *mana* and *tabu* of Polynesia, and more complex and varied beliefs about ancestors, sexual differences, warfare, and the like in Melanesia. The contrast between ancestor spirits in Melanesia and a fixed pantheon in Polynesia may also be noted. These general patterns are quite distinct, and it would be hard to dispute that what makes Tikopia strikingly Polynesian is the culture and social structure brought by the people who settled it; similar technologies, environments, and population densities are found in Melanesia. [There are two types of cases where the distinction is less clear: (*a*) the small, disaster-prone atolls; (*b*) medium-sized chiefdoms, where more abundant resources allow incipient stratification in Melanesia and smaller island size limits the elaboration of chiefly power in Polynesia (e.g. Trobriand and Marquesas).]

Nonetheless, the environment influences social structure and culture in important ways. For Polynesia we can return again to Sahlins's work. *Social Stratification in Polynesia* (262), despite its tendency to neglect the importance of intrasocietal conflict in shaping social structure and some tautologies in the measures of productivity, argues strongly that environmental and technological features (variations on a common Polynesian pattern with some elaboration of irrigation and drainage) account for the particular variations on the common Polynesian theme of chiefly political organization and hierarchically arranged descent groups. The data from Melanesia are less clear and variation within Melanesian social organization is greater than was once suspected (48, 87). However, for similarities between highland and lowland Melanesian groups see (255). Europeans were less interested in them than in the Polynesians, so records for the contact period are poorer. Since the islands are closer, more involved in interisland trade, and were settled earlier, the specific association of social and cultural systems with each island environment is less immediate. However, there is also some association of environment and social structure, as shown by the larger political units in eastern Melanesia (264).

In other words, the environmental factors which influenced social structure and culture were mediated by certain patterns, different for Melanesia and Polynesia. [Cody & Mooney make an analogous ecological argument about Mediterranean climates (52)]. It would be almost impossible to reconstruct the early political histories of the Polynesian chiefdoms, for example, but one can assume that the settlers arrived with certain cultural and institutional patterns that bore a strong resemblance to those of other Polynesians, and that these patterns offered the settlers certain goals, placed constraints on their choices, and thus influenced their social, economic, and political history. Not surprisingly, the largest, richest, and most diverse islands, such as Hawaii, Tonga, Samoa, and Tahiti, supported the largest, most complex, and stratified political systems, and the chiefs had much less power on the smaller island societies; in neither case did they resemble Melanesian social structure on similar islands. Sahlins (265) shows that Tonga social structure and culture is a permutation of their counterparts in Fiji; he argues that this case demonstrates the supremacy of culture over material forces (107). But the matter might have been argued differently: environmental and other material forces favor certain of the many possible transformations of a given social structure and culture. Labby's (160) work, for example, incorporates material factors into an otherwise idealist structuralist analysis of Micronesian social organization.

To take another similar example, Sahlins states that Western meat preferences reflect deeply rooted cultural meanings rather than their nutritional

quality or availability; Harris & Ross (133) present a contrary position, that preferences for different sorts of meat mirror their availability and quality. Sahlins argues by alluding to the symbolic meanings attached to animals in other domains, which transform biologically edible animals such as cattle, swine, dogs, and horses into distinct cultural degrees of edibility and inedibility; Ross (251) juxtaposes data on animal production and meat preservation in the United States with statements on relative preference for cattle and swine. One might argue that the truth lies somewhere in between, as does one analyst (322) of American commodities interested in predicting future levels of consumption; if the price of one type of meat goes down, people will buy more of it, but certain traditional preferences change slowly. It might also be argued that both are wrong since neither one focuses on individuals as actors, but rather on superorganic systems. It is difficult for Sahlins to account for changing food preferences, and Harris & Ross (133) cannot explain lags in changing availability and consumption patterns. Decisions about diet, like many other decisions, are not always made fully consciously, and they reflect a number of goals and constraints, yet their cumulative impact is large.

The relative isolation of island societies and the recent settlement of some make the examination of the interrelation of social and cultural patterns with the environment particularly clear in the Pacific case. Another similar case, however, may be found in Europe. In a study of an alpine valley in northern Italy, Cole & Wolf (54) find striking differences between a Germanic and a Romance-speaking village, despite similarities in environment, technology, and population. Though both villages are Catholic, they partake of the somewhat different cultures of northern Europe and the Mediterranean. The inheritance patterns (335) in each, for instance, represent a compromise between the respective cultural ideals of impartible and partible inheritance on the one hand and the exigencies of alpine agriculture and livestock raising on the other; the two are close but still distinct. Settlement patterns and village political systems also reflect the cultural differences between the two. These facts are taken to indicate some "doubts . . . about the usefulness of ecological anthropology in the study of complex societies" (54, p. 284); it might better be argued that it is neofunctional ecological anthropology whose utility is dubious. The history of each village includes a series of contacts with other villages and wider political units; this, however, is also true of most Melanesian and many Polynesian societies as well. The two villages are the outcome of a long history of interaction between environment, social structure, and culture in the valley and surrounding region. The debate about whether they really have more in common as Alpine peasants or less in common as Germanics and Latins is not wholly

to the point; rather the individual, household, and village decisions over use of land resources and the decisions over ambiguous and shifting political alliances generate the different patterns.

A complementary approach to the one adopted in the Oceanic and Alpine cases is to look at areas with relatively uniform cultures and social structures but varying environments. Such work has been done in the Maya region, where general Mayan patterns of patrilineality and virilocality are shown to covary with population density (55, 56). The numerous works which discuss the impact of the fur trade, technological changes, and population shifts on the hunting and trapping Indian groups of Canada may also be reviewed in this context (28, 105, 152, 248, 272, 280, 282, 284, 298, 306). They also demonstrate the advantages of abandoning the population as the unit of analysis, since they include both individual and nuclear families as actors and examine the wider economic and social context, and the articulation of trapping economies with the capitalist world system and competition between imperial powers. Similarly, variations on a common Andean pattern of social organization may be related to differences in ecology and political economy. There are several core features in the area [bilateral inheritance (219), dual organization, extension of ties to affines and ritual kin, several modes of reciprocal exchange (3), verticality (198, 244)] which combine to generate different patterns. The tension (161) between an adult's ties to a spouse and to married siblings, for instance, is resolved differently in pastoral and agricultural settings (62, 96, 218). Access to different types of land depends on ecological and political economic features (36, 61a, 104, 135, 183, 192, 267, 337). The varying nature of affinal links and reciprocal exchanges reflects scarcity of different factors of productions (184). In all cases, however, these variations are based on common Andean elements of social organization. Such studies (2, 118, 189, 254) exist for other culture areas as well; other authors follow a similar perspective in explaining relatively late state formation in Madagascar (158), East Africa (315), and Southeast Asia (333). Analogous biological arguments (21, 271) can be made about temperature regulation in vertebrates. Physiological systems are coordinated in various ways for a variety of purposes in different environmental settings. The temperature regulatory systems are the outcome of particular evolutionary histories of different species, reflecting their prior physiologies and the environmental pressures to which they were subject. In general, an examination of evolution must consider both phylogenetic inertia and environmental forces. To understand the evolution of bats, it is instructive to study both the elements which they have in common with other mammals and those which they share with more distantly related but functionally similar species of flying insectivores and frugivores. Parallels

can readily be drawn with the previous examples of Oceanic societies and high-altitude peasant groups in the Alps and Andes (244). It should be stressed that these analogies are not intended to suggest that the same processes or mechanisms operate in human history and biological evolution, nor that culture and species are similar entities.

Mechanisms of Change

In processual ecological anthropology, decision-making models can provide a mechanism of change because there is interaction between the choices which actors make, behaviors on an individual and group level, and the biological, social, and cultural systems which influence the distribution of resources, constrain the possible adaptive strategies, and provide some of the goals which the actors attempt to meet. In this view, culture and ideology are not seen as epiphenomena but as proximate causes which shape human action. They influence the options among which individuals select and in turn are influenced by the cumulative consequences of such choices. This view facilitates the synthesis of recent Marxist work and ecological anthropology. These points are supported by recent literature on Highland New Guinea (31a, 187, 188, 195, 279, 299, 320), the Philippines (7, 74, 82), pastoral nomads (148, 225, 226, 269, 270, 278a, 305), and other groups (64, 78, 115, 275, 288, 329).

Other writers, dissatisfied with such eclecticism, have sought more concise and formalized presentations of mechanisms of change. One approach is the previously mentioned cultural determinism of Sahlins and others. His treatment of "transformations" (265), however, looks at qualitative change without examining the quantitative change with which it is inextricably and dialectically linked. To draw an analogy, he would suggest that a comparison of a few frames from a film is sufficient to depict the events and processes which were recorded. Such still photographs, though, even if they were analyzed in detail, could not portray motion. The view of sociobiology (47) is that human behavior, like that of other species, is shaped by the dictates of natural selection on genetic variation. This point resembles that of other writers who emphasize population size and growth as an indication of adaptation, although it differs on insisting on a genetic rather than a cultural basis of behavior. The debates surrounding this approach will not be summarized here. [It is worth noting, however, that arguments made in sociobiological terms can frequently be recast without any reference to the genetic basis for behavior. Thus, in a recent article, Dyson-Hudson & Smith (81) present an argument that human territorial behavior follows the predictions of ecological theory with regard to spatial patterns of resource use and defense; they show that territoriality among Basin-Plateau Indians, the

Northern Ojibwa, and the Karimojong is consonant with such predictions, but neglect to state that they are equally consonant with an economic cost-benefit analysis model of allocation of effort. They fail to recognize the proximate mechanisms by which individuals choose to utilize certain locations and not others.]

Other works link cultural and genetic processes, following Campbell, who "argues that the necessary conditions for the existence of natural selection are met as well by culture as by genes: the trait must be heritable, it must vary between individuals and the replication of trait-bearing individuals must be theoretically infinite but limited in practice" (246, p. 130). Some efforts to link the two emphasize genetic factors more heavily, as Irons' (149) notions that individuals choose the behaviors which maximize their fitness and Durham's (76) argument that culture traits which will maximize biological fitness are more frequently retained. Efforts to apply these models have been limited in success; one need not assume, as Irons (150) does, that Turkmen strive to be wealthy because wealthier Turkmen have more children and biology makes people want to do things that will allow them to have more children (148, 149, 247); and Durham's analysis of fertility differentials (76, 77, 79) has little bearing on his examination (78) of socially mediated patterns of resource utilization which led to the 1969 "Soccer War" between El Salvador and Honduras. Other writers give equal emphasis to both, as Cloak's (50, 51) discussion of "self-replicating instructions" and Ruyle's (260a) concepts of "cultural and genetic pools." Two sets of works, by Richerson & Boyd (32, 32a, b, 246) and by Cavalli-Sforza & Feldman (42–45, 88–91), construct more general and formal models of dual inheritance systems in which the relations of genetic to cultural fitness can be specified rather than assumed. These approaches (233) can potentially examine a wide range of cases; their empirical analyses have so far tended to be restricted to a very general analysis of human kinship behavior in which some of the deviations from the predictions of sociobiology have been explained. A recent exploration (32b) of the behavior of employees in firms demonstrates the potential of extending dual inheritance theory to other areas of activity. These writers apply the methods of populations genetics and evolutionary ecology to culture-bearing organisms, but do not assume that genetic theories alone apply to people. Culture and genes are treated as systems of inheritance, with related but distinct properties. The success or failure of these dual-inheritance approaches remains difficult to assess. Their efforts to unravel the interaction of biology and culture in human kinship systems, for example, though suggestive are still preliminary. It is notable, however, to see biologists and social anthropologists engaging in a debate as colleagues (50, 246).

Specific Cases

Two recent works which exemplify processual ecological anthropology are *The Raft Fishermen* (98) and *Fields of the Tzotzil* (55). The former analyzes the retention of fishing from rafts in a Brazilian village where boats, which would permit larger catches, are also available. The study examines a local population but places it in the contexts of extralocal economic and political systems. Forman's explanation begins with the decisions that individual actors make. He shows that local elites would be able to dominate the fishermen even more thoroughly than they currently do if the shift in fishing techniques took place. The fishermen accurately perceive that they would have an absolutely as well as a relatively smaller share of the total catch if that catch were increased by shifting to boat fishing. The lack of change is thus a dynamic rather than a static equilibrium; if certain aspects of external domination were to change (such as the system of patron-client relations on the regional and national level), the local situation would change as well. [However, Forman (97) has recently been criticized (60, 186) for leaning toward neofunctionalism in making relatively unsubstantiated claims that secrecy about identifying fishing spots serves to reduce competition and prevent overfishing, and his analysis of kinship has been challenged on methodological grounds (191).]

Collier's study in southern Mexico addresses a generally similar question, the reasons for the retention of traditional identities among peasants, as Indians in distinction to *ladinos* and as members of specific communities (*municipios*) in distinction to other such communities. He shows the benefits that these identities would confer on individuals and the difficulties which the loss of identities would bring about. He examines local systems of production in detail and shows the consequences of demographic increase and external pressures on them. He thus retains much of the systems orientation of earlier work without falling into a functionalist bias. The detailed data on changing patterns of lineage composition, land tenure, and labor utilization systematically document the response of individuals to shifting environmental and demographic constraints, and the historical material shows the impact of the cumulative consequences of these decisions on the environment and wider economic and political systems. He also integrates regional and national level processes with the study of local populations more thoroughly than Forman. This work thus draws on the areas of processual ecological anthropology mentioned earlier—the relation of demographic variables and production systems, the response of populations to environmental stress, and the formation and consolidation of adaptive strategies. This work, however, has been criticized recently both implicitly and explicitly for failing to analyze correctly the role of Chiapas

and the Indian populations in regional, national, and global economies. Wasserstrom's (257, 316–319) research, drawing heavily on recent Marxist work, shows the importance of systematically considering the demographic patterns, ritual activities, and work organization in this wider context. Highland Indians' life was even more directly influenced by regional and national elites than Collier would suggest.

This debate over Chiapas resembles disagreements over another more famous ethnographic case: the Nuer. Sahlins's (263) reanalysis shows the organizational strength of the segmentary lineage system. More recently, attempts have been made to relate the presence of the segmentary lineage system among the Nuer and its absence among the neighboring Dinka to different levels of population pressure (206) and to differential spatial patterns of resource distribution (110). Southall (285) offers a detailed analysis of both factors. Sacks' (261) interesting recent treatment emphasizes political economy. The Nuer and the Dinka had different historical experiences with traders from other areas, and these relations led to these characteristic patterns of internal differentiation. As in the case of Chiapas, though, different explanations focus on political economy on the one hand and local ecology and social structure on the other. Efforts at synthesis of the two are still incomplete.

Similar aspects of processual ecological anthropology are shown in the February 1977 issue of *American Ethnologist* devoted to human ecology. Seven of the 11 articles examine the rationality of individual actors and the manner in which external constraints shape their choices. There is a corresponding deemphasis on concepts such as carrying capacity and homeostasis which were favored by the neofunctionalists. It is significant that all the articles examine complex state societies rather than small-scale societies. Neofunctionalist ecological anthropology, which was more focused on local populations in homeostatic equilibrium with their environment, restricted itself to such populations. The greater time depth possible in complex settings, and one series of responses of different groups within such societies, demonstrates the importance of historical change rather than of static equilibrium or long-term evolution, justifying the label of "processual" for such studies. This setting in complex societies clarifies the importance of extralocal ties and of the access to extralocal resources which the neofunctionalists neglected. These settings, as Forman and Collier show, are ones in which conflict can be examined. These aspects of social organization were greatly neglected by neofunctionalists, whose focus on the adaptation of local populations led them to assume that the interests of all individuals and groups within the population were similar and compatible. Aside from a functionalist examination of primitive warfare, a discussion of conflict appears in only a few cases of works by neofunctionalist ecological an-

thropologists, notably Barth (13) and Leeds (170), both of whom have used actor-based models with considerable success in the analysis of social and economic organization of complex societies. Some nonstate settings have also attracted processual ecological anthropologists (36a). New Guinea allows for the testing of Boserup's hypothesis on demographic pressure and agricultural intensification, and the nature of Melanesian social and political organization makes actor-based models particularly appealing. Nevertheless, many of the factors identified in complex societies are at work elsewhere, and even the supposedly isolated local populations studied by neofunctionalist ecological anthropologists have undergone processes of historical change and rely on extralocal resources, as shown by Anderson's (5) criticisms of Rappaport's (236) analysis of Tsembaga in highland New Guinea, Helms' (142) analysis of Miskito Indians in lowland Central America, studied by Nietschmann (207), and Schrire's (275a) reexamination of the San (166, 166b) of southern Africa.

CONCLUSIONS

Processual ecological anthropology is a reaction to neofunctionalist and neoevolutionary approaches, which were also responses to the pioneer work of Julian Steward and Leslie White. Adopting an historical time frame, rather than examining synchronic homeostatic equilibria or the many millenia of human history, permits a closer focus on mechanisms of change. By studying units other than the local population on which the neofunctionalists concentrated, studies have been carried out of larger units (political economy) and smaller ones (actor-based models). The elimination of functionalist assumptions has had several consequences: (*a*) a focus on the mechanisms which link environment and behavior; (*b*) an ability to incorporate conflict as well as cooperation by recognizing that not all goals are population-wide; (*c*) more precise studies of productive activities, settlement patterns, and the like without assumptions about equilibrium maintenance.

Processual ecological anthropology draws on several recent trends in the social sciences: demography, an examination of environmental problems, the concept of adaptive strategies, and recent work in Marxism. Decision-making models link all of them. The gap between anthropologists and biologists is also narrowing, as specialists in each field become more aware of work in the other and have begun efforts to link the two theories (as in dual inheritance approaches) and to borrow more cautiously than in the past. The homologies between actor-based models and natural selection favor this connection between sciences without assuming that they are

virtually identical as the sociobiologists do, and the ecosystem ecologists, neofunctionalists, and neoevolutionists did.

The incorporation of decision-making models as mechanisms of change has led to a greater emphasis on social organization and culture. Social and cultural systems influence the goals which actors have, the distribution of resources which they use, and the constraints under which they operate. It appears likely that the comparative work in ecological anthropology will emphasize culture areas, as in the Pacific, European, Mayan, and Andean cases mentioned here, as well as the comparisons of evolutionary stages and production types which characterized the neofunctionalist and neoevolutionary stages. As this work progresses, materialist and idealist approaches in anthropology are likely to find more common ground through a more thorough interpretation of culture and ideology as systems which mediate between actors and environments through the construction of behavioral alternatives.

As ecological anthropology draws closer to biology and history, it becomes enriched and enriches other fields. Although it incorporates models and research methods from other areas of anthropology and other disciplines, it must rework them to suit its own needs rather than adopt them blindly. This association with other fields, however, creates the danger of a fragmentation of ecological anthropology into a series of specialized areas of inquiry. The current diversification, though it shows a growth of new lines of productive research, could lead to a loss of analytical coherence. An examination of theoretical issues and of the complex history of the field is therefore an urgent task. Future developments in ecological anthropology thus rest on an understanding of the new common elements in processual approaches—the importance of the time frame, the role of actor-based models, a clearer focus on mechanisms of change, and a more balanced position on the role of social organization, culture, and biology.

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