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The Intensification of Production: Archaeological Approaches

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In this paper I reexamine the Boserup model of agricultural intensification and archaeological reaction to it. Although causes have been extensively debated, little attention has been paid to process, and even those who reject the causal efficacy of population may adopt other aspects of the Boserup model. These "unexamined aspects" include the assumption that intensification proceeds along a single course, characterized by gradual decreases in the frequency of cropping. I suggest that the course of intensification is complex and variable and that, only by breaking down the process of intensification into its component strategies, can we come to an understanding of both the causes and the courses of intensification.

KEY WORDS: intensification; economic change; agriculture; production.

INTRODUCTION

Archaeological conceptions of productive intensification underlie much debate and discussion about subsistence change and about the development of surplus production and social complexity. Whether intensification of production is viewed as a response to environmental, demographic, social, or political forces or as a natural and inevitable outcome of the human condition, archaeologists and others have recognized the importance of intensification for understanding change in productive systems. Following a highly visible debate regarding the causes of intensification in which the Boserupian (Boserup, 1965, 1981) view of population as a prime mover was challenged, a polarized set of views on intensification

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has come into being, with prime movers shifted from vaguely conceived population pressures to equally vaguely conceived social factors. While this acrimonious debate is now behind us, it is worth reviving in the context of a more general consideration of the impact of the Boserup model on archaeology. This revival is of more than historical interest, because even where demographic causality has been rejected, many fundamental aspects of the Boserup model have persisted unexamined.

My intention is neither to attack nor to minimize the work of Boserup, but to reconsider the intensification debate in light of two considerations. First, I assert that one of the reasons theoretical ferment surrounding the concept of intensification has died down considerably in recent years is that while perspectives on cause have become polarized, other aspects of the Boserup model have become archaeological dogma. These unexamined aspects include assumptions about the unilinear course of intensification and about the utility of cropping frequency as an adequate measure of intensification. It is my contention that the debates about cause are stalled precisely because of these unexamined assumptions about the nature and course of intensification. That is, I suggest that it is necessary to come to an adequate understanding of the process of intensification to understand the multiplicity of causes and the conditions under which they operate.

This paper explores some of the arguments that have been advanced to account for the process of intensification, with a focus on agricultural intensification. Because the debate has focused primarily on causes, to a lesser extent on consequences, and very little on the specific paths or courses of intensification, this focus is also reflected here. However, I suggest that to evaluate arguments about cause, it will be necessary to come to a better understanding of the course of intensification (see also McGuire, 1984). Ironically, although Boserup's focus on population has engendered the fiercest attacks, this aspect of the model has the most empirical support (see below). Although I argue that population is too simply conceived as a proximate cause of economic change, it is clear that demography is important in the structure of and changes in agricultural production. However, although other aspects of Boserup's model—its technological associations and its unilineal sequence of cropping intensity—have been subject to much less criticism, they are actually based on much shakier empirical ground and, I suggest, have hindered archaeological studies of intensification.

Perhaps the most pressing current problem for archaeology lies in the methodological specification of intensification. How can we both recognize and measure changes in production that may represent intensifica-

tion? To address these issues, it is necessary to begin with a clear conception of both production and intensification.

Conceptions of the Economic

Much of the debate on the causes and nature of change in production stems from disagreement about fundamental characteristics of economies. Views range from universalistic ones, which argue for the existence of cross-culturally valid principles of economic behavior, to particularistic ones, in which the unity of cultural practice and the "embeddedness" (Polanyi, 1957) of economic activities in other cultural arenas are stressed. Attempts to get around these differences without abandoning either economy as an analytic category or an integrated view of culture have ranged from creating a conceptual distinction between "modern" and "premodern" economies to including both in a "systems" model (e.g., Flannery, 1969; Plog, 1975; for critiques of systems models see Bennett, 1976; Jochim, 1979; Friedman, 1974; Salmon, 1978).

Definitions of economy may be broadly classified into *rational* and *integral* approaches. Rational approaches are predicated on the maximization of profit, broadly conceived, and the minimization of effort or cost. This perspective is grounded in a basic assumption of a universal economic rationality (see Plattner, 1989). It is atomistic in character and thus analytically attractive, allowing the isolation of variables and the possibility of consistent cross-cultural comparisons.

Formal economic analyses are one outgrowth of a rational view of economy. Based on studies of modern market economies, they are predicated on the assumption that land, labor, and capital can all be reduced to the measure of price (cost). The standard of valuation in anthropological applications (optimization models, linear programming models, game theory, and their offshoots) is usually energy rather than price (Winterhalder and Smith, 1981; Earle and Christiansen, 1980; see also Martin, 1983), but the guiding behavioral assumptions remain the same. The use of formal economic models as applied to intensification of production is discussed more fully below.

Integral approaches stress the integration of production with other activities, suggesting that the subsumption of productive action under the rubric of economy is problematic (e.g., Bohannon and Dalton, 1962; Dalton, 1969). One classic formulation of this position was made by Polanyi (1957, pp. 248, 250), who noted that the human economy "is embedded and enmeshed in institutions, economic and non-economic." Integral positions may draw an implicit or explicit divide between different forms of

society (or production), with "modern" or "western" societies composed of economically motivated, independent, and rational individuals and "premodern" or "nonwestern" societies constituting religiously or ideologically motivated corporate groups (for a critique of this distinction, see Inden, 1990; Kohl, 1987; Lansing, 1991).

One outgrowth of this conceptual divide was the substantivist–formalist [or descriptive versus normative economics (Barlett, 1980; Johnson, 1978, 1980)] debates. These debates have been exhaustively discussed elsewhere (see Plattner, 1989, pp. 10–15). However, this divide still structures archaeological discussion about prehistoric economic change and intensification and is thus worth keeping in view. Distinctions between the two approaches are evident in several areas, including guiding behavioral assumptions and choice of problem areas. With regard to the latter, Johnson (1980, p. 20) notes that formalists tend to prefer "well-structured problems" over "ill-structured problems," even though the "ill-structured" form of the problem may be the closest to the actual situation of interest. This tyranny of form, he (1980, p. 20) concludes, guarantees that the formal model alone will be uninterpretable without recourse to specific ethnographic (or archaeological) contexts.

The concept of production has received the most attention from Marxist scholars, though in fact most archaeological studies are aimed at investigating production (or the distribution of goods produced) in one way or another: craft production, subsistence production, the production of built environments. Production—the making, constructing, or creating actions of human beings—is a primary focus of investigation into the archaeological record. Persistence and change in production cannot be understood apart from what has been termed "reproduction" (Terray, 1975), the teaching, recreating, and assigning meaning to the social and material world. Godelier (1978, p. 71) sums up this relationship:

> Production is the totality of operations aimed at procuring for a society the material means of existence. . . . In the end we see that all production is a twofold act subject to the technical norms of a certain relationship between men and nature and to the social norms governing the relations between men in their use of the factors of production.

Agricultural production provides an excellent example of this "twofold act," lying as it does, at an intersection between ecological and social forces, broadly conceived.

Intensification of Production: Definitions

The existence of rather divergent perspectives on the nature of economies must stand as background to more specific consideration of

definitions of the intensification of production. Essentially, the notion of intensification requires reference to a constant. That is, the difference between intensification and simple increase involves the introduction of a second variable; the difference is analogous to the difference between *concentration* and *amount*. Intensification of production refers to an increase in the productive output per unit of land or labor (or to some other fixed quantity) (Boserup, 1965, pp. 43–44; Kaiser and Voytek, 1983, p. 329; Tringham and Krstic, 1990). This increase may be achieved in a number of ways. In the archaeological literature, the variable held constant almost always refers to land in reference to food production or hunting and gathering (getting more out of a given area) and labor in studies of craft production (increasing efficiency of production). Alternate situations, such as technological intensification in which both land and labor are held constant while capital inputs are increased, as in industrialized agriculture, are rarely discussed (but see Brookfield, 1984). Thus, what we term intensification may be quite different, depending on whether the variable held constant is space, labor, or technology.

The multivariate nature of intensification is of considerable importance, serving to distinguish it from "mere" expansion or increase. A temporal dimension is generally also implicit in conceptions of intensification. Productive activities take place within definite temporal parameters such as a growing season, and archaeologists may examine long-term temporal trends in strategies of intensification. Thus, we can also speak of courses or paths of intensification. Intensification, then, must be viewed as a process, consisting of multiple potential strategies, rather than as an event. A consequence of this view, discussed below, is that there may also be multiple paths or courses of intensification rather than a single route from long to short fallows.

There has been surprisingly little attention paid to definition, given the voluminous literature on intensification (but see Netting, 1993, p. 271). The seminal definition of Brookfield is worth citing at length, given his influence on later work (e.g., Renfrew, 1982, p. 265). He (1972, p. 31) writes:

> Strictly defined, intensification of production describes the addition of inputs up to the economic margin, and is logically linked to the concept of efficiency through consideration of marginal and average productivity obtained by such additional inputs. In regard to land, or to any natural resource complex, intensification must be measured by inputs only of capital, labor, and skills against constant land. The primary purpose of intensification is the substitution of these inputs for land, so as to gain more production from a given area, use it more frequently, and hence make possible a greater concentration of production.

The process of intensification has been identified and investigated in many arenas of anthropology (e.g., Barlett, 1980); indeed it has been

claimed that increasing levels of energy capture are a general feature of human history (White, 1959). Archaeological problems that have been cast in terms of the intensification of production include the "broad-spectrum revolution" (Cohen, 1977; Flannery, 1965; Harris, 1977; Straus *et al.*, 1980), the origins and adoption of agriculture (Binford, 1968; Bender, 1978, 1981, 1985; Bronson, 1975; Cohen, 1977; Dennell, 1985; Flannery, 1965, 1973; Harris, 1969, 1977; MacNeish, 1958; Sherratt, 1980; Zvelebil, 1986), the development of irrigation (Adams, 1966; Boserup, 1965; Steward, 1955), and specialized craft production (Muller, 1984; Spence, 1981; Wright and Johnson, 1975). While none of these issues are dealt with specifically here, they provide the context in which much of the theoretical and methodological debate is placed.

THE BOSERUP MODEL

The model of population growth and agricultural intensification set forth by the Danish economist Ester Boserup (1965, 1981, 1990) has been, without doubt, the most influential formulation of the problem in this century. Boserup's model has both the appeal and the limitations associated with parsimonious, general, and comprehensive views of structure and of change (cf. Netting, 1977, p. 72). As such, other discussions of the intensification of production can be conveniently organized around aspects of her model. I first consider four aspects of the Boserup model that have been extensively debated. These include the causal efficacy of population, the Law of Least Effort, declines in labor efficiency, and technological associations of intensification. Following discussion of these points, I move on to what I have termed unexamined aspects of the model (although this lack of examination is only relative): the unilinear path of intensification, productive diversity, and risk and variability.

Boserup's model of population (apparently population pressure; the ambiguity of this position is discussed below), as an *independent* variable driving intensification of agricultural production, turned the earlier Malthusian formulation "on its head" (Rubin, 1972, p. 36). While Malthus saw land and, particularly, arable soils as limiting factors to increases in production, production that would eventually be outstripped by a growing population (Malthus, 1872; Rubin, 1972, p. 36), Boserup turned the production–population pair around, asserting that growing populations drove change in land use along an extensive–intensive continuum [although she notes that responses other than intensification are also possible outcomes of population growth (Boserup, 1965, pp. 41–42)]. Population is assumed to be an independent variable (Boserup, 1964, p. 11; Grigg, 1982, p. 37),

not a consequence of food supply. By population, Boserup (1965) apparently refers to sheer numbers of people, though in a subsequent publication, she (1981, p. 66) does consider the issue of population distribution.

By far the most contested aspect of Boserup's model of intensification is the causal efficacy of population in driving the process. The view of population as a causal agent rests on a number of related assumptions. First, producers are assumed to exert the minimum effort possible to meet their needs—the Law of Least Effort (Boserup, 1965). Thus, the most labor-extensive regime possible will always be employed. Second [and not all agree that this assumptions is necessary (Nell, 1972; Netting, 1993)], there are diminishing returns on labor (declining efficiency) with increasingly intensive modes of agricultural production (Boserup, 1965, pp. 28–34). The disadvantages, then, of intensive agriculture—increased labor inputs and declining efficiency of that labor—ensure that such modes of production will be adopted only when strictly necessary.

Boserup also discusses the association of classes of agricultural tools with cropping regimes (1965, pp. 23–27). Her contention is that tool types, if not specific forms, are determined by the prevailing agricultural practice and that technological change is thus also tied to population growth. For example, short fallow farming creates a "compelling" need for plows, while forest fallow requires only digging sticks and axes (Boserup, 1965, pp. 24–25).

The unilineal and monolithic characters of Boserup's model are both evident in her operational definition of intensification in terms of frequency of cropping (1965, pp. 15–18, 1981, p. 23). While this definition has much to recommend it over the more usual models of land use set forth by economists in that it embraces such disparate agricultural practices as swidden and multicropping within a single analytic model, it also glosses over the considerable diversity apparent in productive strategies, both synchronically and diachronically, and in strategies of intensification. The frequency of cropping becomes a de facto measure of progress along a single route of intensification. While Boserup (1965, pp. 56–64) does discuss the coexistence of different cultivation systems, this coexistence is seen as reflecting a sort of evolutionary lag. That is, the diversity is said to be more apparent than real, not reflecting differing adaptations or adjustments but only the misleading result of considering an artificial slice of time along the route of increased cropping frequency (Boserup, 1965, pp. 56–59).

Before considering the various aspects of Boserup's model and the responses to them in detail, it is worth noting that her work was part of a broader challenge to the view that the advantages of technological "progress" are self-evident (see, however, Ammerman and Cavalli-Sforza, 1985; Braidwood and Howe, 1960; Higgs and Jarman, 1969, 1972). The appear-

ance of Boserup's 1965 book at a time when, for example, notions of hunter-gatherer lifestyles were being drastically altered (Lee and DeVore, 1968; Lee, 1969; Sahlins, 1972; Woodburn, 1968) and the recognition that agriculture represented an intensification of labor over hunting and gathering (Clark and Haswell, 1967; Lee, 1972, 1979) are significant for understanding its impact on anthropology (Spooner, 1972; Spooner and Netting, 1972).

Arguments About Cause: Population

Population as an Independent Variable. As noted, Boserup's model requires that population increase not be tied directly to food supply but, rather, have the status of an independent variable. In archaeological applications of the model, population growth has come to be seen as continuous and inevitable, and not as something that itself requires explanation (see Cowgill, 1975). The determinants of demographic parameters are complex, and well beyond the scope of this review. However, there exists considerable disagreement on the degree to which population growth can be considered autonomous or culturally regulated. At one end of the spectrum are those who accept the Malthusian and Boserupian assessment of independence (Cohen, 1977; Logan and Sanders, 1976; Sanders and Price, 1968; Sanders *et al.,* 1979; Smith and Young, 1972). The independence of population is rejected in the systems formulations of Boserup's model (Datoo, 1978). Instead, population increase [or increased population density (Brown and Podolefsky, 1976, p. 212)] is seen both to lead to and to result from the intensification of production (Netting, 1993, p. 269; Sanders, 1972, p. 147; see Boserup, 1990). At the other end of the spectrum are those (e.g., Bender, 1978, 1981, 1985; Friedman and Rowlands, 1978) for whom demographic variables are determined solely by cultural factors (see also Blanton, 1975; Kowalewski, 1980).

Breaking Down Population: Demography and Pressure. Of considerable interest is just what is meant by "population." Both advocates and detractors of a Boserupian approach seem to refer to a sort of undifferentiated mass when speaking of population. In fact, the complexity of human demography virtually assures that such ill-defined conceptions of population are bound to have little resemblance to any actual situation. At issue is the nature of the relationship between demographic variables and aspects of economic organization; it is unlikely that progress will be made toward understanding this relationship by employing an overly simple and unrealistic view of the former. Human populations possess not only size but also structure, so that at any given time, population size and growth rates

will be determined by age-specific fertility and mortality rates (Charlesworth, 1980). In age-structured populations such as human beings, the distributions of various age groups and the nature of the domestic cycle (Wilk, 1989; Wilk and Netting, 1984) impinge directly on the organization of labor in production. Thus, population dynamics must be considered an aspect of the organization of labor and consumption.

When Boserup and others refer to population, there is also a tendency to equate population increase or population density (Turner *et al.*, 1977, p. 396) with "population pressure." The notion of population pressure is intimately associated with that of carrying capacity (Bayliss-Smith, 1978). Dewar (1984, p. 602) describes two ways carrying capacity has been conceptualized. The first, K is the "theoretical" equilibrial population density, and is derived from the application of logistic growth models (Dewar, 1984, p. 602; Glassow, 1978, p. 40). The use of K requires a number of limiting assumptions, including equilibrial environments and a stable population (Harpending and Bertram, 1975, p. 83). The second, Cc, is a feature of both environments and of extractive systems (Dewar, 1984, p. 602; Glassow, 1978, p. 40; Hayden, 1975; Zubrow, 1975). The calculation of Cc requires specification of both environmental "potential" [also assuming stable environments (Hayden, 1975)] and economic pattern (Dewar, 1984, p. 602; see Rappaport, 1968).

The Boserupian version of population pressure clearly employs the Cc version of carrying capacity, adding a dynamic component to the concept in that it emphasizes intensification as a way of overcoming the demographic constraints of a given productive strategy. As Glassow (1978, p. 40) puts it,

> It is proposed that, when population size increases to the point where carrying capacity of specific resources is reached in terms of a particular subsistence technology, there will be a shift to a modified set of subsistence resources or subsistence technology.

As Dewar (1984, p. 601) notes, there is a common view that populations below carrying capacity are in a stage of growth, those at carrying capacity are in a stage of limitation, and those above carrying capacity are in a stage of crisis. However, if production is as elastic as this view implies, then little is left of the concept of carrying capacity. Populations apparently never (or rarely; see Brookfield, 1972, 1984) reach the carrying capacity of their environment.

Archaeological attempts to calculate Cc (Brumfiel, 1976; Flannery, 1976; Kirkby, 1973; Kowalewski, 1980; Pollard and Gorenstein, 1980; Spencer, 1979) have met with problems (Tolstoy, 1982; Glassow, 1978; Street, 1969), given both the conceptual difficulties with the notion of carrying capacity [(Brush, 1975); and, by extension, of population pressure]

and the ambiguous nature of archaeological measures of past population size (Hassan, 1981). Even if it were possible to derive population parameters precisely from the archaeological record, it is not at all clear that population size (or population size normalized to area) stands in direct relation to strategies of production (cf. Binford, 1983; Dewar, 1984; Hassan, 1981). Given our limited understanding of this basic relationship, and the methodological difficulties in measuring population parameters, it seems premature at best either to embrace demography as the prime mover of intensification or to dismiss its relevance out of hand.

Correlation and Causation. The cross-cultural survey has been a favorite form of research for those interested in demonstrating a relationship between agricultural intensity and population density. Note that such studies employ population *density* rather than popular pressure or carrying capacity. Several such studies have been carried out in the topics (Brookfield and Hart, 1971; Brown and Podolefsky, 1976; W. Clarke, 1966; Turner *et al.,* 1977). These and similar surveys elsewhere (Burton and White, 1984; Gleave and White, 1969; Hart, 1990; Pryor, 1986; see also Dow, 1985; Keeley, 1988) generally have succeeded in establishing some statistically significant correlations between population density and agricultural intensity at the level of whole "societies" (see also Sanders, 1972, p. 150). It is not clear that such studies really advance our understanding of the process of intensification, however. Not only do they tend to employ an averaged measure of "intensity," homogenizing what may be a very diverse set of productive strategies, but they do not even directly address the "population pressure" issue (cf. Keeley, 1988, pp. 375, 395). While the existence of a relationship between agricultural intensity and population density is certainly of interest, the nature of that relationship or, indeed, of causal connections is not elucidated. Importantly, the correlation coefficients, while statistically significant, do not by any means account for all of the variability in the samples. For example, Turner *et al.* (1977, p. 389) report an r^2 value of 0.58 for an exponential regression curve that takes agricultural intensity as a dependent variable of population density. Thus, population density *in itself* is not sufficient to account for agricultural intensity.

More specific analyses of the relationship between agricultural intensity and population density (Dow, 1985; Ford, 1986; Galla, 1985; Geertz, 1963; Hart, 1990; Netting, 1969) also support the existence of a relationship between these two variables but make much less of population as a proximate cause for change in productive systems. Most telling may be the study carried out by Brookfield (1972, p. 36) on 44 places in Melanesia, a study that employed attribute analysis of agricultural practices rather than collapsing diverse activities of one "people" into a single variable. He (1972, p. 36) writes,

> I found a number of instances in which no correlation between agronomic practices and population density, past or present, could be credibly sustained. Often intensive practices were applied to only a part of the total productive pattern, specifically to that part having ritual significance, or used in large-scale prestations.

While these cross-cultural studies do indicate that demography is implicated in the practices of production, the nature of the cause is not straightforward, nor does population density sufficiently account for the observed variability. Actual situations appear to be much more complex than allowed for by the simple deterministic models employed. However, it would be a mistake to conclude from this that because no *simple* relationship between demography and intensification is apparent, no relationship exists at all.

Of interest is the reversibility of the population–intensification relationship. If depopulation leads to extensification, or disintensification (Brookfield, 1972), the strength of the association might be increased, though certainly this would establish only the broad relevance of population as a variable, not its specific role (Boserup, 1965, pp. 62–63). In fact, there is good evidence for the reversibility of the process in North America (Lycett, 1989; Ramenofsky, 1987) and the Pacific (Brookfield, 1972, p. 30) following European contact, but the "reverses" are by no means an automatic consequence of population decline. Agricultural intensity, then, is not a simple consequence of human–land ratios. Decisions by producers to intensify or extensify production in specific historically and ethnographically studied cases are best understood as economic strategies, inseparable from contingent conditions such as environmental potential (Padoch, 1985), the overall structure of the agrarian settlement system (Stone, 1994, or mediating factors such as the price of land, labor, and produce (Allan, 1965; Linares de Sapir, 1970; Morrison, 1992a; Netting, 1968, 1977, 1993; Stone *et al.*, 1990). I do not mean to suggest that demographic factors are of no importance but, rather, that they may be mediated by other proximate factors and constitute only one aspect of human productive organization.

Population Mediated: Defining the Parameters. In previous sections "cause" has been treated in a simplistic way, as direct pressure and response. Such a view has been adopted by some population enthusiasts (Cohen, 1977; Cordy, 1974; Sanders and Price, 1968; Smith and Young, 1972; Wilkenson, 1973), but in general more complex notions of cause and effect have been employed. As noted, explicit reformulations of Boserup into a systems model have been attempted (Datoo, 1978), and many other researchers have stressed the "feedback" relationship between changes in population and productive strategies (Brown and Podolefsky, 1976; Logan and Sanders, 1976; Sanders, 1972; see also Dow, 1985). From this per-

spective, the cross-cultural surveys cited above *do* provide an adequate account of intensification in that they establish the existence of a relationship between variables.

If we are not content to accept the equilibrial assumptions and functional causality of systems models, however, we must move beyond these views of cause to examine the possibility that different variables may come into play in the process of intensification at different times and that other factors may be of relevance. Further, while demographic factors may represent an ultimate (and partial) cause of intensification, they may be mediated by a number of more proximate variables.

Two such mediating factors might be broadly classified as mobility constraints and sociopolitical structure. The first extends the notion of population density to include more specific geographic constraints and attractions and, also, refines the causal trajectory. Carneiro's (1970) circumscription model postulates that intensification takes place due to mobility constraints and resultant population pressure on a restricted land base. What Zvelebil (1986, p. 9) refers to as the second-generation population models (Binford, 1983; Newell, 1984; Wobst, 1974) incorporate rather similar notions of population packing and of "pseudo-density" (Bronson, 1975, pp. 40–41) caused by small- or medium-scale locational constraints, irrespective of larger-scale population levels. In these models, population density or population growth per se is not the focus. Rather, interest lies in situations of population–resource imbalance, no matter which side of the equation tipped the balance (Harris, 1973, p. 405; see Zvelebil, 1986, p. 9). Such models take a step away from the "naive demographic" (Bronson, 1975, p. 33) model in recognizing the importance of mobility and transport costs (Sanders and Santley, 1983; Sutton, 1985), the existence of multiple productive options [including abandonment (Stone, 1994)], and the impact of productive strategies themselves in shaping responses to changing conditions. The focus, then, falls on access to resources, broadly conceived, and not simply on the number of mouths to feed.

Without discussing the literature in detail, it is necessary to note the link between sedentism and intensification (Kaiser and Voytek, 1983; Testart, 1982; Hitchcock, 1982; Hitchcock and Ebert, 1984): a link that incorporates both biological and organizational elements. Several authors have examined the demographic consequences, both direct and indirect (e.g., Binford and Chasko, 1976; Handwerker, 1983; but see Keeley, 1988, p. 397), of increased sedentism. No less important are the organizational correlates such as increased investment in architecture, in storage, in development and maintenance of more elaborate forms of conflict resolution (Kelly, 1991; Lee, 1969; Kaiser and Voytek, 1983), and in crops or cropping strategies with delayed returns (Gilman, 1981, 1991). Intensification of pro-

duction *in situ* and mobility constraints, whether positive or negative, appear to be inexorably linked.

Perspectives similar to the "mediated demographic" views outlined above include those in which social and political forces are added to or replace locational considerations. For example, in addition to the obvious locational constraints presented by the island settings, Kirch's (1984, 1985) discussion of agricultural intensification in Polynesia incorporates demographic, political, and social dynamics. The development of Polynesian agriculture after initial island colonization is presented as a three-step process of adaptation, expansion, and intensification (Kirch, 1985, p. 435), occurring in concert with growing population levels (Kirch, 1985, p. 449). Contrary to both the single-factor Boserupian (Kirch, 1985, p. 448) and the "political economy" models (Kirch, 1985, p. 449; discussed below), Kirch (1984, p. 164) describes a multicausal, hierarchical relation (see also Earle, 1978, 1980; Kirch, 1977, 1992) in which chiefly demands for surplus are seen as the proximate, and population growth as the ultimate, cause of intensification.

Cities and towns are examples of aggregated population distributions in which particular political and economic conditions are operative. Grigg (1982, pp. 41–41), for example, describes the complex route of economic intensification in Holland between A.D. 1500 and A.D. 1630, in which dairying became an important specialization. He also describes agricultural intensification around towns and its integration with other economic activities (see also de Vries, 1974, pp. 137–155; Grigg, 1980):

> The growth of industry in the towns led to the production of hemp, rape, woad, flax and hops while near Amsterdam a substantial area was devoted to horticulture. The towns in turn provided manure for intensive farming. Indeed it was the extraordinarily rapid growth of the town which prompted commercial intensive farming rather than simply the growth of the rural population (Grigg, 1982, p. 42).

Indeed, urban and suburban areas merit special consideration as loci of intensification, for the demands of cities have been integral in shaping the structure of agriculture in the contemporary world (but cf. Williams, 1989). A description of the intensification of production, then, must include not only its component strategies, but also their relative proportions (W. Clarke, 1985, p. 867; Netting, 1974, p. 39) and the role of producers in the larger economic setting.

One additional demographic mediator must be mentioned—the mechanism of price in market economies (de Vries, 1972, 1974; Hassig, 1985; Slicher van Bath, 1963). Boserup has been criticized for ignoring the role of markets in mediating productive and consumptive demands (see discussion by Netting, 1993, pp. 288–294). This is an important topic, and

may involve asymmetrical power relations and extractive demands on production as well as transport considerations and market forces themselves. In a recent case study, for example, I (Morrison, 1992a) found that although population density and agricultural intensity in the region around a large South Indian city were temporally correlated, it was also necessary to consider the growing degree of monetization of the economy and the structure of agricultural investment and opportunity to understand adequately the course of intensification. It seems clear, then, that in urban, market economies population must be considered a mediated variable, and not a simple and proximate cause for change.

Arguments About Cause: Nondemographic Factors and Intensification

The assignment of causal efficacy to population has been subject to spirited criticism, and many scholars have pointed to the importance of nondemographic factors, which include, in Bronson's (1975, p. 33) terms, "considerations of security, of prestige, of comfort, of health." Counter-demographic arguments, however, often come down to motivational discussion; intensification occurs because (some) people want it to, and a search for motivation follows. Such arguments present serious methodological problems for archaeologists. Or nondemographic variables may be seen as acting in concert with, as alternates to, or as intermediaries between demography and intensification. Serious consideration of nondemographic variables constitutes a fundamental challenge to Boserup's model. If factors other than population can drive intensification, or if demographic factors are of variable importance in different cases, the universality of Boserup's sequence becomes suspect. In fact, detractors of population pressure models have often incorporated other aspects of the Boserupian view while rejecting the causal role of population.

Consumption. In the definitions of production given above, no explicit mention was made of use, or consumption. This deficiency is apparent when we begin to consider what the intensification of production is *for*. Without necessarily having to isolate motives, the purpose of the good must be of importance in considering the context of its production. Thus, the factors conditioning intensification of production of subsistence and nonsubsistence goods are likely to be quite different. The focus of this discussion is on agricultural production, but it is important to consider that even agricultural products do not have solely caloric value (cf. Hastorf and Johannessen, 1993). If indeed production includes the organization of technology, "the nature of the labor force, the organization of work, the

behavior of the consumers, the relation of producers to consumers, the power structure in the organization of production, and the role of the exchange of products in the relations between societies and in a particular society" (Tringham and Krstic, 1990, p. 589), then consumption must be included in consideration of production.

If production is to be understood in these terms, attention must be paid not only to ultimate and proximate causal mechanisms, but also to issues of organization and process. How intensification proceeds may be as important to understand as why it occurs. As noted, Boserup's model pays scant attention to the process of intensification, operationalizing it as cropping frequency plus technology, with only minimal concern for issues of organization.

Purposes of Production: Social Models of Intensification. A common thread running through discussions of nondemographic factors in intensification is that of surplus. Whether production is thought to be geared up to meet the requirements of markets, to alleviate risk, or to meet demands, elite or otherwise, for trade, tax, tribute, or ritual, such production is generally meant to refer to "surplus," or production beyond that biologically necessary for subsistence (Halstead, 1989). The specification of surplus in nonagricultural production is more ambiguous, given the lack of a baseline for consumption similar to that provided by biology.

Brookfield's (1972, pp. 37–38) four "purposes of production" provide convenient organizational categories (see also Godelier, 1978, pp. 66–68). The first is production for subsistence, after Marx's (1954, p. 208; cited by Brookfield, 1972) notion of production for use (Brookfield, 1972, p. 38; see also Kirch, 1984, p. 161). The second, "normal surplus," is taken from Allan (1949) and refers to agricultural produce that must be stored or otherwise reserved, for seed, to cover wastage, decay, and yield variability (see also Halstead, 1989). "Social production" (Brookfield, 1972, p. 38) is devoted to ritual, reciprocity, and so forth. It is the most variable of the four, Brookfield argues. Finally, "trade production" (1972, p. 38) is essentially a version of production for use, in that it includes, for example, cash crops grown for the purpose of obtaining subsistence goods. The only real problem with this breakdown is that the categories are so self-contained. Subsistence production appears to have little to do with production for ritual when, for example, religious contribution may have significant material benefit (Appadurai, 1978; Breckenridge, 1985). Standard of living (tied to production for use) may vary with price fluctuations among peasants participating in a market economy (trade production).

Surplus has also been defined as "that portion of production which extends beyond the sphere of individual households" (Kirch, 1984, p. 161; cf. Pearson, 1957), differentiating principally between forms of disposition

of the produce rather than its context of production. Childe's (1951, 1952; and see Brumfiel and Earle, 1987, p. 1; Sherratt, 1973, p. 421) vision of surplus as permissive of the development of complexity is similarly conceived. In almost all models of intensification that follow, surplus production is assumed to be a goal, in that it "finances" political and social elaboration, trade, and other public or elite ventures.

The role of markets in shaping the organization of production has already been noted. Grigg (1979, 1982, p. 49) argues that producers may attempt to increase profit and, thus, intensify production, even in the absence of any coercion (see also Rubin, 1972, p. 39). The very nature of population and land distribution in market economies has also been suggested to require intensification. In Brookfield's terms, the "necessary surplus" of a producer at the whim of both environmental and market fluctuations might be sufficiently high to promote a sort of ongoing intensification (but see Patir, 1987, pp. 233–234). Von Thunen's (1966) model of the "isolated state" stressed the importance of proximity to markets, transport costs, and perishability in influencing intensity of cultivation and choice of crops in an urban landscape (see also Chisholm, 1968; Rawski, 1972; Smith, 1975). Bronson (1975, p. 43) would also include land values and produce prices in this equation. The role of market forces and, particularly, of transport costs in shaping nonagricultural production has also been examined (Sanders and Santley, 1983).

While it is argued that Brookfield's four purposes of production are not self-contained categories, his "social production" comes the closest to satisfying the purpose of increased productive output in "political economy" (Kirch, 1985, p. 449), or social extraction models. Social production, as Brookfield (1972, p. 38) notes, is the most variable and unpredictable form of production. Models focusing on the role of social production in intensification tend to emphasize the role of agricultural produce in nonsubsistence activities, with intensification seen as a deliberate strategy or set of strategies designed to meet these productive demands. This is a vast body of literature and cannot be reviewed completely here, but as discussed below, the usual tone is antidemographic and antienvironmental; social needs not only are viewed as discrete from and indeed unassociated with environmental parameters or demographic pressures, but also are of paramount causal significance. Partly a response to simplistic and mechanistic population pressure models, these social extraction models often simply deny the relevance of demographic variables in understanding intensification. Given our limited understanding of demographic parameters in the past, and of the nature of the relationships between demographic variables and economic behavior, such out-of-hand rejection

appears to be more an article of faith than an evaluation of existing theoretical or empirical scholarship.

While this simple juxtaposition of "socially" and "environmentally" oriented models is overstated, there is a clear tendency to see the two as opposing players. Sometimes one is viewed as more appropriate to "complex" and the other to "simple" societies (cf. Trigger, 1980; Kohl, 1987). This insidious (and usually mostly submerged) view is beginning to break down, but it is often replaced with one or other of the extremes. In other cases, isolated and *in situ* development is viewed as more "natural" than change that takes place in nonisolated societies (but see Headland and Reid, 1989; Kohl, 1987; Wilmsen and Denbow, 1990; Wobst, 1978). Renfrew's (1982, pp. 264–265) "auto-intensification" refers to intensification that takes place without outside assistance (pressure), in what W. Clarke (1985, pp. 865–866) refers to an "autonomous territories," or areas not subject to external pressures. In situations with documentary sources (Breckenridge, 1985; Hanks, 1972; Geertz, 1963; Stein, 1980), the role of social variables is difficult to ignore, as are environmental and demographic imperatives—some of the most balanced accounts of intensification are found in these cases (see also Kohl, 1981, p. 105).

Analysts concerned with social and political components of intensification have focused primarily on more complex societies, but there are also examples of such work among hunter-gatherers and on agricultural origins (Bender, 1978, 1981, 1985; Hayden, 1990, 1992; Tringham and Krstic, 1990; Kaiser and Voytek, 1983). Bender's (1985) analysis of intensification in the Midwestern Archaic concentrates on the role of socially created demands on production in inducing intensification of gathering and hunting. She notes that there is archaeological evidence for increasingly intensive subsistence activities in the Late Archaic. This evidence seems to indicate increasing labor investments in the construction of facilities such as weirs and pits and in the processing and harvesting of such "difficult" foods as shellfish and acorns. Mobility constraints are also noted. At the same time, there begin to be indications of exchange and of elaborate burials (Bender, 1985, pp. 53–57). Bender (1985, p. 57; see below) suggests that alliance and exchange systems act as arenas for social inequality and that the accrued debts and demands of exchange promoted what she calls "technological intensification." Thus, intensification and sedentism are seen to stem from particular conditions of ritual, exchange, and political structure (see also Brookfield, 1972; Earle, 1978; Kirch, 1984, 1992). It is Boserup who is "turned on her head" in this view of demography and intensification. Because labor is reorganized as part of the process of intensification, Bender, (1985, pp. 57–59; see also Schofield, 1983)

suggests that people choose to have large families to effect "closure" of the social system.

In an earlier paper on agricultural origins, Bender (1978) argues that an understanding of intensification is not germane to an account of the shift in subsistence commitment from hunting and gathering to agriculture. This confused argument is based on an extremely limited dictionary conception of intensification. Ironically, it is a very technological, land- rather than labor-based view of intensification (Bender, 1978, pp. 205, 213–214), "increased productivity per given area." Bender correctly points out the difference between increased productivity (per unit area) and increased production: a difference between intensification and increase. However, she goes further in asserting that increased productivity never leads to increased production but, rather, contributes to a reduction of the workload [the labor–leisure tradeoff (Bender, 1978, p. 206; see also Bender, 1981, p. 153)]. Her technological conception of intensification (equals increased productivity) leads her to reject it as uninteresting and irrelevant to the issue of agricultural beginnings.

Because her definition measures intensification from the perspective of the plot of land, rather than from that of the producers, Bender (1978, p. 205) is led to assert that "intensification, unlike commitment, need neither cause nor result in social or demographic change." There is no consideration of the organization of labor within or between social units, of scheduling, or of the social consequences of intensification such as changes in land tenure, dispute resolution, ownership, etc. Bender is concerned with these issues, however, and with patterns of consumption, so she turns to increased *per capita* production (read increase or expansion; intensification is not presented as a way of achieving this increase) as the decisive element in promoting reliance on agriculture. *Per capita* consumption increases can be accounted for by her preferred mechanism of "internal" and socially generated demand. It is unfortunate that intensification has been reduced to a mere technological phenomenon and exorcised from Bender's model. As a process its consequences are social, organizational, political, and sometimes even demographic. Much is lost by consigning intensification to the realm of technique and technology.

Gilman's (1981) paper on agricultural intensification and social stratification in Bronze Age Europe presents a similar argument (see also Gilman, 1991). However, Gilman focuses specifically on elite productive demands rather on the more generalized social requirements generated by exchange discussed by Bender. In this paper, Gilman (1981) rejects the functionalist arguments for state formation and the development of social inequality that stress the "services" elites provide for their followers (Fried, 1967; Renfrew, 1972; Service, 1962; Wittfogel, 1955, 1957; Wright and

Johnson, 1975), emphasizing instead that elites tend to serve their own ends, not those of the common good (see also Gilman, 1991, pp. 146–148; Brumfiel, 1992, pp. 555–556; Kirch, 1984, p. 166). The economic changes that accompany political development hinge on elite mobilization of resources, the extraction of goods and services (surplus) from producers (but cf. Galla, 1985). This model (see also Brumfiel, 1992; Brumfiel and Earle, 1987; D'Altroy and Earle, 1985; Earle, 1978, 1991; Friedman and Rowlands, 1978) is not unlike earlier (e.g., Childe, 1951, pp. 97, 107) models in which surplus production was viewed as permissive of the development of complexity. In this case, elite machination simply replaces technological innovation. Intensification proceeds, then, to meet increasing elite demands for status. Status is achieved either directly or indirectly, via the control and manipulation of surplus and the creation of wealth (see Friedman and Rowlands, 1978, pp. 209–217). Elite demands, presumably, need not be accounted for, as they stem from vital human properties (Gilman, 1981; Friedman and Rowlands, 1978, p. 209; see a similar critique by Hayden, 1990, p. 36).

The power of models such as that of Friedman and Rowlands (1978) is diminished by this fallback to essentialism. Zvelebil (1986, p. 10) comments that "social disequilibrium" models of intensification, which assume that human society is essentially competitive, are faced with the same methodological difficulties as are those of population pressure enthusiasts, in that ranking, social competition, and surplus production are not unambiguously identifiable in the archaeological record. The challenge faced by proponents of socially oriented models, then, is to investigate rather than to accommodate. It is not sufficient simply to look at intensification in a different way—we must develop methods for evaluating our propositions.

In all of these studies, environments define the boundaries of possibility but do not dictate form. Friedman and Rowlands (1978, p. 203) express it most clearly, when they describe a "hierarchy of constraints" through the social formation, from the level of the ecosystem, up to the level of productive forces, to relations of production. This nondeterministic position is a major contribution of the social extraction models, as are considerations of difference and competition within social groups (Kohl, 1981, p. 104; Brumfiel, 1992), interest in the organization and social constitution of labor in production and consumption, and the focus on extrasubsistence aspects of food production (Hastorf and Johannessen, 1993). It is surprising that although Bender (1978) and others (e.g., Friedman and Rowlands, 1978) assert that demography is culturally determined or mediated, they do not allow it status as an "internal" factor in economic change, thus admitting it as a relevant variable. The social aspects of intensification are undeniable—much more needs to be done to integrate

these aspects with demography and ecology in consideration of both the causes and the courses of intensification (see Brush and Turner, 1978).

Social production (Brookfield, 1972, p. 38), then, cannot be excluded from accounts of intensification, even among hunter-gatherers. A kaleidoscope of pressures and opportunities presents itself to producers: taxation (Bronson, 1972, 1975; Nell, 1972; Grigg, 1976, 1979, 1982), tribute (Harris, 1973; Hassig, 1985; Slicher van Bath, 1963), government incentives (Patir, 1987), exchange (Bender, 1978, 1981, 1985; Hayden, 1990; McGuire, 1984), and ritual presentation (Breckenridge, 1985; Brookfield, 1972).

The Law of Least Effort

Boserup's model assumes that the most labor-efficient solution will be chosen to meet a given level of demand. This view has been widely accepted. Thus, in much discussion of cause, researchers seek a "push" or a "pull," whether social, political, environmental, or demographic, that would have induced people to overlook the declining marginal returns and extra effort of intensifying production. These two conjoined assumptions: the reduced efficiency of intensive agriculture (Boserup, 1965, pp. 28–32) and the Law [or principle (Zipf, 1949)] of Least Effort create the conditions under which population pressure is called in as a prime mover of economic change. Note that although overall levels of production per unit of land or labor may rise, the assumption of declining marginal returns suggests that the ratio of outputs to inputs actually falls. This assumption is generally made only for agricultural production, not craft production. If anything, the latter is assumed to increase in efficiency with intensification (Wright and Johnson, 1975; see Costin, 1991).

Although it is widely employed (Brookfield, 1972, p. 34; Turner *et al.*, 1977, p. 384), there are a number of difficulties with the Law of Least Effort. It assumes that producers will universally maximize leisure rather than labor (Grigg, 1982, p. 37), presupposing the existence of a valid cross-cultural definition of effort (Bronson, 1972, p. 199) and of a trade-off between labor and leisure (de Vries, 1972, p. 47). Bender (1978, p. 218) notes the essential ethnocentrism of the Law of Least Effort, based as it is on Western notions of labor and work belonging to a discrete and uniquely "economic" sphere. It may be useful to distinguish between labor and work, in that work can be operationally defined in terms of effort or energy expenditure, while labor involves a dimension of organization. As such, work is only one component of labor, which is structured in specific contexts.

But is work effort minimized? Hakken (1987, p. 67) points out that the implicit Western industrial model of work tends to fall down in anthropological discourse. Work expended in agricultural production cannot be neatly divided up into subsistence and social components, or production for use as entirely distinct from social or other production (see also Godelier, 1978; Ruyle, 1987). Work, in Hakken's (1987, p. 71) final definition, cannot be extricated from its social context, even in consideration of subsistence. The "Law" of Least Effort appears to be on shaky empirical ground when effort is operationalized in this very general way. It seems clear from the ethnographic record that effort is *not* minimized in production for ritual, exchange, gifting, and so on, and perhaps not for subsistence either. If all forms of effort are integrated as the above definition suggests, then the least effort assumption appears to be untenable, except as a limiting case.

Further, in Boserup's formulation, agricultural work tends to be equated with work in general (de Vries, 1972, p. 47), making the conservation of agricultural labor result in increased free time. In actuality, the organization and scheduling of labor among agriculturalists are considerably more complex, and changes in the duration, intensity, and timing of agricultural work necessarily involve reorganization of other productive activities (Kaiser and Voytek, 1983; Stone, 1993; Stone *et al.,* 1990; Tringham and Krstic, 1990). de Vries (1972, p. 47) notes that peasants, for example, are not just cultivators, but are also engaged in "home handicrafts, capital improvements, transportation, and marketing." Tools and other goods not manufactured within a household may have to be acquired with income from either agricultural produce, household manufactures, or labor exchanges. The mix of productive and consumptive strategies employed by households may be complex and variable, and changes in the labor investment of agriculture may have little to do with increased leisure time (Hymer and Resnik, 1969, p. 494; see Chayanov, 1987; Thorner, 1986).

The Boserupian formulation of the Law of Least Effort is explicitly ahistorical. That is, the amounts and forms of labor inputs involved in different agricultural strategies may be directly contingent on past efforts. The production of crops on terraced hillsides involves differing degrees of effort depending on whether terrace walls need to be built, already exist, or are in need of repair. Decisions regarding work take place within historically and situationally specific contexts. Thus, Lansing (1991, p. 12; after Marx) refers to the highly modified Balinese agricultural landscape as the product of the "congealed labor" of cultivators' forebears. Decisions about labor can be transformative, creating new contexts that must thereafter be taken into account (see also Morrison, 1992a, pp. 418–419).

Declining Returns, Production Functions, and Formal Analyses

The contention that intensive agriculture is necessarily inefficient agriculture has been questioned on empirical grounds. This issue cannot be completely separated from a consideration of Boserup's (1965, pp. 15–18, 1981, p. 23) operationalization of agricultural intensity in terms of cropping frequency, since the empirical support marshaled by Boserup (1965, pp. 43–48) is intended to demonstrate the labor efficiency of long-fallow swidden over shorter-fallow systems. Boserup's data are derived largely from Africa, and her stage sequence appears to work best in tropical settings. Sanders (1972, p. 147) notes approvingly, for example, that Boserup's thesis that extensive systems are more productive (per unit labor) than intensive ones is "sound" in areas with high rainfall and original forest vegetation. Other studies, such as that by Pingali and Binswanger (1983), found empirical support for declining returns (and see Netting, 1993, pp. 273–274). Like that of Boserup, this work is focused on Africa. There is, however, no unanimity of opinion on this point. Waddell (1972) casts doubt on the comparative efficiency of swidden over more intensive forms of agriculture in the New Guinea highlands (and see Grigg, 1982, pp. 40, 73–79; Nell, 1972, p. 40). The specific conditions of wet rice cultivation also appear to violate the assumed inverse relationship between intensity and efficiency (Hanks, 1972, pp. 64–66; Nakana, 1980, p. 61; Padock, 1985, p. 274; W. Clarke, 1985, p. 868) to a certain point (Geertz, 1963). It may be that marginal returns to intensification vary significantly with the crop grown, methods of cultivation, and environmental constraints (cf. Padoch, 1985).

Brookfield's definition of intensification cited above is formulated explicitly with respect to the economic margin. This concern is typical of formal models of intensification, of which one of the most widely employed is the production function (Sachs, 1966; Friedman, 1979; Kirch, 1984; Renfrew, 1982). Although as a formal model, the production function requires no assumption about sequence, in practice the curve is often viewed as an historical trajectory. The production function plots total output on the Y axis versus labor input (Renfrew, 1982, p. 266) on the X axis (Fig. 1). The form of the curve—the production function—is assumed a priori to have an initial positive slope, leveling out to an area of zero slope and, finally, dropping to a negative slope [this segment of the curve is not a universal feature (e.g., Brookfield, 1972, pp. 34–35)]. At the area of zero slope, the marginal return gained by increasing the value of the X axis (input) becomes zero. The slope at any point is defined as the marginal utility (MU) at that point (Renfrew, 1982, p. 266). This is the productive

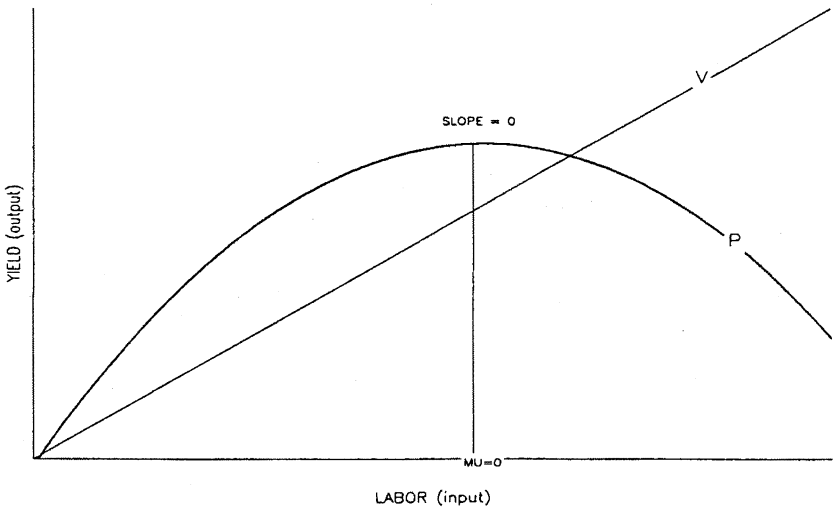

Fig. 1. Simplified production function. The production function expresses the relationship between labor and yield. *V* represents the necessary production for subsistence. (After Kirch, 1984, pp. 162–163.)

limit of a given curve, which is variable for each environment (Renfrew, 1982, p. 266) and extractive technology.

Environmental parameters are held constant in this formulation (Kirch, 1984, p. 165), even though factors such as climatic change and environmental degradation may be significant to processes of intensification. This model also assumes a mathematically simple (i.e., constant and direct) relationship between input and output. If that relationship were found to be temporally variable, discontinuous, or erratic, the usefulness of the production function as a graphic device would be reduced correspondingly.

The production function also assumes a constant per capita labor input, even as marginal utility declines (Renfrew, 1982, p. 266). As Renfrew (1982, p. 268) points out, this assumption may not be correct, and indeed it is the change in quantity and organization of labor inputs that is one of the most interesting aspects of intensification. Although Renfrew (1982, p. 265) and others employing cost curve analysis reject the notion that the model necessarily implies the operation of "economic rationality" in production decisions, Brookfield's "staircase" version (1972, pp. 34–35) of the production function does just that. The model describes a temporal progression of extractive and/or productive technologies. When the maxi-

mum marginal utility of one production curve is reached (at some point at or after the curve flattens), a new technology or set of technologies with a higher potential output is adopted. The increase in the absolute value of outputs is gained at the cost of increased labor inputs. There is no stated assumption that the ratio of the two must decline, however. The "step" up the staircase is essentially the Boserupian revolution; in Malthus' version there is only a single technological limit. However, Malthus is also integrated into Brookfield's (1972, p. 34) staircase, in the form of the "Malthusian endpoint," after which no further technological "progression" is possible. Leading to this Malthusian end point (the model assumes multiple possible paths) is the cul-de-sac corresponding to Geertz' (1963) "involution" (Brookfield, 1972, p. 34). Presumably, the transition up to the next technological step is prompted by the condition of diminishing or zero marginal returns—economic rationality.

What may be the most limiting factor in formal input–output analysis (cf. Patrick, 1985) stems from the fact that a given cost curve (Earle, 1980, pp. 13–14) is specific to a *single* extractive or productive strategy. Actual economic systems consist of multiple, diverse strategies, the balance of which may vary considerably over time and between individuals, households, or other groups within a single society. Aggregate curves can, of course, be calculated to represent a mix of strategies characteristic of that diversity, but what such a curve cannot illustrate are changes in the organization of that mix. The use of formal models may not strictly require adherence to an economic model of communities as diversified firms (Earle, 1980, p. 14) rationally selecting the optimal mix of subsistence options, but it does promote a segmented and static conception of subsistence strategies and economic organization. Models such as Brookfield's staircase imply, if they do not actually state, that technological change occurs primarily because of input–output balances and that intensification is primarily a technological change (see also Glassow, 1978, p. 40). Organizational changes are rather difficult to graph and, thus, have low visibility in the "well-structured" solution (Johnson, 1980, p. 20) to the problem of intensification.

A step beyond those employing production functions as a descriptive device are the overtly economic formalist analysts, who take as given the operation of economic rationality and of some variety of optimizing tendency in the selection of production options (Christiansen, 1980; Earle, 1980; Keene, 1979). Numerous discussions of this position exist in the literature (Keene, 1983; Martin, 1983; D. Clarke, 1972). A straight Boserupian account of intensification is usually adopted (but cf. Green, 1980; Jochim, 1976). The declining returns of intensification are generally assumed, and this, together with cost minimization assumptions analytically equivalent to

the Law of Least Effort, provides the conditions for forced "nonoptimization." Increased output is assumed to be a direct result of population growth in subsistence economies (Christiansen, 1980, pp. 33–34), and population consequently also directly determines subsistence mixes and subsistence change (Earle 1980, p. 19).

Technological Change and Intensification

Boserup (1965, p. 26, 1983) has argued that, contrary to notions of independent technological progress (cf. Bray, 1986, pp. 2–3), specific systems of land use require specific kinds of tools. Thus, technology does not drive intensification, but the reverse. Hoes replace digging sticks when forest fallow is replaced with bush fallow, plows arrive with grass fallow, and irrigation with annual or multicropping (Boserup, 1965, pp. 24–25). Ultimately, population drives technology to the "green revolution" (Boserup, 1983). The status of technology as a dependent variable of demography (Smith and Young, 1972, p. 3; Turner *et al.*, 1977, p. 395), rather than as an outgrowth of innate "inventiveness," is continued in many cost-benefit analyses (e.g., Renfrew, 1982, pp. 268–269, 271).

A feedback relationship between population and technological change is favored by some researchers (Dow, 1985). Bender (1975, p. 6) writes, "Population pressure may stimulate innovation. . .; innovation stimulates population growth," while Sanders (1972, p. 148) adds that technological innovations both permit and stimulate population growth. For others, causation runs from technological change to change in land use (Galla, 1985, p. 795). Whatever the direction of change, however, these perspectives all share an underlying notion of technological progress along a path of increased complexity (e.g., Sherratt, 1973, p. 427), in ironic counterpoint to the notion of diminishing returns. Bray (1986), among others (e.g., Bronson, 1975, pp. 25–26), has challenged this unilineal view of technological change, noting that the most intensive and organizationally complex agricultural systems (such as paddy rice cultivation) may use very simple tools.

A major difficulty with the views of technological change characterized above is the rather narrow definition of technology. Bray (1986, pp. 113–116) distinguishes between "skill-oriented" and "mechanical-oriented" technologies to describe the labor intensification of Asian rice agriculture and the capital intensification of Western industrial agriculture. If technology is to be considered an aspect of intensification, it must include not only tools and techniques, but also the organization of production (Bender, 1985; Stone *et al.*, 1990; see also Condominas, 1986).

Consideration of technology in intensification is of particular importance to archaeologists, who often make inferences about productive strategies based on the material evidence of tools used in productive activities.

BOSERUP AND BEYOND

The Unilinear Path of Intensification

Part of the great appeal of Boserup's model is its simplicity and comprehensiveness. Patterns of land use, demography, and technology all follow a unitary course, and relevant variables are easily charted as matched sets of fallowing systems, population density groups, agricultural tasks, and agricultural tools (Boserup, 1981, Tables 3.7, 5.1). Archaeologists, in particular, are fond of comprehensive, multicomponent developmental schemes (such as those of Fried, 1967; Sahlins, 1972; Service, 1962), perhaps because these allow us to construct an integrated picture of the past from the recovery of only a few elements of the scheme.

Intensification, in Boserup's (1981, pp. 46, 53) scheme, is also assumed to be a steady and gradual process, with labor inputs added continuously through time. Bronson (1972, p. 206) comments, "It is a common assumption in anthropology and in culture history that the development of agriculture is a substantially regular and predictable process whereby an initial extensive type of farming slowly, through the millennia, becomes intensified." The notion of gradual addition of inputs can realistically be sustained only for certain activities—perhaps manuring can be gradually increased, but irrigation networks, for example, represent more discrete "packages" of labor and capital outlay.

The operational definition of intensification as cropping frequency reflects Boserup's focus on continuous variability and gradual change. Technological change is allowed to be more discontinuous but is ultimately a reflection of fallowing length. The adequacy of cropping frequency as a measure of the actual course of intensification (cf. Boserup, 1965, p. 18) in specific areas has been questioned (W. Clarke, 1985, p. 867; Morrison, 1992a), and some attempts have also been made to develop alternate, more complex classifications of land use (Conklin, 1957; Denevan, 1980; Brookfield and Brown, 1963). The problem with fallow length as a measure of intensification lies finally *not* in its inappropriateness (see, e.g., Shajaat Ali, 1978, but in the fact that fallow length constitutes a univariate measure of a multivariate phenomenon and can provide only a partial index of that phenomenon.

Specific routes of intensification have been shown to violate Boserup's (1965, pp. 15–16) proposed sequence of fallow lengths (Morrison, 1992a), calling into question the universality of this sequence. I suggest that this gradualist and unilinear view of intensification is one of the principal unexamined aspects of the Boserup model that continues to structure archaeological assumptions about economic change. Because our arguments about cause largely ignored process, Boserup's fallow length categories continue to be used as an a priori universal sequence of developmental stages.

Productive Diversity and Intensification

The lack of emphasis on variability and diversity in Boserup's model is worth considering. In part, this lack stems from the scale and scope of her model, with societies and even countries classified according to a single fallowing classification (Boserup, 1981, p. 23). However, the measurement of intensification by frequency of cropping works to obscure variability both in strategies of production and in the process of intensification. Economic systems typically consist of multiple components, and this diversity, Colson (1979, p. 19) notes, is itself a protection against uncertainty: "I see the mixed economies of hunter-gatherers, pastoralists, and subsistence agriculturalists, as a mixture of coping strategies which reduced their long-term vulnerability to weather and to other natural forces that affect food supplies." Nell (1972, p. 40) also discusses diversity of productive strategies, but from a perspective of cost-benefit analysis. As noted, Boserup (1965, pp. 56–64) sees the coexistence of cropping systems as an example of evolutionary "lag," rather than as a deliberate economic strategy. Netting (1977, pp. 63–65) comments,

> Though such typologies provide handy classifications, their suggestion of an evolutionary development of agriculture from simple shifting systems to complex intensive ones may obscure more basic functional relationships. . .. The more we learn about indigenous agricultural methods, the more clearly it appears that food producers characteristically practice varieties of both shifting and intensive cultivation simultaneously.

Diversity can also be seen in the purposes of production, with what Brush and Turner (1987, p. 33) call the "dual farmer" producing for both subsistence and exchange.

The process of intensification, too, may incorporate a greater degree of variability than allowed for in the Boserup model. Kaiser and Voytek (1983, pp. 329–330) divide the proces into three components: specialization, diversification, and intensification proper. These aspects of intensification involve changes in the amount and organization of labor, and in

its application through technology, and cannot be measured in terms of a single variable such as cropping frequency (see below).

Risk, Variability, and Intensification

Intensification has also been examined as a strategy for reduction of risk and buffering of uncertainty. Halstead and O'Shea (1989, p. 1) argue that what they term the structure of variability—its frequency, duration, scale, severity, and predictability—is important in shaping consequent coping strategies. Risk can be defined as the probability that such variability will have adverse consequences (see also Cancian, 1980, pp. 162–163). Those who argue that risk prompts intensification generally cast risk in terms of subsistence, although non-subsistence-related negative sanctions may also be considered. In general, risk arguments can be classified into two varieties. In one, environmental or other risks are suggested to create population–resource imbalances even in the absence of population growth or pressure. Thus, risk is conceived as a factor mediating or even replacing demographic stress. In the other, arguments about risk are simply a way of recasting the argument about social demands for surplus.

In regions with high-frequency (and/or high-amplitude) environmental variability, it has been argued that agriculturalists intensify production as a strategy for coping with uncertainty, either directly (Nichols, 1987; Sanders and Webster, 1978) or indirectly through the creation of exchange relations (Cancian, 1972, 1980; Plog, 1978) or other social obligations. Obviously, many other strategies besides intensification may alleviate risk (Breckenridge, 1985; Halstead, 1981; Hegmon, 1991). Increased production might be included in the category of normal surplus [and be intended for storage (Kirch, 1984; Smyth, 1989)], but for areas with extremely unpredictable environmental parameters such as rainfall and temperature, this "normal" surplus could require alteration of cropping regimes or construction of specialized facilities—in short, methods of intensive cultivation—even in the absence of demographic stresses.

Although discussions of risk almost always center on features of the physical environment (e.g., Hegmon, 1991), other factors may be of equal importance. For example, peasants subject to periodic depredations by invading or resident armies must take those into account in strategies of cultivation and of storage (see also Brookfield, 1984, pp. 37–38; Netting, 1993, p. 267). However, although such demands can be conceived of as relating to a socially "risky" environment, they can equally well be considered a form of external demand for surplus.

Colson (1979, p. 18) warns that there really is no such thing as a "normal" year for most self-sufficient agriculturalists and that they take into consideration (and we ought to) periods longer than the annual cycle in decision making (see also Dean *et al.,* 1985; Halstead and O'Shea, 1989). Thus, the components of normal surplus are seen to be considerably more complex than indicated above, and the "normal" surplus may in some cases be sufficiently large and/or difficult to gauge that intensive techniques of production are required to meet its demands. Simple input–output analysis ignores the temporal implications of subsistence risk at its own peril. Short-term costs of the maintenance of diversity may actually be higher, but the long-term "cost" lower; the reward can be understood in terms of risk. Risk has been presented in the literature as operating in a number of ways, from conscious incentive, to mediator in situations of population-resource imbalance, to hidden prime mover.

It is extremely difficult to specify risk in any particular instance, given that it depends on both the structure of variability and the somewhat elusive probability of adverse consequences. The measurement of risk is as problematic as its specification. In general, variability in some environmental or social parameter is employed as a proxy measure of risk, although it is clear that the mere existence of variability is insufficient to establish risk. It may be that conditions of risk are simply conditions under which imbalances between resources and demand, however generated, are more likely to occur.

AGRICULTURE, INTENSIFICATION, AND THE ARCHAEOLOGICAL RECORD

For archaeologists, one of the most difficult aspects of the study of intensification is the methodological challenge it poses. The investigation of past agriculture presents particular difficulties because of the large spatial scale of agricultural activities and their often ephemeral material remains. For this reason, it may be necessary to consider a constellation of direct and indirect indicators of past land use at a number of spatial scales. Such indicators may include artifacts, historical documents, settlement distributions, agricultural features, and botanical remains.

To evaluate competing arguments about the causes of intensification, it is necessary to infer the existence of social and political demands (and their consequences) from the archaeological record, to determine demographic rates or at least broad demographic parameters from the material record, and to reconstruct the organization of and changes in productive strategies. Clearly, these are ambitious goals and it is not possible even to

begin to address all of these issues here. One place to begin, however, is with the third topic, the reconstruction of the structure of and changes in productive strategies. If we can develop an understanding of multiple courses of intensification, we might, for example, be able to determine whether there is but a single route of intensification, measurable by a single parameter such as cropping frequency. Further, if we can begin to understand specific instances of change and the roles that, for example, elites played in different aspects of production, we might be in a better position to evaluate the causal efficacy of elite demands in stimulating productive intensification. Certainly archaeological investigations of the process of intensification possess certain advantages over ethnographic ones, in terms of the long time depth and greater potential variability of cases in the archaeological record.

Archaeological studies of agricultural production typically employ several complementary forms of evidence. Artifactual indications of agricultural practice may include farming implements (Steensburg, 1973; Harding, 1976), from which some organizational information can be derived. Sherratt (1981), for example, notes the presence of ards and simple plows in Britain in the third millennium bc; these tools have rather different implications for agricultural practice than do hoes in the same context (Barker, 1985). However, the problematic association between technology and cultivation intensity suggests that such finds will not be unambiguous indicators of intensification (cf. Rowly-Conwy, 1984).

Written documents provide information on agricultural practices and strategies for some places and time periods (e.g., D. Hall, 1982; I. Hall, 1983; Slicher van Bath, 1963). Written materials cannot provide all the answers, however. Such records typically record only the components of the agricultural economy of interest to the literate elite, and often omit reference to small-scale or marginally productive strategies (Morrison, 1992a). Attempts to trace the antiquity of names for crops, agricultural implements, or practices via linguistic analysis have also been made (Ehret, 1984; see also Stahl, 1984). However, this approach requires the rather questionable assumption of stability in meaning through time.

Studies of plant remains are extremely important in investigating past agriculture, as they reflect the record of both anthropogenic and natural vegetation. Macrofossils from crops and weeds (Dennell, 1976; Hastorf, 1988; Hillman, 1984; Miksicek, 1990) in settlement and field contexts may indicate what species and even what varieties (Constantini, 1990; Kirkby, 1973) were being grown. Charcoal studies may inform on both environmental conditions and the nature and intensity of human burning (Clark, 1988; Morrison, 1994b; Murakami, 1989; Smart and Hoffman, 1988), and pollen analyses can reveal regional-scale vegetation patterning (Birks and

Birks, 1980; Bryant and Holloway, 1983) as well as smaller-scale patterns of agricultural land use (Byrne and Horn, 1989; Covich, 1978; Edwards, 1988; Morrison, 1994a). Phytolith studies, while still facing some methodological difficulties (for a discussion see Piperno, 1988), show promise, particularly for identifying crops such as bananas (Wilson, 1985), cucurbits (Piperno, 1988), and maize (Pearsall, 1978; Piperno, 1988).

The material record of past agriculture may also include the physical remains of agricultural features and facilities and their distribution across the landscape. Soil ridges and plow marks (Bradley, 1978; Butzer, 1982; Fowler and Evans, 1967; O'Connell, 1986; Tusa, 1990), raised and bordered fields (Denevan and Turner, 1974; Fish and Fish, 1984; Matheny, 1978; Siemens and Puleston, 1972; Turner, 1974), gravel-mulch fields (Anscheutz and Maxwell, 1987; Buge, 1984; Vivian, 1974), indications of manuring (Wilkinson, 1982, 1989), terraces (Donkin, 1979; Fowler and Evans, 1967; Spencer and Hall, 1961; Wheatley, 1965), and canals and reservoirs (Farrington, 1985; Farrington and Park, 1978; Matheny, 1978; Morrison, 1993; Mosley and Deeds, 1982) all indicate agricultural practice. Related features may include field boundaries (Fish and Fish, 1984, p. 155) and other property markers. Clearly, the chronology of such facilities is important for tracing sequences of change; the growing trend toward excavation in field contexts reflects that concern (e.g., Newman, 1972; Pearsall and Trimble, 1984; Tuggle and Tomanari-Tuggle, 1980).

The development of regional, or landscape approaches has been extremely important for studies of past agriculture. Human use of the landscape is complex, and agricultural strategies may relate to disparate spatial scales. Residents of a single settlement, for example, may plant intensive manured and irrigated "kitchen gardens" (Doolittle, 1992; Killion, 1992) near individual households, have irrigated fields in a valley bottom, have extensive rain-fed fields on a terraced hillside, and perhaps also manage stands of certain useful wild species. Such an internally differentiated system might be expected to leave a complex archaeological and archaeobotanical record, and one that looks different in different locations. A research strategy for investigating this hypothetical case would require multiple lines of inquiry at several spatial scales (cf. Harrison, 1978, p. 6). On a regional or subregional scale, archaeological evidence of past land use might include the location, content, and temporal placement of settlement sites (cf. Stone, 1993) and of various special-purpose sites and features, in addition to geological, geochemical, and botanical profiles. In such settlement pattern studies, the locations of archaeological sites and features in relation to one another and to the structure of resources are related to their economic, social, and political context.

THE COURSE OF INTENSIFICATION: BREAKING DOWN THE PROCESS

While discussion on the causes and consequences of intensification, and particularly of agricultural intensification, has been extensive, less attention has been paid to the paths or courses that such intensification may take. If, however, we wish to develop understanding of intensification as a *process*, or indeed to begin to develop adequate archaeological methods for identifying intensification, it is necessary to break it down into its component processes or strategies.

It is useful to recall the distinction between intensification and expansion, where intensification involves some fixed quantity, most often land. Clearly, mobility constraints and mobility options, which are entailed in structures of access to land, are relevant to both expansion and intensification, either of which may be employed in response to similar imperatives. In fact, agricultural change may involve both expansion and intensification, such that expansion can be considered in certain cases as a component strategy of intensification (Farrington, 1985; Morrison, 1992a). I would also like to suggest that the process of intensification is itself quite diverse, including what may be termed "intensification proper" (after Kaiser and Voytek, 1983), or the process by which the yield per unit of land and/or labor of an existing resource base is increased, as well as the allied processes of specialization and diversification.

Intensification Proper

Intensification proper involves increased labor and/or capital inputs to a plot of land and may involve changes in the types and combinations of cultigens produced. Intensification proper may also take the form of increased investments in practices such as plowing, seed bed preparation, weeding, transplanting, manuring, and the construction of soil and water control facilities, of which the latter are certainly the most archaeologically visible product of this strategy. Increased frequency of cropping (cf. Boserup, 1965), possibly facilitated by improved control over conditions of plant growth, is also one strategy of intensification proper.

It is clear that what Kaiser and Voytek (1983) have termed intensification proper is a large category, but one that has a certain coherence in terms of standard views of intensification strategies. It is also apparent that of the various forms of intensification proper noted above, some require large outlays of capital or access to specific resources, such as water, tools, draft animals, or building material, while others involve only in-

creased labor. Thus, within this conceptual category, some strategies will be possible only where producers have access to nonlabor resources, and the adoption of these strategies can be expected to be tied to the economic and sociopolitical opportunities of producers. Certainly labor itself constitutes a resource that is not uniformly distributed (cf. Patir, 1987).

Kirch (1994) distinguishes between what he terms "landesque capital intensification" (after Blaike and Brookfield, 1987), in which primary labor investment results in a permanent modification of the landscape, and other forms of labor intensification, which do not create permanent facilities (landscape modifications such as canals or terraces). The construction of facilities may, he notes, actually reduce labor demands for subsequent producers. It is necessary to disaggregate the labor organization involved in constructing facilities from the subsequent demands of maintenance and production. As Lansing (1991) has noted, the process of landscape transformation is historically contingent, so that decisions about productive strategies, decisions that may involve the construction of facilities, have consequences for all future producers. The history of decisions is represented in the "congealed labor" (Lansing, 1991; see above) of past activities, features that have themselves become part of the productive landscape (see also Netting 1993, p. 267).

Specialization

Specialization, or the reduction of diversity, is another possible strategy of intensification. Costin (1991, p. 4) defines specialization in terms of entire societies as "a differentiated, regularized, permanent, and perhaps institutionalized production system in which producers depend on extra-household exchange relationships" (see also Muller, 1984). Specialization in craft production is generally viewed as promoting efficiency, while intensified agriculture has often been depicted as necessarily inefficient (producting declining returns). Certain forms of agricultural production, such as wet rice agriculture, may be viewed as specialized strategies. Wet rice entails very specific and labor-intensive techniques of field preparation, irrigation, and drainage and promotes major modification of soil structure. Specialization may not refer simply to restricting one's efforts to a single crop or production strategy, however. Crop varieties may themselves be developed as specialized responses to local environments (e.g., Gallagher, 1989; Kirkby, 1973), and most traditional agriculturalists employ a number of different locally adapted varieties.

Specialization in agriculture implies exchange. As such, it is not intelligible outside the context of the entire economic and social system and

must be considered in concert with the structure of productive diversity. In urban societies, specialization in agricultural production may be related to production for markets and there may be various degrees of involvement by nonagriculturalists in agricultural decision making. As with other aspects of productive intensification in complex societies, specialization might most profitably be considered as a strategy of intensification and, possibly, as a strategy differentially available to and differentially employed by different groups of producers (Morrison, 1992b).

Diversification

Diversification is probably the least obvious aspect of productive intensification, in that it may involve the addition or elaboration of productive strategies that seem to be *extensive* rather than *intensive* of land or labor. Diversification relates to an increase in the number of components of a productive system (diversity), as well as to changes in the organization of that diversity (cf. Stone *et al.,* 1990). Temporal and spatial diversification might include strategies such as staggered planting and harvesting times (Mencher, 1978), dispersed land holdings, and the cultivation of crop mixes and of multiple varieties of a single crop, each with different growth characteristics. In considering strategies of diversification, it is necessary to look beyond agriculture itself, as households, individuals, and groups may seek to diversify not only in terms of plot sizes and locations, types of crops, and forms of soil and water control facilities, but also in terms of other productive activities (craft production, wage labor, etc.). Nonagricultural strategies of diversification include the forging of social or other ties and the creation of entitlements across regions. Changes in labor organization might also be considered under the rubric of diversity. For example, in South India, dependent low-status landless laborers [but not slaves (Netting, 1993, p. 283)] are differentially concentrated in areas of intensive wet rice production (Mencher, 1978; Ludden, 1985), and indeed, a greater diversity of occupations and statuses is seen in these areas.

DISCUSSION

The Boserup Model

This consideration of intensification has been organized around aspects of the Boserup model and responses to it, in recognition of the way in which this single view has shaped subsequent discussions of intensifica-

tion. The Boserup model revolutionized views of intensification, demolishing progressive and technologically determinist positions (see Netting, 1993, pp. 261–264, 270). While there is much insight in Boserup's formulation, it does not provide a useful framework for investigating intensification. Although compelling by virtue of its generality and parsimony, use of the Boserup framework by archaeologists has led to typological and unilinear views of intensification and has worked against the development of research that would investigate spatial, environmental, and historically specific dimensions of intensification sequences. The model cannot take into account the great variety of human productive strategies, including strategies of intensification, and their complex organization in both time and space. Boserup's operationalization of intensification as frequency of cropping also presents two very serious problems for archaeologists investigating change. First, and most problematic, it is not at all clear that this single measure adequately captures or characterizes the intensity of cultivation for most agriculturalists. This univariate measure neither takes into account the internally diverse strategies of even a single household at a single point in time nor encompass the range of strategies of intensification that may characterize a long sequence of change. Second, cropping frequency is difficult to determine archaeologically. Paradoxically, it is much easier to discern the existence of a range of productive practices through their archaeological and botanical traces than it is to reconstruct this simple measure.

Finally, then, the Boserup model falls down as a typological approach that, instead of accounting for what appears to be a complex and variable process, merely places societies into categories. Instead of searching for universal stages of intensification, and universal causes, research now needs to be directed toward delineating the actual paths of intensification and examining such contextually specific factors as the organization of labor, the role of surplus production, mobility strategies, markets and trade, ideology and ritual, and the effects of environmental variability in time and across space. In addition, demography must be integrated into production through consideration of population structure (not just size) and household composition and their effects on productive strategies.

The Future of Intensification Research

Although I have suggested that any investigation into the process of intensification requires "breaking down" the process into component strategies, it is worth noting that the concept of intensification as a whole remains an important one in studies of long-term change. The importance

of this concept may, paradoxically, be evident from the present silence regarding intensification in the archaeological literature. Following the acrimonious debates associated with the adoption and rejection of Boserupian demographic causality and the subsequent polarization of positions, there has been much less explicit discussion of the concept, although specific instances of intensification continue to be discussed. To resolve the now quiescent debate on the causes of intensification, I suggest that it is first necessary to understand particular courses of intensification in some detail, examining both strategies of intensification and the factors conditioning their operation. Only by determining how intensification proceeds, how production is organized in specific situations, and the conditions under which forms of intensification occur can we begin to come to a more grounded understanding of the forces shaping changes in productive strategies.

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