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Industrial Agriculture in Evolutionary Perspective

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Industrial agriculture is the highly volatile, capital-intensive food production system characteristic of industrial societies. This article will explore the characteristics of this form of agriculture and will use ecological and bioenergetic perspectives to interpret the current crisis in the U.S. farm sector. Evolutionary theorists in this area have tended to focus on the level of the total system, while this analysis will include the actor level as well (see Paul, this volume). Although the conditions of U.S. agricultural production are highly determined by the state and by other aspects of the economic context, different family traditions and farm strategies nevertheless play an important role in balancing among diverse pressures for maintaining tradition and for change. The current farm crisis may result in an escalation of the volatility and instability of U.S. agriculture, or it may begin the process of evolution to a more stable food production system.

When viewed from the ecological and cultural evolutionary perspective in anthropology, human subsistence modes have evolved in two general directions: toward labor and capital intensivity. Responding to the imperatives of population pressure and elite surplus extraction (see Brown, this volume) and the desire to produce a surplus for exchange, human groups have developed more productive means of obtaining food under less favorable conditions (Barlett 1974, Boserup 1965, Polgar 1975, Service 1975). Agricultural evolution can be conceptualized as a process of intensification of resource use and capture of energy (Adams 1985; Bennett 1976; Rappaport 1979; Wilkinson 1973). A continuum of increasing total output and labor intensity per land unit can be seen in the evolution from swidden systems to plow agriculture and irrigation agriculture (Netting 1974, 1977). Industrial agriculture can be placed at the end of this continuum in terms of total resource and energy use; in other ways, it deviates from this evolutionary line. Productivity per land unit is less important than productivity per labor unit, and land is often used extensively. The hallmark of industrial agriculture is capital intensification and heavy investment in machinery and purchased industrial inputs. In the United States, industrial agriculture emerged out of initial conditions of abundant land, scarce labor, high soil fertility, favorable weather, available capital, and abundant energy resources in trees, water, minerals. Later, a dominant position in international trade aided the capture of energy from other world areas (Adams 1985; Rappaport 1971). Goals of food system stability and sustainability that prevail in most other subsistence adaptations are superseded by a growth ethic based on constant innovation. The system is now characterized by greatly increased instability, uncertainty, and volatility, created not only in the on-farm production process, but by the actions of industries and the state as well.

Aspects of Darwinian evolutionary biology and bioenergetics are useful in understanding the emergence and characteristics of industrial agriculture. As the biologist Lotka observed, so long as there is unutilized matter and energy available, natural selection will operate to increase the "total mass of the organic system, to increase the rate of circulation of matter through the system, and to increase the total energy flux through the system" (cited in Adams 1985:7). In other words, as organisms colonize such a new habitat, they can be expected to maximize energy flow-through. This colonizing phase is followed by a climactic phase in which lower energy flow-through is used more efficiently in a less abundant environment (Rifkin 1980:54). As a colonizing adaptation reaches its resource limits, it experiences larger fluctuations in mortality and population size. Increasingly volatile conditions create boom and bust cycles in which organisms adapting to the greater scarcity of energy in the system are eventually rewarded. This phase of high instability eventually resolves itself, after considerable population losses, in new adaptive patterns of survival. This article will explore some interesting parallels in the way these biological concepts can be used to understand complex economic and social processes in a hierarchically organized human society.

Industrial agriculture is of particular importance at present because its energy-using, resource-depleting methods are being promoted and adopted in many areas of the world. At the same time, in the United States, the farm sector is experiencing its most severe crisis since the 1920s and 1930s. U.S. agriculture has clearly been a colonizing adaptation, maximizing energy use, circulation, and flux. The increasing instability of the system can be expected to act selectively on long-term cultural strategies for farm and family survival in different areas of the country. Research in Illinois reveals contrasting yeoman and entrepreneur farming types (Salamon 1985), and patterns of farm survival over the next few years can be expected to reinforce some cultural values and family goals over others. The volatility of the industrial agricultural system may cut off certain cultural lineages that have more long-term beneficial effects but which cannot, in the short-run, survive. The difficulties of the current situation will either be resolved in ways that enhance the volatile, high-energy characteristics of industrial agriculture or in ways that begin the transition to a lower-energy, more stable food production system. The outcome of this transition has important consequences for human groups and natural resources far beyond the political boundaries of the United States.

Volatility is used here to mean both changes in absolute amplitude of certain conditions that affect farming and the increased rapidity of such changes in conditions. Though not all aspects of industrial agriculture show increased instability, the highly changeable environment and production techniques of this system reflect greater volatility than previous subsistence adaptations. The following discussion is based on analysis of U.S. agriculture and as such pertains to a capitalist system. Many aspects of industrial agriculture are similar in socialist countries, but the comparison will not be explored here. Likewise, though industrial agriculture is characteristic of European and Japanese farming systems as well, the United States case will be the focus of attention.

The Industrial Context

By definition, industrial agriculture uses manufactured products in its capital-intensive production system. In 1976, it was estimated that U.S. farmers purchased \$60 billion of goods and services, supplied \$22 billion of goods and services themselves from the farm operation, and produced a net food and fiber product worth \$14.5 billion (Cochrane 1979:160). This product is sold for \$96.5 billion and, after processing, packaging, transport, and retail, is valued at \$308 billion. Provisioning farmers has become a major industry over the last 100 years. Differentiation of on-farm tasks has occurred, spinning off a wide range of seed, fertilizer, and chemical companies, and purveyors of services such as aerial spraying, grain storage, accounting, and futures contracting. In this way, profits are extracted from the production process by an expanding agribusiness sector.

The industrial context of modern farming adds uncertainty and instability to the production system in three ways that will be discussed here. First, competition among farm supply companies leads to rapid technological innovation, surrounding the farmer with new products and complex choices. Second, industrial agriculture is bound up with international supply and demand forces, both for inputs, such as petroleum, and for markets. This linkage with conditions in other countries adds volatility to the system. Third, declining numbers of companies in key agricultural industries have at times exacerbated these fluctuations. The concentration of economic power gives these companies greater market control, at the expense of other groups in the agricultural sector. Although certain aspects of these three parts of the industrial context of agriculture decrease volatility and stabilize the system, in the aggregate they contribute to greater complexity and instability.

Competition among farm supply industries promotes innovations in technology. Expanded production or greater efficiency of production are the immediate goals of technological change, but a constantly fluctuating economic environment is also the result. Genetic manipulation through scientific plant breeding, for example, has increased the productivity of many crop varieties, but often these improvements come at the cost of more vulnerable or more delicate strains. D. F. Jones, a leader in corn breeding, warned that "genetically uniform pure line varieties are very productive and highly desirable when experimental conditions are favorable and the varieties are well protected from pests of all kinds. When these external factors are not favorable, the results can be disastrous due to some new virulent parasite" (Perelman 1978:47).

United States farmers learned this lesson dramatically in 1970, when a widely adopted new corn variety showed itself to be particularly susceptible to

corn leaf blight. The resulting epidemic wiped out nearly half the corn crop in some areas of the country (Tatum 1971), and the 1970 losses from the blight cost the nation about \$1 billion (Perelman 1978:47).

Because seed companies are constantly innovating, seeking to improve their lines to compete with other companies, farmers are faced with the uncertainties of unknown seed types. In contrast to the slow pace of careful experimentation with new seeds in many traditional agricultural systems (Johnson 1972), U.S. farmers are faced annually with new recommendations of seed varieties from researchers and the agricultural extension service. Local performance may be unknown, and disease and pest resistance may likewise be unclear under local conditions.

Genetic diversity of plant types is also weakened under industrial agriculture. "Half a dozen cultivars or inbreds of each of our major field crops—corn, wheat, soybeans, sorghum, and cotton . . . cover about half the surface area of each crop in the U.S." (Duvick 1984:116). Duvick and others point to progress since 1970 in increasing genetic diversity and the hardiness of new strains of crops, but compared to traditional agricultural systems in which many different crop varieties are planted in the same field, the U.S. system is more vulnerable. Mechanized harvesting requires that all plants in a field mature simultaneously and prohibits the use of such risk-reducing seed variation that can assure that some strains will do well, even under extreme conditions.

Agricultural chemicals present a similar problem to the farmer; hundreds of new chemicals have been developed and marketed in the last twenty years. The long-term effects of their use—on human health and on the environment—are in many cases unknown. Interactions with other plants and desirable insects as well as correct application techniques add to the complexity of the farmer's management task.

International linkages in the industrial food system cause local perturbations on other continents to affect farming conditions in the U.S. Demand for U.S. products fluctuates according to weather conditions, political alliances, embargos, currency values, and debt loads. Prior to the export boom of the 1970s, U.S. agriculture was more removed from these demand fluctuations. With the world shortages and the grain sales to the Soviet Union in 1972, soybean prices jumped from \$4.50 a bushel to \$13.00 (Morgan 1979:265). By 1974, inflation and other adverse effects of high grain prices forced the Ford administration to threaten to suspend a two million ton corn sale to the Soviet Union. Grain markets collapsed, and one trader estimated his losses to be \$25 million. The sale was later allowed to go through, but grain market instability remained (Morgan 1979:266–267).

Dependence on international supplies of inputs, especially petroleum, is another aspect of industrial agriculture's volatility. High levels of fossil fuel energy use is one of the hallmarks of U.S. agriculture, a development that seemed for several decades to be an inexpensive way to increase productivity. A gallon of gasoline, when used to operate a mechanical engine, can replace nearly 10 hours of horse labor and 97 hours of human labor (Pimentel 1984:107). Fertilizer use has increased over 500% since 1950 (Schertz et al. 1979:27). Fluctuations in petroleum supply and price, however, have wreaked havoc with U.S. farmers since the mid-1970s, bringing home forcefully the vulnerability of import-dependent food production. Fuel costs have increased between 400 and 600% between 1972 and 1984, and fertilizer prices have gone up 140% since 1977 (USDA 1984:12– 14).

The high energy inputs in other aspects of the food system make food costs vulnerable to swings in energy costs and availability. Of the total energy cost to produce a loaf of bread, 45% is spent in producing wheat, and the rest is spent in milling, baking, packaging, and transportation (Pimentel and Pimentel 1979:119). In the case of a can of sweet corn, only 10% of the total energy is required to produce the corn. When manufacture of the can, transportation, cooking, and serving the corn is included, 9 kcal. of fossil energy are required to deliver 1 kcal. of corn energy to the table (Pimentel and Pimentel 1979:120). Disruptions in local power plants, ocean shipping lines, or manufacturing output all affect the volatility of such an interconnected system. Although there have always been fluctuations in the values of foodstuffs traded by nonindustrial agriculturalists, and weather cycles and natural disasters have created uncertainty, the magnitude and frequency of changes is much greater in the industrial system.

Concentration of power in the hands of agricultural suppliers, grain traders, and food processing companies adds to the volatility of the U.S. food system. Just six companies handle 85% of the world's grain trade, and their business activities both take advantage of and exacerbate fluctuations in international grain prices. For example, the momentous 1972 grain trade with the Soviet Union began in the private negotiations of Cook Industries to sell one million tons of soybeans. By 1974, the monopoly control of multinational grain traders came under fire in Brazil, the world's second largest supplier of soybeans. "Farmers got about \$130 a ton for their soybeans that year while the world market price reached \$400 a ton" (Morgan 1979:327). In response to the instability in world grain prices, the United Nations undertook to set up an international grain reserve, to create buffer stocks and even out price fluctuations. These negotiations in the late 1970s were unsuccessful, largely due to the demands from grain industry negotiators. The failure of efforts to create a grain reserve contributed to continued instability in the world grain markets.

A few giant firms dominate production in the farm supply industries as well. The top four companies in harvest machinery and tractor attachments control 80% of sales (Wessel 1983:116). The largest eight firms sell over half of all fertilizers, and the eight top chemical companies control 64% of total chemical sales (Wessel 1983:116). When the Arab oil embargo and rising energy prices more than doubled farm production expenses in the late 1970s, profit margins on machinery increased from 65 to 225%, far beyond the percentage increase in price (Wessel 1983:115). Large fertilizer companies took advantage of rising energy costs as well, feeding a boom and bust cycle in nitrogen prices (Perelman 1978:175). The farm recession that began in the 1980s led to a 40% drop in tractor sales in 1982, but John Deere weathered the slump and even increased its already large market share. Deere chose to ''trim inventories rather than prices,'' leaving farmers unable to benefit from a decline in their equipment costs (Wessel 1983:117).

Concentration among industrial food processing and retailing firms has been suggested by Wessel and others to feed inflation and economic instability. Though there are 20,000 food companies in the U.S., the top 50 control two-thirds of the industry's assets. Over half of sales are controlled by only four firms in many key product groups, such as canned soups (Wessel 1983:119). Antitrust suits against several large food conglomerates were filed in the 1970s (Paarlberg 1980:208). When prices paid to farmers decline, the market dominance of these firms allows processors and retailers to keep prices up and profits high. As these aspects of industrial agriculture illustrate, increased complexity of the system, international interdependence, and the diversification of farm tasks into agribusinesses decrease the farmer's control over the production process and increase volatility in the system.

The State

In industrial society, the state has come to play a major role in almost every aspect of the economy, including agriculture (Goldschmidt 1978). In the complex web of laws and agencies affecting the farm sector, policies designed to promote stability can have opposite effects. As the number of farmers declines and the state must respond to the political demands of nonfarm constituencies, fluctuations in policies and programs greatly increase the uncertainty in the farmer's economic environment (Paarlberg 1980).

Adams (1985) has described economic development as an increasing intensification in energy use, accompanied by a number of other characteristics, among them a tendency toward increasing differentiation and stratification. Enhanced societal complexity involves an expansion in the regulatory sector, the governmental, educational, political, and economic elites who benefit from and control developmental processes (Adams 1985; Rappaport 1979).

This tendency toward regulatory sector growth can be seen in the federal government's increasing dominance in U.S. agriculture. Since 1940, employees of the U.S. Department of Agriculture have increased in number by 45%, though the land in farms in the same period has decreased 4% and the number of farms has declined 62% (United States Department of Commerce 1940, 1986). This increase in bureaucratic personnel is only part of the total regulatory sector, however, since expansion in county and state agricultural agencies has occurred as well.

Federal farm programs control many aspects of crop and livestock production throughout the country. Production is determined in some crops by acreage or marketing restrictions. Price controls and guarantees, subsidized credit and insurance, soil conservation programs, and market-generating agencies all affect farmers' production decisions. Easily a dozen different programs can affect a farmer in any one year, each one subject to new regulations. In some areas of the country, every farm in each county is recorded in a federal office, and annual acreages of crops produced are checked for program compliance using aerial surveillance and on-site inspections. Paperwork in certain programs may involve half a dozen forms, to be filled out by farmer, buyer, and government agency, for any size plot. In the farm policy turmoil of the last decade, there have been annual changes in regulations involving support prices, loan rates, allotments, and required conservation acreage. Often, these new rules are published after optimal planning dates for the crop year have passed, adding to farmers' uncertainty.

The intervention of the state brings differential rewards to different sectors. In the settlement period of the mid-1800s, for instance, the homestead acts were designed to make land available for family-owned farms. The administration of land sales, however, allowed urban speculators to reap considerable benefits from these government programs (Gates 1960). Since the New Deal era, special support for peanut or tobacco growers provides higher incomes and assures farm survival in specific regions of the country. In the last 30 years, farm support programs have favored large, capital-intensive farmers, thereby feeding the concentration of farms and overproduction (Buttel 1983; Cochrane 1979). Removal of federal support for the Soil Bank in the Nixon administration led to an increase in cultivated acreage and the use of vulnerable dust bowl lands. Not only did this policy reverse significant soil conservation gains, it added to the persistence of crop surpluses and low prices.

The state not only affects the price, acreage, and marketing aspects of agriculture, but its labor supply as well. In the Southwest, large-scale industrial-type farms developed in the context of a cheap, mobile labor force (Padfield and Martin 1965; Thomas 1985). In Arizona, large-scale corporate agriculture developed on a base of "noncompetitive labor either in the form of labor surplus, or highly mobile, unsophisticated immigrant populations. The whole cost structure of Southwestern agriculture in general is based on this condition" (Padfield and Martin 1965:253). When labor shortages emerged, the state intervened to provide prisoners of war, Puerto Ricans, Mexican immigrants and others, creating artificial conditions when compared with the rest of U.S. agriculture that "must function under the stress of intensive labor competition" (Padfield and Martin 1965:253). Changing government policies toward different laboring groups and toward enforcement of immigration laws favors certain farm sectors over others and creates a fluctuating environment for farm operators (Wells 1981).

The federal government also sponsors agricultural research, "a major component of the United States' food system" (Busch and Lacy 1984:289). In this capacity, state and federal agencies contribute to the technology treadmill and fluctuating economic environment described above (Coughenour 1984:4). Unlike innovations in most nonindustrial farming systems, however, these innovations come from above. They are not as likely to have emerged from felt needs or onfarm experimentation that spreads to other operators with similar needs or conditions, as occurs in many nonindustrial farming situations.

Agricultural extension activities, funded by federal, state, and local sources, seek to promote "scientific farming" through the dissemination of research. One important aspect of "modern" farm management has been careful cost accounting, in which the economic principles of other businesses are applied to farming. Though these capitalistic accounting methods may seem to be more appropriate,

they may lead to riskier management strategies. Average annual profits or productivity are considered the primary criteria of success, and issues such as sustainability, ecological impacts, or adverse effects on family relations are considered less important and sometimes not included in farm management advice. As Bennett and Kohl (1982) have shown, family farms involve the long-term coordination of a farm enterprise and a family unit, each with separate needs and goals. Most traditional farming systems seek a balance between these two units, together with concern for the long-term health of the land and water resources used by the farm. Following these concerns, cultural traditions in many parts of the country have urged the cautious farmer to save in good years, buy land and equipment for cash, and avoid debt. This conservative management style is sometimes criticized by extension workers as poorly adapted for survival in the competitive world of modern agriculture (Bennett 1982).

In the current commodity slump, the dangers of such a path are all too evident. Management styles that were considered prudent leveraging in the inflationary 1970s have resulted in overextended, critical debt loads today. Decisions made on the basis of the average year's performance may or may not provide the cushion to survive disaster years. In this way, agricultural extension philosophies have added to the risk and uncertainty of industrial agriculture.

Instability in the Production Process

A number of aspects of industrial agriculture increase instability in the onfarm production process. Examples to be explored here are: the effects of technology in masking ecological change, the role of technological change in increasing management complexity and farm vulnerability, and the changes in family consumption patterns that increase demands for cash income.

Land use in industrial agriculture is characterized by methods that increase erosion and soil depletion: the use of heavy machinery, uniform, deep cultivation, a decline in use of organic fertilizers, crop residue-free fields, and a tendency toward specialization that reduces crop rotation. United States cropland erosion has proceeded at a rapid rate—five billion tons of topsoil a year are lost (Napier and Forster 82:138). Nearly one quarter of all U.S. cropland is experiencing unacceptably high levels of erosion. Over the next 50 years, if farming techniques are not altered to prevent erosion, the equivalent of over 25 million acres of land will be lost (Sampson 1984:12).

Depleted and eroded soils add to farmers' vulnerability to poor weather and pests. In the recent series of drought years suffered in the Southeast, eroded or depleted fields with low organic matter content were observed to succumb to dry conditions sooner than less eroded fields. Even in the same plot, crops in an eroded section die, while in areas with deeper topsoil or better quality soil, crops remain alive. The connections between erosion, soil depletion, and yield loss are sometimes invisible to farmers because they are masked by heavy fertilizer use, improved planting methods, and crop varieties (Sampson 1984:12). In addition, heavy chemical and fertilizer use has suppressed or destroyed the soil's ability to recycle nutrients naturally and to control weeds, diseases, and insects; the soil is, in effect, addicted to these inputs (Sampson 1984:15). Farmers' yields are likewise addicted to the heavy expenses these inputs incur.

Widespread pesticide and herbicide use has important ecological effects beyond damage to the soil. Broad-spectrum elimination of pests necessarily destabilizes the populations of desirable insects and animals; when chemical-resistant pest species emerge, natural predators are gone (Woodwell 1967a, 1967b). Escalating chemical control then becomes necessary. Use of synthetic organic pesticides has increased over forty times since the 1940s, but it is estimated that total elimination of all pesticides would reduce crop, livestock, and forest production by only 25% (Paarlberg 1980:126). Crop losses to pests are approximately the same today as in the 1950s, despite the farmers' perception that chemical use saves them from major crop loss. Though traditional, nonindustrial agriculture has always suffered from grasshopper infestations or other plagues, the multistranded stability of the larger ecosystem made these depredations less frequent or less serious than the vulnerabilities faced by industrial agriculture. In addition, chemical disruption in the current system affects the entire food chain, not just local conditions.

An important characteristic of a highly mobile industrial workforce is the potential to leave farming and move into other economic activities. Especially for farmers or farm owners who have been successful in capital accumulation, there is always an option to sell the farm and use the proceeds in some other business. Under these circumstances, the long-run ecological stability of farm practices can be ignored if they are profitable in the short run. In simplified terms, in industrial agriculture it is possible to have good results from bad practices.

Another example of the disjunction between the welfare of the producer and the product is food quality. Industrial agriculture is famous for the development of the cardboard tomato; chemical contamination of fruits, vegetables, and grains are also accepted by the consumer. It is significant that some farmers who raise hogs or cattle for home consumption will do so differently—using fewer antibiotics or chemicals and different feed—from animals raised for sale.

Even when farmers can perceive the adverse ecological impacts of their land use practices, they may have little incentive or ability to respond. The use of irrigation in the Southwest has grown rapidly, putting pressure on water sources in the region. "Current water use exceeds average stream flows in most of the West's major watersheds, while groundwater is being depleted in many important basins" (LeVeen 1984:62). The mining of aquifers has become a political as well as an agricultural concern in some states. The complexities of federal, state, and local governments and competing economic interests for water make it very difficult for farmers to respond to this depletion of underground water supplies with positive changes to restrict use. In this case, the multistranded economic system makes coordination of many diverse groups necessary to avert ecological disaster.

The case of Western water supplies also illustrates the rapid pace of change in industrial agriculture. Plow or swidden agricultural techniques have also been known to deplete soils, salinate fields, and destabilize ecosystems. But evidence

suggests that such changes occur slowly, giving several generations time to observe and respond. The rapidity of innovation in industrial agriculture has made some ecological disruptions reach a crisis stage in only a few decades.

Technological changes in farming methods may be designed to reduce risk, but may also add to the managerial complexity and economic instability of industrial agriculture. One example comes from animal breeding efforts. New hog varieties have been developed that fatten more efficiently and show more desirable meat/fat characteristics. However, these purebred hogs require greater care than older varieties and are less resistant to diseases and temperature extremes. Southeastern farmers found that hybrid animals lost the ability to make nests to protect themselves and their young from the cold. Expensive housing facilities become necessary, but in turn introduce greater disease problems from animal crowding and waste management. Improved hog breeds produce more offspring per litter, and with good farrowing facilities and management, productivity per sow can be substantially higher than with traditional breeds. But the costs involved are much higher as well, increasing the farmer's financial burden when animals are lost.

The way technology can increase managerial complexity and stress can be seen in the recent increase in the use of irrigation for rowcrops in the Southeast. By removing dependence on rainfall and assuring optimal yields of ground moisture, irrigation boosts yields and reduces risk. The costs of farming are increased sharply, however. Some sophisticated irrigation systems cost over \$100,000 to purchase and install, and electricity or other fuel to operate the pumps adds to annual production expenses. One Georgia farmer reported that it took his centerpivot irrigation system three days to make a full circle and give his fields one and a half inches of water. In a year of poor rainfall, he watered ten times, at a cost of over \$7,000 in fuel. Repairs to the new system cost an additional \$2,000 that year.

Once the decision is made to supplement rainfall, the investment requires continued watering; "You can't turn around—it's like jumping off a cliff," said one farmer. The increase in annual production costs can be particularly damaging in a year of low crop prices. Irrigation can insure a harvest in a moderately dry year, when a farmer dependent on rainfall might suffer a severe loss. But it also keeps production up, preventing prices from rising with drought losses. Farmers in Georgia give mixed reviews of this latest episode in the technology treadmill. It can assure some harvest in a drought, but in a time of low prices, the extra costs of production and the debt load to purchase the system may be the final burden that drives a farmer out of business.

Even on large-scale farming units, technology designed to decrease risk can increase volatility and managerial responsibility. Large-scale tomato growers in California responded to a threatened loss of cheap Mexican harvest labor by turning to mechanization. University researchers had been working for years to develop a machine and an appropriate variety of tomatoes (Friedland and Barton 1975). Machine harvesting destroys the tomato plant and therefore requires uniform flowering and fruit maturation. Ripeness is controlled by spraying ethylene, which induces redness. Each innovation seems to reduce complexity and risk but also increases it. An error in ethylene application, a two-day labor shortage, or a breakdown in a tomato harvester may result in the loss of an entire field (Kramer 1980). Only a proportion of any field can be lost under less highly managed tomato production methods, where plants continue to produce and hand picking continues over several weeks of ripening tomatoes.

Many of these examples of changing on-farm technology have resulted in higher costs of production, and land prices have risen as well. Farmers have responded by borrowing more heavily. The total U.S. farm debt soared from \$6.9 billion in 1950 to \$212.5 billion in 1984. This use of credit puts new pressure on financial performance every year, since a bad harvest and unpaid debts means compounded interest the following year. "Now, you can go broke in one year," said a Canadian potato farmer (Barlett 1987b). Increasing scale of production and the costs of land and equipment are an important factor in many farm bankruptcies.

Changes in family consumption patterns also affect the stability of the farming system. Just as technological changes in farm production methods increase farm costs, commercialization of domestic tasks has fueled a demand for cash incomes. The demonstration effect of elite lifestyles in the mass media also changes farm family consumption goals. With farm specialization, much less food is now produced for home consumption, and farm families spend amounts similar to nonfarm families at the grocery store (Fink 1986). The use of dry cleaners, restaurants, and other businesses reflects the commercialization of household tasks (Craig, Lambert, and Moore 1983). The competitive advantage of family farms has always been the ability to reduce expenditures in bad times. With the change in desire for appliances, vehicles, and other times, farm families are locked into maintenance expenses for electricity and gasoline, as well as the cost of consumer purchases. Changing consumption standards create expenses that reduce the farm family's belt-tightening option and increase the risk involved in normal yield, price, or weather fluctuations.

Farming Strategies and the Evolutionary Outlook

The increasing volatility of the industrial food system exemplifies some of the maladaptive aspects of complex, hierarchically organized biological systems. Rappaport (1979:161–165) describes two important "interlevel conflicts" that commonly emerge: informational distortions to and from the regulatory elite and emergence of dominant special-purpose subsystems. Both maladaptations are clearly present in industrial agriculture as will be discussed below. A third maladaptive aspect of complex, hierarchical systems affects the "worker" level (Adams 1985) and focuses attention on the individual actor level of analysis. Agricultural producers face increasing difficulty in balancing traditional wisdom about the use of resources and farm management with the constraints of an economic and political context of constant innovation and uncertainty. Long-term and shortterm consequences of technological and other changes are both difficult to assess and to reconcile. As feedback to farm managers is clouded, short-term farm sur-

vival as well as the long-term impact on human and natural resources are called into question.

In the first kind of interlevel conflict, the disruption of necessary information flow to regulators at the top of hierarchically organized systems can result in disorders that further harm the homeostatic mechanisms of the system. "The delay, loss, or distortion of information transmitted to system regulators" (Rappaport 1979:161) increases the difficulty in state bureaucracies of correct interpretation of signals and of appropriate response. Bureaucratic bungling, overresponse, or underresponse may rob the system of needed flexibility. The volatility in federal agricultural programs and the uncertain environment created for United States farmers conforms to Rappaport's generalizations. Information to governmental agencies is further distorted by political influences on research agendas and the mass media. Even the agricultural extension service activities that urge seemingly adaptive solutions and farm management philosophies can ultimately increase risk and reduce long-term chances for survival.

Increasing systemic complexity can also result in the emergence of specialized subsystems that seek to promote their own purposes above the purposes of other sectors, including the sectors responsible for regulating them (Rappaport 1979:163). In U.S. agriculture, the industrial differentiation of farm tasks illustrates this pattern. The needs of farm supply companies for technological innovation or market dominance may not serve the long-run survival of the system. "Short-term instrumental goals of high specificity are elevated to the status of enduring fundamental principles'' (Rappaport 1979:165), as these specialized but powerful subsystems degrade basic societal values and replace them with lowerorder principles that serve their own interests. Critics of the industrial food system who point to lack of concern with food security, sustainability, resource depletion, and the distribution of wealth and benefits are responding to precisely this loss of fundamental principles that support long-term system viability (Busch and Lacy 1984; Hightower 1978; Jackson, Berry, and Colman 1984; Kramer 1980; Perelman 1978).

The farm operator is the local-level actor who mediates among the imperatives of farm, family, industry, and state. Though increasingly constrained, the farm family determines the use of resources, the adoption of technology, and the response to changing societal values. Maladaptive decisions on the part of regulators may hurt the larger system but usually will not challege the regulators' elite status or economic security. Farmers must face a situation in which the long-term impacts of each decision are unknowable, but the immediate consequences of farm loss are often all too visible.

Cultural traditions passed down within the family context have provided some guidance for agriculturalists in the industrial system (Bennett 1969; Chibnik 1987; Gladwin 1983; Gladwin and Zabawa 1984; Rogers 1985; Rogers and Salamon 1983; Salamon 1980; Vogt 1955). Salamon (1985) has reported that different European ethnic groups have sustained distinct patterns of farm management and family goals over several generations in the same agricultural zones of Illinois. She distinguishes two general styles: yeoman and entrepreneur. Yeoman groups have continuity in farming as a primary family goal. Steps are taken by parents to assure resources will be adequate for their children to be supported on the farm. Farm operations tend to be smaller, more diversified, and more labor intensive. Yeoman farmers tend to avoid riskier enterprises and high debt. In contrast, the entrepreneurial tradition values individual achievement and business success over farm continuity. Farming is just one accepted avenue to personal accomplishment, and farms are purchased and sold to meet business or income goals more commonly than among yeoman farms. Children sometimes continue entrepreneurial family farms, but usually after proving themselves in independent activities. Parents do not facilitate succession and, in fact, may even see heirs as competitors. Farm operation is more often based on large-scale grain farming, with heavy use of capital and rented land. Entrepreneurs value autonomy and achievement and accept higher-risk strategies as appropriate (Salamon 1985).

In an independent study of farm continuity in the settlement period of Kansas, Flora and Stitz (1985) found two farming orientations that conform to Salamon's Illinois types. Yeoman families were found to be more persistent in county census records, while entrepreneurial families more frequently left farming. Entrepreneurial wheat farmers who successfully remained in the study area adopted more yeomanlike labor intensive methods over time. Recent evidence from Georgia (Barlett 1984, 1987a), from Wisconsin (Salant and Saupe 1986), and from Illinois (Salamon and Davis-Brown 1986) suggests that more conservative yeoman-type strategies may have an advantage in the current U.S. farm crisis. Other researchers have argued that the largest farms are favored in the current slump (Leistritz et al 1985; Tweeten 1984; Buttel 1983). With the constantly changing national and international farm situation, the results of these divergent orientations are not yet clear. Perturbations in the food system and maladaptations that affect farm survival affect the larger industrial economy as well. The health of the banking system, commerce, and rural communities is linked to the results of the current crisis.

The yeoman/entrepreneur dichotomy can be seen in the cultural evolutionary and bioenergetic perspectives of Lotka, Rappaport, and Adams. The yeoman strategy uses less energy and is more oriented toward sustainability. Aspects of it are more like a climactic adaptation than the entrepreneurial strategy, which seems more like a colonizing adaptation to abundant energy resources. The highenergy, capital-intensive, high-risk entrepreneurial style may be interpreted as part of a general societal value orientation towards growth, consumerism, competition, and individualism. This pattern is designed to maximize capital accumulation, though it involves high risk and failure for some who use it. The entrepreneurial style is useful for the global capture of energy, resources, and power. The values are consistent with the goal of global economic and political hegemony (see Knauft, this volume).

Industrial agriculture is not indefinitely sustainable, since its methods use resources faster than they can be replaced. At some point, the system will have to move toward a less energy-intensive, climactic adaptation. It is possible that the current volatility of industrial agriculture is only an early phase in which the costs

of the system begin to be more visible. On the other hand, it is also possible that the increasing number of farm, consumer, and environmental advocacy groups who support varieties of "alternative agriculture" and call for a more sustainable farming system foreshadow a transition period in the near future. If yeoman-type, conservative farm strategies are shown to have an advantage in the current crisis, their survival may presage the ideological and energetic shift toward recognition of a world with resource limits, in which concerns for sustainability and stability play a larger role. If, on the other hand, the entrepreneurial strategy is rewarded under the volatility of the current system, the demise of smaller, more diversified family farms may be seen as an escalation of energy-intensive, capital-intensive trends. It has happened before in biological evolution that short-term conditions of flux can lead to the demise of a lineage that is more viable for a species over the long run.

Further study of the dynamics of farm survival in the United States today will illuminate the trends that will emerge to reorient or reinforce the evolutionary directions of industrial agriculture. Such research will also serve to refine the sophistication with which evolutionary concepts from biology and ecology can be applied to the anthropological study of complex societies and agricultural change.

Notes

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