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The Earth As Transformed by Human Action

Global and Regional Changes in the Biosphere over the Past 300 Years

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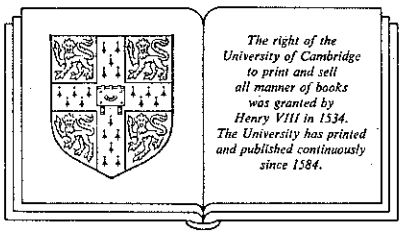

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The Realm of Social Relations: Production, Reproduction, and Gender in Environmental Transformations

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> Whenever [man] plants his foot, the harmonies of nature are turned to discords. . . . Indigenous vegetable and animal species are extirpated and supplanted by others of foreign origin . . . with new and reluctant growth of vegetable forms, and with alien tribes of animals. These intentional changes and substitutions constitute indeed great revolutions.
>
> MARSH (1864: 36)

About halfway through the past 300 years of great population and social change, George Perkins Marsh was able to observe the major environmental transformations of the earth through human action – transformations that have grown increasingly acute. For example, the massive colonization of overseas lands from the seventeenth through the nineteenth centuries by Europeans, accompanied by their livestock, crops, weeds, and diseases, caused *colonial* ecological revolutions in the lands of immigration. Beginning in the eighteenth century, industrialization and drains on Third World resources, both human and physical, accompanied *capitalist* ecological revolutions. Today, as the resource depletion and pollution associated with industrialization continue and as world population increases, doubling about every 30 years, *global* ecological revolution is taking place. These three phases of ecological revolution – colonial, capitalist, and global – involve transformations in the way people interact with their environments.

A number of theories have been proposed to explain the historical processes underlying such human–environment transformations. In this chapter, the strengths and weaknesses of those approaches that focus on the social relations of production, reproduction, and gender are explored briefly. A synthesis of these theories is also offered, using a dialectical approach to explain the three phases or types of ecological revolution of the past 300 years. Ecology, production, reproduction, and ideology are the key themes of this synthesis. Examples are used to illustrate the abstractions, especially drawing upon my own research on the environmental transformation of New England (Merchant 1989).

Theories of ecological transformation can appropriate methods from a number of disciplines or fields of study. The synthesis of these elements, however, should display three characteristics. First, they must be dynamic, to account for change in human-environment relations. Second, they must be able to handle specific and varying environments. Third, they must be able to explain complex changes in cultural wholes. In addition to these characteristics, a complete synthesis should incorporate the roles of science and technology and gender, as well as the elements traditionally included. A theoretical synthesis of this kind is attempted here.

Analytical Frameworks: Revolutions, Structures, and Systems

Kuhn's (1962) concept of paradigm change forms one useful backdrop for a theory of environmental transformations. It views science as both maintaining and revolutionizing human ways of representing the world. Scientific paradigms are structures of thought shared by scientists within which problems are solved. When a sufficient number of anomalies challenges the theory, new paradigms are constructed in a "scientific revolution." In the late 1960s, the "internalist" features of this concept were challenged by a revival of the social history of science that questioned the degree to which the development of science could be independent of economic or social activities (e.g., Basalla 1968), a subject not addressed in Kuhn's original study. Simultaneously, the environmental movement in the western world raised questions about the history and significance of attitudes and behaviors toward nature represented in scientific paradigms (Commoner 1972; Merchant 1980). When elaborated to include society and environment, Kuhn's concept of scientific revolutions can be expanded to one of "ecological revolutions" – of far-reaching changes in economy, society, and thought related to transformations in nature–society relations.

Kuhn argued that when a significant number of unexplainable anomalies accumulated within a long-accepted paradigm of "normal" science that a period of scientific revolution ensued, in which fundamental assumptions were challenged and a new explanatory framework emerged. By analogy, in an ecological revolution a number of external introductions

or internal "contradictions" accumulate in a long-accepted "mode" of interaction between a society and its environment. A period of ecological revolution ensues, in which new nature-society relations emerge. Thus in colonial ecological revolutions a series of external introductions (e.g., biota and pathogens) into a given habitat break down indigenous modes of interacting with nature. In capitalist ecological revolutions internal contradictions (e.g., between land use and inheritance patterns), when combined with market incentives, may propel a society toward the industrial-capitalist mode of interaction. Today, an accumulating set of contradictions within the global capitalist mode of interaction (e.g., the greenhouse effect, ozone depletion, species extinctions, and population growth) may be initiating a global-ecological revolution.

Ecologically sensitive approaches to society-environment interactions draw upon ecology and systems theories as a point of departure. Cultural ecologists have been especially interested in the development of ways to examine human uses of and adaptations to various types of environments, both past and present. Steward's (1955) *Theory of Cultural Change*, with examples drawn from his work on the Shoshone Indians of the Great Plains of North America, dealt with the ways in which traditional societies adapted to such environmental features as topography, climate, and physical resources. In his scheme, technologies, economics, and population size are expressions of these adaptations – products of the interplay of the society with the habitats occupied. Cultural features, such as language, religion, and art were affected too, but could also diffuse from other cultures. Steward's approach worked best for relatively isolated societies characterized by long-term stablilty in both the human and physical realms; conditions of change were found more difficult to treat (Fig. 41.1).

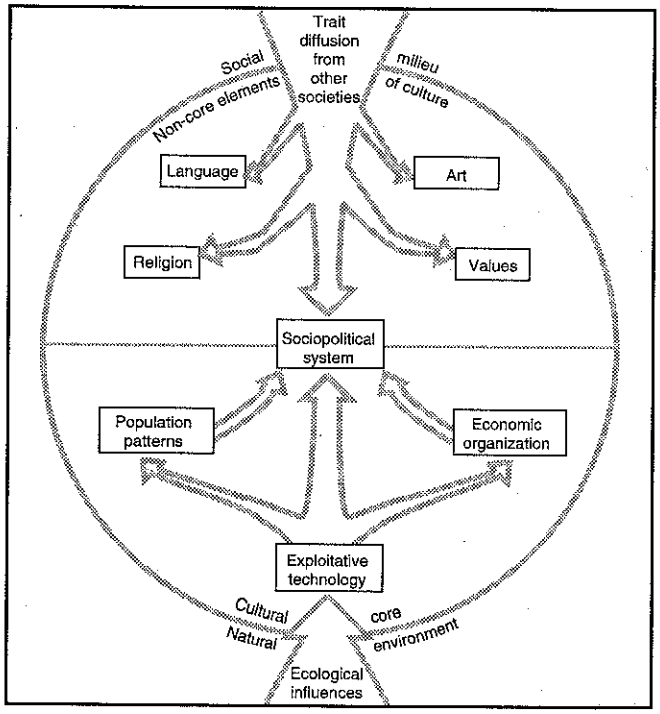

Figure 41.1 The model of cultural ecology. Source: Rambo 1983: 7.

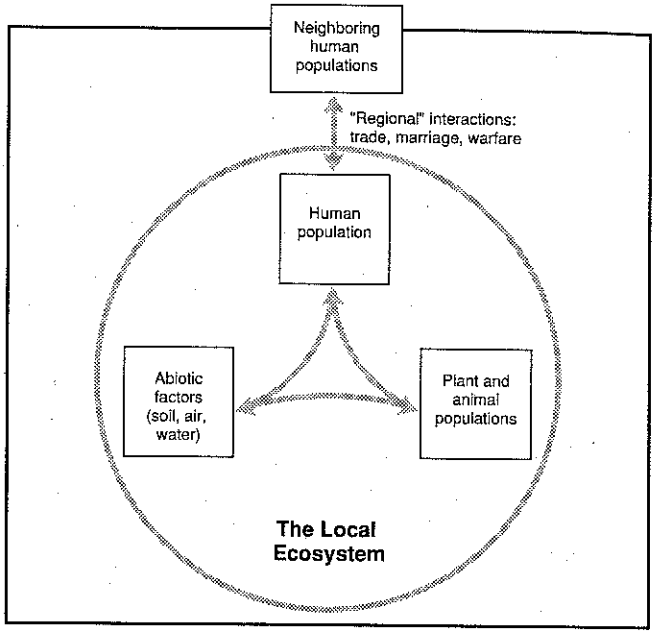

Figure 41.2 The ecosystem-based model of human ecology. Source: Rambo 1983: 14.

Rappaport (1968), drawing on structural-functionalist and ecological concepts, formalized an ecosystem approach that related culture to abiotic and biotic components of the environment as a spatially bounded unit. Cultural attributes were explained by their ecological survival value; even religious and ritualistic features were seen as a product of the ecologically adaptive mechanisms of that survival. His major test of the approach dealt with the Tsembaga of New Guinea, whose ritual warfare around pig populations was explained as a control mechanism to keep the human population in balance with the habitat (Fig. 41.2).

Ellen (1982) reviewed these and other cultural ecology- and ecosystem-based approaches, showing that each represented an advance over earlier ones, but arguing that a holistic approach had yet to be developed. This could be accomplished, according to him, by incorporating a materialist-ecological approach. Ellen's (1978) major example detailed the flow of energy and materials among the Nuaulu of eastern Indonesia, presuming that "[t]he material basis of human existence ... underlies an adequate materialist explanation of human social relations and history of those relations" (Ellen 1982: 122). Organisms within an ecosystem are linked by transfers of energy, according to the laws of thermodynamics and the circulation of materials through biogeochemical cycles. Because of technology, the potential impacts on the environment of attempts by humans to supply energy are increased. This supply of energy allows the population and social formation to reproduce themselves (Ellen 1982: 100–101). Ecological reproduction results from species and population reproduction, whereas economic production creates value in order to reproduce social and economic formations (Ellen 1982: 130).

Rambo (1983), using general systems theory, describes a unified model of human ecology as the interaction of two

open systems – one social and one ecological – that receive inputs and outputs from one another. They exist in a complex, dynamic relationship with multicausal, multidirectional exchanges of energy, material, and information. Each system is open to external influences through diffusion, migration, and colonization. Changes in the system as a whole can be sudden and catastrophic (primary changes) or adaptive and incremental (secondary changes). The social system responds to the choices available to and the decisions of the individual actors, which if "correct," lead to survival and become institutionalized as social norms. Rambo's examples are drawn from studies of deforestation in Southeast Asia (Fig. 41.3). While dynamic in a systems sense, his approach is not well developed to explain environmental history or cultural evolution.

Bennett (1976) has offered an energy-output model that addresses these shortcomings. The ability to extract and transfer energy from the environment, he argues, has led to broad unidirectional trends toward growth. Human actions change situations of equilibrium to disequilibrium because, over the long haul, humans have opted to change the system by seeking new sources of fuel, food, medicines and space, rather than by controlling environmental change and limit population growth. Our present ecological transition is the result of "reducing human labor and hand tools and increasing powered machines" (Bennett 1976:51). In this scheme, historical changes in the nature-society relationships are the result of decisions to increase energy and goods (Fig. 41.4).

While each of these examples is helpful, each has inherent limitations for developing an integrative theory of environmental transformation. First, these approaches do not adequately specify the processes of social change that lead to environmental impacts, and do not account for the power relations that both maintain class structures and lead to social struggles that break them. Second, in discussing human action, they do not account for the inequalities created by class relations, inequalities that do not give all people within any system similar choices, including environmental ones. Third, these approaches assume the unity and structure of systems, perhaps not recognizing that, like the platonic form, a system is nothing more than a conceptual framework with which we interpret the world. Fourth, the use of structural-functionalism in many of these examples leads to approaches

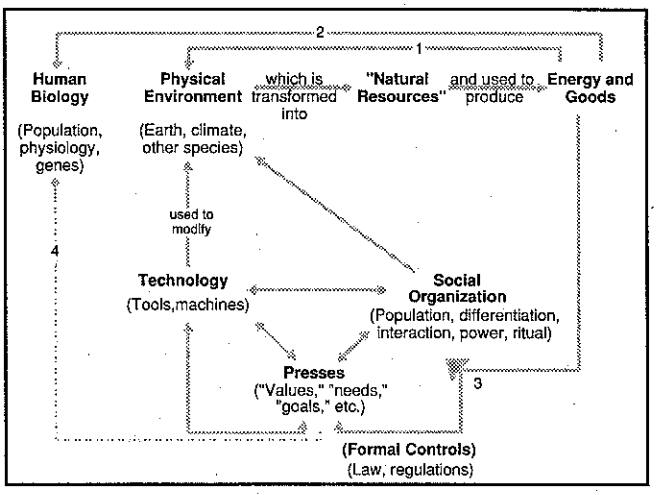

Figure 41.4 A paradigm of human (or cultural) ecology, emphasizing the output function. Source: Bennett 1976: 38.

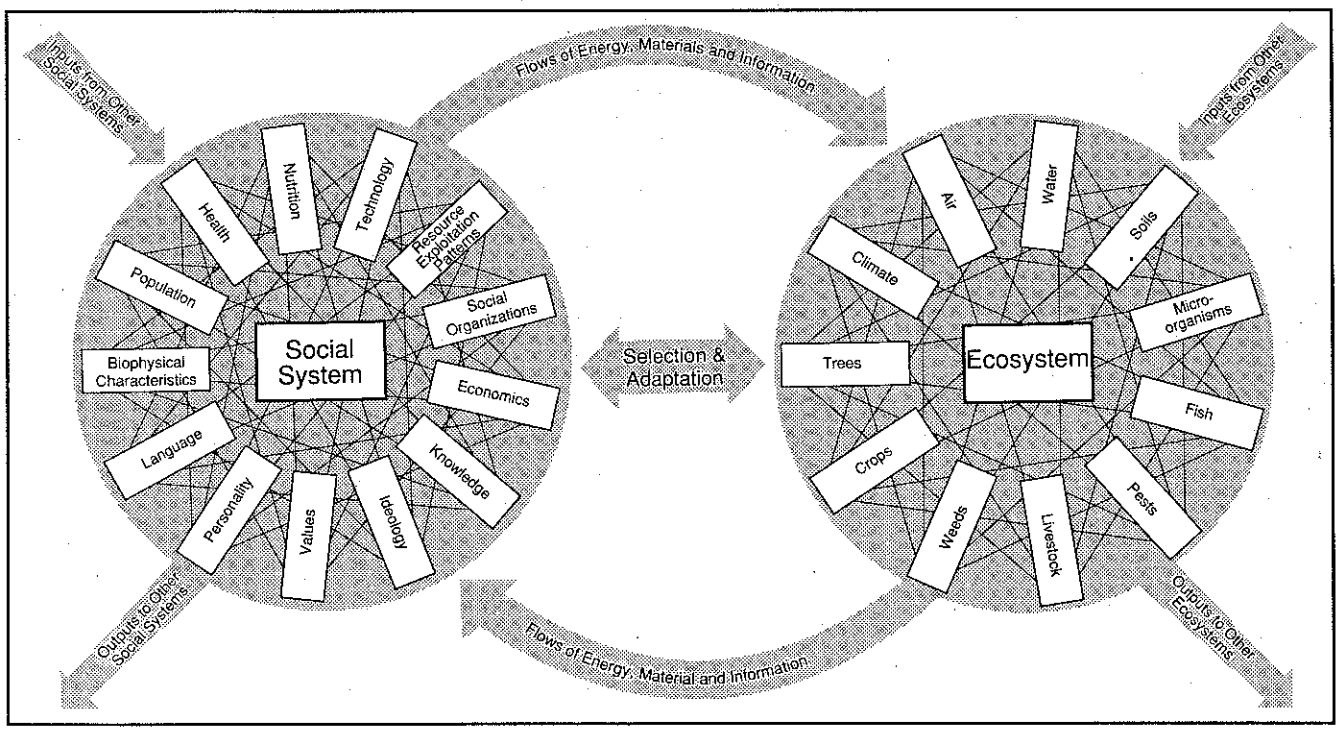

Figure 41.3 Social system-ecosystem interactions. Source: Rambo 1983: 26.

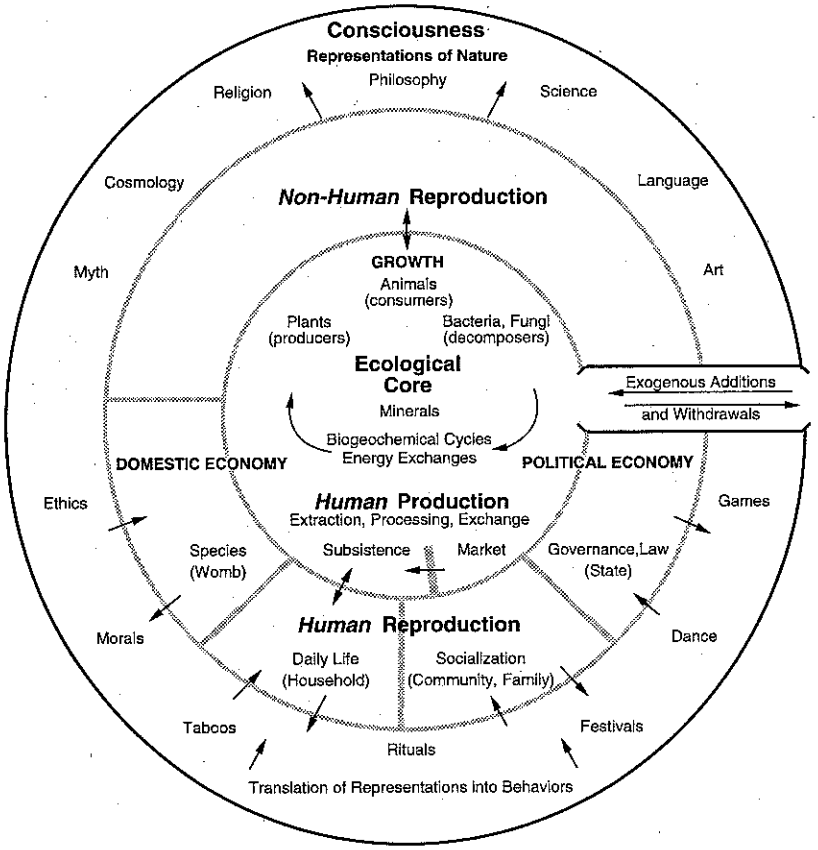

Figure 41.5 Conceptual framework for interpreting ecological transformations. Adapted from Merchant 1987.

that are ahistorical and do not account for the fact that environmental transformations are the product of decisions made in specific social systems and locational settings. Despite these criticisms, these approaches, combined with Kuhn's, serve as a base from which a more comprehensive and historical approach can be distilled. This approach is developed next by a consideration of the significance of the social relations of production, reproduction, and gender (Fig. 41.5).

Ecology and Production

An important contribution to this effort was made by Parsons (1977), who made clear the relevance of Marx's and Engels' insights into human–environment interactions, as well as the problems raised by their concept of the domination of nature through science and technology. Engels was especially sensitive to the ecological impacts of production. "There [was] devilishly little left of 'nature' at the time when Germanic peoples immigrated into it," he observed in 1878 (quoted in Parsons 1977: 141). Human activity continued to change the landscape, often with unforeseen side-effects for the production of subsistence. Nevertheless, it was only by continually increasing human control over natural processes by new modes of production that humanity could realize "true freedom." "The conditions of existence forming man's environment, which up to now have dominated man, at this point pass under the dominion and control of man, who now for the first time becomes the real conscious master of Nature" (Parsons 1977: 141). The individual's control over the production process was the passage to human freedom; the domination of nature through science and technology offered the possibility of liberation from nature.

Marx and Engels were criticized during the 1970s for their advocacy of the domination of nature. Neo-Marxists, such as Herbert Marcuse, instead treated nature as an equal but opposing partner, while Marxist ecologists, such as Commoner (1971), argued that human production must operate with the limits of the laws of ecology and that science and technology must create sustainable relations with nature. Production and ecology are, in this view, the same, rather than hierarchically different, levels, changing the domination of nature to a relation of creative reciprocity between humans and the nonhuman world (Fig. 41.5).

Despite this concern, Marx's and Engels' concept of the inherent activity of nature is valuable for a theory of environmental transformations because it offers the possibility of making nature an actor on the stage of history – internally dynamic and responsive to human actions. In asserting the activity of nature as flux, tension, impulse, and change, Marx and Engels opposed their own dialectical materialism to mechanical (or metaphysical) materialism. The mechanistic science that had arisen in the seventeenth century analyzed

nature as a collection of parts that were rearranged through the action of external forces. But this "... habit of observing natural objects and natural processes in their isolation," complained Engels, "detached [them] from the whole vast interconnection of things." It presented them "... not in their motion, but in their repose; not as essentially changing, but as fixed constants; not in their life, but in their death" (Parsons 1977: 130). The dialectic, in contrast, asserts the primacy of change over parts, of context over isolation, of internal dynamism over passivity. Out of conflicts and tensions within nature, new material combinations are formed. Causality is not linear and unidirectional, but reversible. "Causes and effects are constantly changing places, and what is now or here an effect becomes there and then a cause, and vice versa. ... Nature is the test of dialectics ... and in the last analysis Nature's process is dialectical and not metaphysical" (Parsons 1977: 131).

The mechanistic approach to nature can often lead to, for example, engineered structures such as factories that employ wage laborers and high-rise office buildings that house corporate managers that operate in isolation from their surroundings and are geared toward maximization of profits. The impact of effluents and pollutants on air, water, and humans is not integrated into factory design, and the impact of polluted, recirculated air on human health is not part of the office-planning process. The dialectical approach proposed here would start with the human – environment interaction as primary and would construct work and home places that sustain both human and environmental life.

In the Marxian view, humans express their "species being" in the activity of production. The mode of production, or economic base of the multileveled social formation, consists of the forces of production and the relations of production. The forces of production are the technologies and labor processes by which humans extract livelihoods from nature. The relations of production are human-to-human interactions, such as cooperation or exploitation. At a level once removed from the economic base of the social formation is the superstructure – the political–legal and ideological–symbolic structures. They are the human institutions and the forms of consciousness that are generated historically with the mode of production and function to support and maintain it. Economic revolution takes place when the forces of production conflict with the relations of production. The products are new ideologies and new forms of consciousness that support the new power relations of production (Marx 1968: preface).

This view offers a multitiered, dynamic approach to both history and ecology in which uneven development and major upheaval are more critical than continuous evolution. Periods of social transformation are explained as revolutions in modes of production, as in the transition from feudalism to capitalism in western Europe. By analogy, ecological revolutions can be characterized as fundamental changes in human–environment relations, in large part generated by such social changes.

Carr's (1977) study of the pastoral Dasanetch of Ethiopia demonstrates the utility of this framework for explaining ecological relationships. She identifies four major habitats used by the Dasanetch: plains, riverine lands, delta, and mesic lands. The pastoralists used them for stock rearing, horticulture, fishing, hunting and gathering, and settlement (their village is moved seasonally). This environmental–economic fabric was influenced by such "exogenous" factors as the flow of the Omo River and exchanges with other tribes.

This component-systems framework is analyzed by way of modes of production, defined as "... a recognizable set of relations (among producers and the means of production) of economic production and distribution of goods and services" (Carr 1977:237). To survive, the group needed not only to produce its means of subsistence, but additionally to reproduce the conditions that allow survival. The associated environmental and social complexes were both essential to the reproduction of the mode of production. The reproduction of the economic base "depends upon the social formation or society as a whole and the environment as a whole" (Carr 1977: 244). Therefore, the social arrangement of the Dasanetch was fundamental to its economic base and, ultimately, to the manner in which the Dasanetch perceived, used, and transformed their environment.

Carr's work on the synthesis of ecological ideas and Marxist concepts, some of which is under revision (C. Carr, personal communication), provides a starting point for the development of a more dynamic nature–society approach. First of all, this new formulation must not assume that change is even over time, for periods of slow evolutionary development may be punctuated by periods of major transformation in human–environment relationships. For example, Crosby's (1986) "ecological imperialism" identifies the sudden and dramatic changes wrought by associations of biota, pathogens, and people as introduced by European colonization of the world. Second, a means of relating human-induced transformations of the environment to other so-called revolutions in human history is needed. Examples include those associated with the scientific revolution of the sixteenth and seventeenth centuries (Merchant 1980), the industrial or capitalist revolutions in Europe and America in the eighteenth and nineteenth centuries, the introduction of western capitalism into the so-called Third World in the nineteenth and twentieth centuries, and long-term but regionally specific transformations from hunting–gathering to agricultural economies. Third, the formulation must be able to handle climatic and other "physical" changes that can trigger new human responses. Thus environmental devastations caused by natural catastrophes such as droughts, hurricanes, volcanos, and insect plagues, or by human induced crises such as wars, dam failures, or nuclear-power-plant accidents may lead to major reorganizations in society–environment interactions.

Environmental transformations with the characteristics just described are illustrated in several of the case studies in this volume and in the story of New England. Until the colonization of New England in the seventeenth century, Amerindians there were characterized by two broad modes of production: the gathering-hunting-fishing tribes of the north (today's Maine, New Hampshire, and Vermont) and the tribes to the south (Massachusetts, Connecticut, and Rhode Island), which added horticulture. Their ecological relations

were initially disrupted by colonial settlers, who took heavy tolls on beaver and other animals for the fur trade and on forest habitats for wood products. The introduction of livestock, cultigens, weeds, and disease altered the land uses among the Indians and lowered their population numbers. The activities of the settlers were stimulated not only by the desire for land for subsistence but by their involvement in mercantile exchange (Cronon 1983; Merchant 1989) – issues of production, and, as shall be shown, reproduction. These changes constituted what I have called the colonial ecological revolution.

The economic transition to industrial capitalism in the nineteenth century, in part fueled by the availability of a wage-labor force of landless sons, single women, and immigrants, further altered the trajectory of ecological change in New England. Large dams for textile and iron mills halted the flow of migrating fish, and dyes and sewage polluted streams. Portable sawmills penetrated forests distant from navigable rivers, and railroads brought markets ever closer to the inland farmer. By midcentury, much of New England's forest had been lost to lumbering and farming. Again, the degree of ecological change exceeded what the subsistence of the population required; the economics of accumulation accounted for much of it.

The shift to global capitalism in twentieth-century New England has altered many of these transformations, even reversing some. Many of the mills are gone and agriculture is largely confined to dairying. As a result, the forests have returned. The subsistence of the region is now virtually all imported, making the region vulnerable to price and production fluctuations from afar. Outside the vast urban and suburban buildup of New England, which creates major problems of water supply and waste disposal, much improvement has occurred in the quality of once-degraded lakes, ponds, wetlands, and woodlands – features now critical to the quality of life that is expected by the inhabitants. The environments of New England today reflect an economy that does not rely on local production of food and fuel. But new problems have emerged. Acid precipitation now drifts from the industry of the Ohio River Valley, threatening the life of the regenerated forests of the region (Reidel 1982). Beyond New England and at a global scale, this international economy has propelled us into a global environmental transformation, the subject of this volume.

Reproduction and Gender

The relationships between production and ecology alone are insufficient to explain the complexities of decisions that drive environmental transformations. Issues arising from population changes, gender patterns, and political considerations also must be incorporated into the framework to understand fully those driving forces. One such attempt has been made by Harris (1980), who criticized Marx's system for not including a distinct "mode of reproduction." He reorganized Marx's economic base (mode of production) and superstructure (legal-political and ideological) into three levels: infrastructure, social structure, and superstructure. He divided the infrastructure into modes of production and reproduction, the social structure into domestic or household economy and political economy, and the superstructure into behavior and ideology.

The mode of reproduction consisted of the technologies and sexual practices that maintained, limited, or increased human population. The latter was added to deal explicitly with issues of population pressures on land and production, as well as with their effects on social structures and ideologies. Why has global population increased over time? Why have some groups grown in numbers and others not? Harris argues that for most of human history people have used an array of malign techniques, such as senilicide, infanticide, killing female infants, assaults against pregnant women, and clitoridectomies as well as benign techniques, such as coitus interruptus, incest taboos, and delayed marriages, to control population growth, maintain high levels of subsistence, and conserve resources. Therefore, the mode of reproduction was fundamental to environmental transformations as it controlled population growth.

One step removed from direct interaction with the environment was social structure, and twice removed was the superstructure. These, in Harris's model, played the roles of maintaining and conserving the system as a whole. Changes in the infrastructure – major transformations in modes of production or reproduction – carried with them a high probability of changing the entire three-tiered system, whereas changes in the superstructure merely weakened resistance to this change. Harris's principle of cultural materialism asserted, then, that modes of production and reproduction *probablistically* determined the domestic political economy, which in turn, *probablistically* determined the behavioral and mental superstructures.

Cultural materialism is helpful for our synthesis for several reasons. Unlike systems models, it allows for historical weighting of the levels of the three-tiered system with respect to the immediacy of their impact on the environment and their roles in both change and legitimation. Thus humans using bulldozers and chain saws in land-clearing have a more immediate impact on the environment than do legislators formulating environmental policies. Policies must be translated from paper guidelines to physical behaviors before the environment experiences a change. Secondly, cultural materialism accepts a material basis for the physical world and culture, removing some of the problems associated with more abstract approaches. Thirdly, it specifically introduces population pressure and reproductive behavior as a problem for analysis and elaboration.

This approach, however, has been criticized on several grounds. Harris's view of population pressure has been seen as too close to "vulgar Malthusianism." That is, population growth in Harris's model is linked to genetic behavior – an abstract biological drive independent of cultural norms – and his controlling mechanisms are too simplistic and deterministic (e.g., Sahlins 1978). Further, if infrastructure gives rise to social structures, why do different social structures exist in technologically similar environments? Actual historical transformations are not explained, whereas too much emphasis is placed on the material conditions of a technology, such as

irrigation, rather than on the social relations, such as the state bureaucracy (Friedman 1974).

Meillassoux (1981) expanded the Marxist meaning of reproduction as both biological and *social*. Here, the production and exchange of human energy is the key to reproduction, both intra- and intergenerational. Human energy, according to Meillassoux (1981: 50), is an advance over the Marxist concept of labor because "[it] covers all the energy produced by the metabolic effects of foodstuffs on the human organism. . . . Labor-power is only that fraction of human energy with exchange-value." In gathering, hunting, and fishing economies, the return from the land is instant food converted to human energy. In contrast, agrarian economies usually involve a period of nonfood production, in which accumulated food stores are consumed for energy, although this seasonality is absent in some parts of the tropics. Stored foods allow a lag between production and consumption, and during noncultivation periods energy is expended toward reproduction of the social relations within and between domestic communities. "It is evident that reproduction is the dominant preoccupation of these societies. All their institutions are organized to this purpose" (Meillassoux 1981: 38).

This energy circulates in the form of material products, and enough surplus product must be stored over time to allow reproduction. Poor harvest or extraction of surplus will stymie demographic growth. Only after the community maintains and reproduces its own subsistence can demographic growth or commercial development take place. In agrarian societies, production for use dominates, thus sustaining biological reproduction. The community as a reproducing unit is maintained by social reproduction. "The process of reproduction in the domestic community is achieved by means of very long-term commitments (vows, engagement, marriage, dowry, etc.)" (Meillassoux 1981: 39). These juridical structures result from the requirements of production and serve to perpetuate them.

Female exploitation, according to Meillassoux, is heightened in agrarian communities because women are necessary both for the conversion of the agricultural product into food and for procreation. As biological reproducers, women circulate either by forcible abduction by a neighboring community or peaceably through marriage. In either case, a woman is subordinate in juridical reproduction. Her value begins at puberty, when she becomes capable of bearing children; continues through motherhood, as the reproducer of social norms; and ends after menopause, unless she temporarily perpetuates the line of descent and property inheritance as a widow. Thus, women "are hidden behind men, behind fathers, brothers and/or husbands" (Meillassoux 1981: 75).

This approach, then, allows one to move from *gender relations* to reproduction to population and its impact on the environment. To date, however, these linkages have not been made, and Meillassoux's view of gender relations has been challenged by feminists for its assumption that female subordination is a given rather than a problem. In writing the history of environmental transformations, sensitivity to such issues can show that women are actors in their own societies, rather than passive receivers of patriarchy (Mackintosh 1977; O'Laughlin 1977), and that their decisions are important to the ultimate human–environment relationship.

Environmental transformation can be linked to biological reproduction, which is linked to social reproduction. The last-named raises issues about socialization and politics. Giddens (1979) has developed a theory of the interaction between social structures and human agents that incorporates these factors. Socialization is an integral part of social reproduction and is institutionalized in three ways: interactions among people that take place daily, over lifespans, and over historic time spans. It involves a familiar repetition of practices in familiar settings (including the physical environment) by human agents. Socialization involves both the individual and the group, and the perceptions of both are continually transforming interpretations of their surroundings as they themselves are being transformed. Unfortunately for our purposes here, Giddens does not directly link socialization to environmental change. An example can be drawn from colonial New England. Boys were socialized by their fathers to assist in barn and field work, girls by their mothers to help in dairy, poultry, and textile production. Environmental impacts in each case were mediated by colonial farming practices – thus the male practice of grazing cattle and pigs in tillage plots after harvest added manure to the soil, while the female practice of tending poultry in orchards and gardens kept down insect pests and added manure. Socialization changed under capitalism. Young men were schooled in human intensive techniques of soil management and in agricultural specialization, including dairying and poultry raising, whereas young women worked in textile mills or were taught to emphasize indoor domestic work.

Peterson (1984) provides the rudiments for adding politics to social reproduction. In capitalist societies, the division of labor between sexes results in a situation in which men are responsible for and dominate the production of exchange commodities, and women are responsible for reproducing the work force and social relations. In this form of patriarchy, reproduction is subordinate to production. Peterson (1984: 6) argued that ". . . women's responsibilities for reproduction includes both the biological reproduction of the species (integenerational) and the intragenerational reproduction of the work force through unpaid labor in the home. Here too is included the reproduction of social relations – socialization." A taxonomy of this followed: issues related to the interests of (1) intergenerational reproduction, (2) intragenerational reproduction in the family and (3) in the public sector, and (4) reproduction workers (women) – the so-called women's liberation issues.

This taxonomy has been applied to issues of the environment through an examination of the politics of reproduction in the Swedish environmental movement (Peterson and Merchant 1986:472–74). Women's political involvement in biological reproduction is exemplified in their concern over radioactive damage to their reproductive organs and to children, leading to heightened activity in antinuclear campaigns. For example, 43% of Swedish women in contrast to only 21% of the men opposed the use of nuclear power in a

1980 national referendum on the subject. Women's political involvement in family reproduction is exemplified in improving the quality of food, clothing, and shelter for the family, opposing the use of pesticides and herbicides, and encouraging the use of cooperatives based on sustainable agriculture and the equitable distribution of food products. With respect to reproduction in the public sector, they protested changes that threatened their roles in reproducing the social system of the welfare state and the quality of the care provided. Finally, as reproduction workers, they are concerned about bringing more women into the environmental–science professions and about developing alternatives to the domination of nature through technology.

Peterson's taxonomy can be fused with the ideas of Meillassoux to apply to all types of political economies. A *sphere of reproduction* can be defined as having two biological and two social manifestations: (1) intergenerational reproduction of the species, and (2) intragenerational reproduction of daily life, (3) the reproduction of social norms within the family and community, and (4) of laws and politics within the public sector (Fig. 41.5). These manifestations can be linked directly to the physical environment. Biological reproduction and the social forces that maintain, limit, or increase population operate at a level once removed from immediate impact on the environment and are mediated by the production process. The legal–political framework that helps to reproduce and maintain the production systems is also on a level removed from immediate environmental impact. The reproduction of daily life and social norms are an integral part of production in precapitalist economies, but are separate from production in capitalist and socialist economies. Reproduction in this fourfold scheme is, therefore, one step removed from immediate interaction with the physical environment for most contemporary situations. Because the impacts of reproduction are mediated by production, environmental effects will differ in different types of economy.

The New England example illustrates the linkage between these four manifestations of reproduction and gender and human-environment relationships (Merchant 1989). About 300 years ago, New England's Indians were involved in production for the sake of reproducing the tribal whole. Gender roles and reproduction practices within the society maintained a population commensurate with the limits of the production–environment relationship. In the northern gathering, hunting, and fishing tribes, population was apparently limited to the technology–environment capacity of about 11,900 persons – a density of about 0.2 person/km^2; in contrast, the southern agricultural tribes supported some 65,000 individuals, or 2/km^2. The environmental impacts were obvious; a long-term sustainable system in which much more forest was cut at any one time in the south than in the north.

This situation changed with the arrival of the Europeans. Very rapidly, mercantile capitalism and private farming developed in association with an intergenerational reproduction dedicated to an expanding population for labor. Social and religious norms and legal–political frameworks developed to support this purpose. The seventeenth and eighteenth centuries witnessed, therefore, considerable land-use changes and deforestation throughout the region. The nineteenth-century move to full-scale capitalism elaborated most of these trends, but also included water pollution, natural-resource management, and agricultural improvement. The twentieth century has witnessed major adjustments in gender and reproduction, as the global capitalist system no longer required large amounts of labor in the region; the related transformations of the environment are well known and already were discussed.

The key point here is that reproduction, interpreted as both biological and social, contributes to an understanding of how mechanisms once removed from the human–environment interface are critical to an understanding of how society and culture establish the means to sustain or change that interface.

Production and Reproduction in Tension

Given these explanatory categories of production, reproduction, and gender, what are the dynamics that drive change over time? Environmental transformations may be viewed as the results of interactions between a society's ecology and production and between its modes of production and reproduction. Marx and Engels discussed the reproduction of human beings as distinct from, but dialectically related to, the mode of production. As Engels (Parsons 1977) noted: "The determining factor in history is, in the last resort, the production and reproduction of immediate life . . . this itself is of a twofold character: on the one hand, the production of the means of subsistence . . . on the other, the production of human beings themselves." It follows from this point that population pressure on the environment is mediated by production. This view is not to be confused with Malthus's ([1798] 1986: chap 2) argument that population presses directly on the land because it has the capacity to grow faster than the technological ability to produce food. Marx and Engels argued that population presses on the land only through the mode of production, which involves much more than the mere technology of food production as detailed earlier. They showed how changes in these modes resulted in changes in the means of production and the overall social order, and how they led to differential adjustment by class. Marx and Engels believed that it was vital to understand the forces that drive technological change and to translate them into social conduct in order to understand nature–society relationships.

Again colonial New England provides an example. Because labor was scarce and land plentiful, a low person/land ratio existed. Hence, each family had to reproduce its own labor force, and population grew rapidly during the seventeenth and eighteenth centuries. Industrialization ultimately helped to bring about a demographic transition to smaller families, as children ceased to be an economic asset. In Sturbridge, Massachusetts, for instance, women marrying between 1730 and 1759 bore an average of 8.8 children, whereas those marrying between 1820 and 1839 bore an average of 5.3 children (Osterud and Fulton 1976). Nationwide, women who

married in 1800 bore an average of 6.4 children, but in 1849 the figure was 4.9 children and in 1879 it was 2.8 children (Wells 1985). This demographic transition was aided by social-religious controls and the flow of information about a large number of family-planning practices (Mohr 1978).

Such gender relations of production and reproduction can be made dynamic and transformative, as shown by socialist–feminist scholarship. Bridenthal (1976) contends that changes in production give rise to changes in reproduction, creating tensions between them. For example, in colonial agrarian New England, production and reproduction were symbiotic (Bridenthal 1976; Merchant 1989). Women participated in both; children were socialized at home. But with the rise of industrial capitalism, production moved out of the home, and farms became specialized and mechanized. The symbiosis was broken. Unmarried women were employed outside the home, whereas married women remained within it. Thus, production became more public and reproduction more private, leading to their social and structural separation. The reproduction of daily life and the reproduction of social norms came into tension with the sphere of production – they separated under capitalism.

The rise of industrial capitalism also fueled tensions between intergenerational and legal–political reproduction and the sphere of production. Again we draw on examples from colonial New England. Inland farms had developed in a subsistence mode and required the reproduction of their own labor. Inheritance, however, tended to leave some sons without land, who became a general labor force. Hence, the tensions between farm-labor needs (production) and the juridical system (reproduction) created the needed labor for the transition to capitalist agriculture. The commercial boom of the 1790s and the interlinked transportation and market revolutions of the early nineteenth century made use of this labor pool to expand production, increasing marketable surplusses.

These shifts, of course, ultimately link to the way in which New England's rural landscape was used, creating a second dialectic in the relations between production and ecology (Merchant 1989). The colonial ecological revolution had introduced both the mercantile economy of the coast and the subsistence economy of the inland towns. Settlers used slash-and-burn agriculture that depleted soil fertility, requiring continual forest clearance for new plots. Old plots were seeded for pasture before they reverted to forest. The landscape was a mosaic of small fields within forests, polycultures, forests and stubble burning, and upland pastures. These methods reduced pest problems and helped to restore potassium in the tilled soils through pasturing cattle in the seeded meadows. With the move, however, to a capitalist agriculture, farmers increased their hectarage under cultivation, dramatically reducing forest cover. Although fertilizers helped to restore worn tillage, pasture quality deteriorated with the transfer of manure to hay production. With industrialization of textile production, sheep grazing increased, contributing further to pasture deterioration, while textile mills and dams polluted rivers with dyes and interfered with fish spawning. These changes, among others, constituted the "capitalist ecological" revolution, a 75-year period between the American Revolution and 1850.

Today a global ecological revolution may be occurring that may also be interpreted in the light of tensions between ecology and production and between reproduction and production. The new global economy, for example, transfers resource extraction to poorly developed regions with rapid population growth – regions in which domestic production conflicts with global market production. This is witnessed in the need for large farm families – as described for early colonial New England – a need now undertaken in a context of improved medical technology and leading to population increases. This population, in turn, provides both a demand and a cheap labor supply that fuels expanded production and contributes to environmental problems – the very ones documented in case studies dealing with the Gangetic Plain, Amazonia, Borneo, Nigeria, and the East African Highlands.

Science and Ideology

Ecological transformations are accompanied not only by major changes in the relationships of ecology, production, and reproduction, but also in the ways in which people perceive and represent the natural world through ideas such as science, myth, and religion (Fig. 41.5; see also Chap. 40). Social historians of science have focused on external causes for the rise of scientific ideas and on science as an ideological legitimation of the existing social order (Basalla 1968). Science – along with mythology, cosmology, religion, philosophy, language, and art – symbolizes nonhuman nature and legitimates particular human behaviors toward it. Science and ideology are socially mediated through ethics, morals, taboos, rituals, festivals, and games. Scientific, philosophical, and literary texts are sources of the ideas, symbols, and attitudes of the elite; the rituals and festivals of popular culture provide clues to those of the nonarticulate. These ideas, symbols, and other representations of reality are at a level twice removed from immediate impact on the environment (following Harris's superstructure).

How are ideas translated into ethics and behaviors that affect the environment? Berger and Luckmann (1966) argue that symbolic universes mediate between conceptual universes and social reality. Societies are influenced by symbols in which ideas are embedded (see chap. 40). Additionally, scientific descriptions of nature contain norms, or prescriptions for action. Cavell (1971) holds that normative meanings are contained within statements of existence – that is, "ought" and "is" are not separable. For example, the description of nature as a vast machine made of atomic parts facilitates the development of an ethic that people can manage, manipulate, and repair the environment, just as a mechanic repairs machines (Merchant 1980). Geertz (1973) argues that religious beliefs establish powerful moods and motivations that translate into social behavior. The New England Puritans' belief in success as an index to predestined salvation implied a life of hard work that resulted in clearing and "improving" the land through agriculture and artifact. Through symbols, norms, and religious beliefs, the sphere of ideas

interacts with behaviors in the spheres of reproduction and production.

An environmental transformation may be accompanied by changes in the dominant ideology or world view for particular societies. Taylor (1973) holds that ideological frameworks "secrete" norms; intellectual frameworks give rise to a certain range of normative variations. When sufficiently powerful, frameworks can override social changes, and if weak or weakened, they themselves can be overridden. For example, the Puritans had a religious view–a transcendent God who preordained salvation – that held their communities together. But this view came into conflict with the needs of the new economy that emerged in the region; the fundamental changes were sufficient to weaken this world view, and it was supplanted by others.

The ideological superstructure both legitimates the levels of production and reproduction through ethical and power relations and responds to ecological, economic, social, and political changes. Even the forms of consciousness through which humans represent and interpret nonhuman nature may change. During the colonial ecological revolution, vision became dominant among the other senses. Daily life for most settlers was guided by imitative, oral, face-to-face transactions, but Puritans emphasized a transcendent God who sent down word in written form. Protestants learned to read so that they could interpret God's word for themselves. In turn, interpretations of the biblical word legitimated land clearing, "improvement" of the wilderness, and "civilization" of the Indians. The fur trader, lumber merchant, and banker viewed nature as a resource and commodity. Such changes from Puritan farmer to merchant-trader were part of the colonial ecological revolution.

Ideological frameworks are more than the ideas of controlling elites, however. They are also power structures. For example, shifts in scientific paradigms have at stake power over society and nature, as argued by Haraway (1983), because they are contests for power over the terms of the argument. Foucault (1980) has linked power, knowledge, and space in this manner. According to him, increasing power over space devalues and deadens it. Whereas space "used to belong to nature," when mapped by explorers and cartographers, catalogued and inventoried by traders and naturalists, and coded by militarists and computer scientists, it is controlled by an "eye of power" and subjected to unlimited surveillance. Foucault's model of the Panopticon of Jeremy Bentham, in which an entire prison can be surveyed from a single central tower by an overseer, translates to the concept of a cultural overseer. All things are made visible through the dominating, overseeing scrutiny that controls not only social institutions, such as schools, hospitals, and prisons, but also nature, resources, national parks, wild rivers, endangered whales, herds of wild antelope, migrating warblers, and indeed the "whole earth" itself through satellite surveillance (Associated Press 1985). The history of the "eye of power" over nature becomes a history of spaces, spatial arrangements, spatial metaphors (site, field, habitat, soil, and so on), strategies of control, and modes of mapping, tabulation, recording, classification, demarcation, and ordering.

The rise of mechanistic, quantitative consciousness is an ideological feature of the capitalist ecological revolution. The relations in this system emphasize efficient management and control of nature. With the development of Newtonian science and the use of perspective diagrams, the dominance of vision in the colonial era was integrated with numbering. The eye of empiricism and the disembodied mind's eye conspired to focus attention on the study of natural objects. The printing press and the rise of perspective art linked the mental to the material through what Latour (1986) calls "immutable mobiles." These mobiles are reductions of three-dimensional natural objects, such as stars, birds, rocks, and bones, to two-dimensional inscriptions, such as drawings, diagrams, lists, graphs, curves, texts, and archives. The latter allow the subject to be circulated unchanged among researchers, accumulated, arrayed in a single laboratory, superimposed, compared, and reconstructed as natural order. "The result is that we can work on paper with rulers and numbers, but still manipulate three-dimensional objects 'out there'. . . . Distant or foreign places and times [can] be gathered in one place in a form that allows all the places and times to be presented at once" (Latour 1986:29). The visual and material thus combine to produce power over nature through science.

A global ecological revolution is developing that may again alter our consciousness toward nature. This view has been stimulated not only by the warnings by the numerous "alternative" scientists concerned about a sustainable biosphere, but also by the apparent "actions" of nature to the long-term impacts of the capitalist ecological condition. These actions are well-known and are now having immediate impact on the people of the world as the almost weekly lead stories of national magazines in 1988 testify – the ozone hole over Antarctica, the impending "greenhouse effect," acid rain, and the unusable bays and shorelines of North America. One perspective argues that the global ecological revolution requires more than environmental reform. It requires a fundamental transformation in western epistemology, ontology, and ethics – a change from a mechanistic to an ecological consciousness rooted in species equality, appropriate technology, recycling, and bioregions (Devall and Sessions 1984).

This pending revolution has also been heralded by a spectrum of new sciences infused with assumptions based on nature's inherent activity, self-organization, permeable boundaries, and resilience. The Gaia hypothesis of Lovelock (1979) proposes that the earth's biota as a whole maintain an optimal chemical composition within the atmosphere and oceans that supports its life. The thermodynamics of Prigogine (Prigogine and Stengers 1984) contrasts the equilibrium and near-equilibrium dynamics of closed, isolated physical systems so common in the mechanistic model with open ecological and social systems, in which matter and energy are being exchanged constantly with their surroundings. The new physics of Bohm (1980) contrasts the older mechanistic picture of atomic fragmentation with a new philosophy of wholeness expressed in the unfolding and enfolding of moments within a "holomovement" – that is, process has primacy over parts. Chaos theory offers tools for describing complexity and turbulence, with the idea that nature as

an actor offers surprises and catastrophes that cannot be predicted by linear equations and mechanistic descriptions (Gleick 1987).

Recognizing nature as an actor on the historical stage helps to show the instability of the "nature" that underlies many of science's major assumptions. Bird (1987) argues that science is actually engaged with "nature" in a process of negotiation for what counts as reality. Science does not achieve paradigmatic representations of a pristine nature behind human alterations of it, but engages with it in an ongoing historical process of negotiating representations of reality. These realities change over time, both materially (in that nature creates new species and ecological arrangements) and metaphorically (in that human images of it change). Humans transform nature through such activities as colonial additions and withdrawals of species, through industrial development of insecticides that creates mutant insects, or through genetic engineering of new bacteria. Humans thus alter the ecological webs in which they are embedded. Nature accommodates to these changes by adaptation and resilience or creates through mutation and evolution. Nature is, then, an actor both in the sense of a personified mother in precapitalist constructions or as in laws of ecology in modern constructions. It (she) engages with science by offering natural–technical objects prior to observation and experimentation and by resisting or accommodating to technological applications of laboratory "truths." Science is thus both a social negotiation for meaning, theory, and paradigm, and a political negotiation for power over what realities are to be seen and what metaphors may be used to describe them.

Summary

The concepts of ecology, production, reproduction, and ideology, together with their structural and dialectical relationships, help to illuminate the ways in which societies transform their environment over time and in turn are transformed by environmental change. Where human-environment transformations in specific habitats are relatively rapid (perhaps 50–100 years) and uneven, as in European colonial expansion or in change from agrarian to capitalist development, ecological revolutions – changes at all three structural levels – may be identified. Through dialectical interactions between a society's form of production and its local ecology and between its spheres of production and reproduction, its dominant world view and forms of consciousness are undermined and replaced. New forms of production, reproduction, and ideology arise that hold a culture together for another period of time. These themes must be understood if we are to understand adequately the transformation of the biosphere by human action.

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