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Critical Essay

DIALECTICAL MATERIALISM AND NATURE

An Alternative to Economism and Deep Ecology

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Two commonly held views about the nature of Nature lead to a systematic misunderstanding and mismeasurment of natural processes. The "economistic" view conceives of the natural environment as a repository of resources, available for human exploitation, and "services" provided by mechanistic ecological processes. The economistic perspective leads to a failure to properly recognize the sharp distinctions between ecological and economic processes, by positing that environmental-sustainability issues can be successfully addressed by "economizing ecology and ecologizing the economy." The deep ecology view conceives of nature in an idealized manner as a harmonious system in eternal balance unless disturbed by humans. This perspective fails to appreciate the material basis of nature and society and views changes in value systems as the key to achieving ecological sustainability. The authors advocate an alternative conception—one developed by Marxist scholars in the natural sciences that eschews both mechanistic and idealized conceptions of nature in favor of a dialectical, historical, and materialist view of natural processes. This approach allows us to better understand natural history and the dynamic processes of human interaction with the environment.

Keywords: *dialectical materialism; dialectical biology; deep ecology; green capitalism; global environmental crisis; species extinction*

What is the nature of Nature? Although, for the most part, scholars in the environmental social sciences do not directly examine the natural environment or explicitly struggle with this question, their (often implicit) assumptions about the natural world can have a substantial influence on their analyses of human-environment interactions. We note that there are two common conceptualizations of the natural world. One, especially prominent among economists, views nature as fundamentally mechanical and maintains an optimism about the ability of human societies to tinker with its machinery so as to improve its utility (for those in power, at least). Another, common in environmentalist circles, sees nature, when unmolested by industrial society, as existing in a grand harmonious order with which we must become in sync if we are to overcome environmental crises. Here, our aim is to present a different conception of nature, developed largely by scientists in the Marxist tradition, which is fundamentally materialist, although not mechanical, and concerned with interconnections and emergent order in nature,

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although not functionalist. Our main concern is with the emergence of apparent order and the nature of change and how these relate to the human-environment relationship, particularly in the current era of global environmental crisis.

Over the past 40 years, the human relationship with the environment has become an ever-more prominent topic in public discourse. It was as if the environment had "just been rediscovered by the people who live in it" (Commoner, 1971, p. 5). The first Earth Day in 1970 helped to make environmental degradation and pollution major concerns. The Club of Rome and the 1970s oil crisis placed scarcity and natural limits at the forefront of social concerns. Public debates raged over logging, mining, and drilling on public land. Social movements pushed forward concerns with environmental racism and environmental justice, nuclear energy, and the poisoning of ecosystems. For some, direct action—through various forms of sabotage, such as spiking trees, tree sitting, and road blockades—became the primary means to confront the powerful forces that organize social production. Corporations shifted their marketing campaigns to present their products as healthy, environmentally friendly items for eco-conscious consumers.

Social science scholars, slowly, came to focus on the environment as an important realm of study, noting human dependence on nature. Sociologists such as Catton and Dunlap (1978) and Schnaiberg (1980) helped raise awareness in the social sciences of the role the natural environment plays in maintaining societies. However, for the most part, the environment remains peripheral to the thinking of most social scientists, and many, particularly in economics, are actively hostile to the notion that environmental crises threaten the sustainability of societies.

In social sciences, as well as in various other intellectual and popular communities, nature takes on either an ideal form, existing as a harmonious order separate from society, or a machine that provides resources, waiting to be molded and operated at human convenience. The tension between idealized and mechanistic conceptions of nature has persisted for thousands of years, shaping philosophical discourse and social understandings of the world (Foster, 2000b). Appropriately, today, much of the social science focus is on the intersection of human society and nature, especially in regard to issues of production. Too often, however, nature remains in the background, as either a passive, harmonious realm "out there" beyond the bounds of urban society or as the source of "free goods" that fuels the engines of industrial society. Little time is spent understanding natural processes and patterns: how they operate on their own, how historical social systems interact with nature, how nature influences social conditions, and how natural processes are transformed by social interactions. The measure of nature remains bound by our assumptions about how it operates and what purpose (if any) it serves. Our understanding of the human-environment relationship, the conditions of nature, and the direction of society is affected by these conceptualizations. Beyond the economistic and the idealized approaches to assessing the human-environment relationship, a dialectical materialist position offers a dynamic position for grappling with the complexities of the natural world and for assessing the environmental conditions on which we depend.

We are positing that the economistic (mechanical, reductionist) and deep ecological (idealist) perspectives lead to a systematic mismeasurement and misunderstanding of nature. The economistic view seeks to measure "nature's services" and resources in terms of exchange value and pretends that such an approach can lead to sustainability when value is estimated accurately. Deep ecologists make assessments of environmental conditions by comparing them to an abstract, ideal "natu-

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ral" state of balance and harmony and conclude that unsustainability exists when actual conditions do not match this idealized state. We reject both the idea that exchange value can capture the value of nature and the idea of an idealized natural condition. We, therefore, argue that in trying to measure these constructed properties economistic and deep ecological approaches are not measuring the state of nature but are, rather, serving to reify their own contrivances. Nature and the human place in it need to be understood in their own terms not in the contrived terms of economics or philosophical idealism.

ECONOMISM AND "GREEN" CAPITALISM: NATURE AS AN INPUT

In an era when neoliberal capitalism dominates the world economy and is assumed to be the only political-economic option available, it should come as no surprise that an economistic understanding of human-environment interactions is highly prevalent. Of course, economistic approaches are not unified, given the wide range of their interests and variation in the extent that they directly address the environment. But they are connected by both their mechanical view of nature and optimism that human society can surmount any natural barriers that exist through technological innovation. For them, economics is the measure of the world, in all of its aspects. Nature, if it is considered at all, is seen as a problem, a barrier to overcome. It remains a world of Newton's clock, mechanical in its organization, malleable before our ingenuity. Proponents of economic modernization, ecological modernization, and green capitalism adhere to the position that the ongoing development of the capitalist economy, often simply referred to as "modernization," will provide the means for addressing and correcting environmental problems.

Although the Club of Rome's report was not without shortcomings, it did highlight that an economy driven by the ceaseless accumulation of capital, through the endless expansion of production and consumption, exists in conflict with a finite world (Meadows, 1972). Furthermore, scientists noted that an economic system based on constant growth generated ecological scarcities and environmental degradation that could not be reversed within human time frames (Commoner, 1971; Ehrlich, Ehrlich, & Holdren, 1973). The short-term focus of economists on profits conflicted with the long-term health of the environment. Orthodox economists could not account for the concerns being raised by the environmental movement at the time. One approach, by economists, was to deny concerns regarding "limits to growth" by arguing that so long as technological innovation continues and substitutes exist for natural resources, no immediate concern existed (Simon, 1981; Solow, 1974). In this, the conditions of the environment were assumed to be effectively irrelevant to society. Characteristically, nature was seen as simply a reserve of resources, waiting to be used in the production of commodities for the market.

Although the degree to which environmental concerns occupy public debates and interests has varied, often related to historical events and economic fluctuations, the issue persists as a central concern. The broadening and diversification of the environmental movement to include concerns from the preservation of wilderness to urban pollution and public health helped to make it an ongoing part of social discourse (Gottlieb, 1993). At the same time, the range and scale of environmental problems—global warming and climate change, loss of biodiversity, deforestation, the accumulation of radioactive wastes, increasing levels of toxins throughout ecosystems and in our food, the contamination of water, overfishing, and desertifica-

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tion—continue to expand, making the environmental crisis more than a threat that exists in the distant future (Buell, 2003). All these events have forced economists, corporations, and social scientists to address the environment.

Environmental economists from the neoclassical tradition acknowledge that economic development has generated environmental problems but argue that further economic development can solve these problems rather than add to them (Grossman & Krueger, 1995). The environment is seen as a luxury good, subject to public demand through the market. Grossman and Krueger (1995) contend that during the early stages of capitalist development environmental impacts increase, but as the affluence within these societies rises the value the public places on the environment—including wildlife, wilderness, clean air, and clean water—will increase. The public desire for environmental quality, in large part expressed as consumer demand for "green" products and services, will, economists expect, place pressure on the government and businesses to invest in eco-friendly technologies and commodities, which they will be able to afford due to the wealth generated by economic expansion. Thus, environmental economists tend to argue that if the market is allowed to operate without dramatic interference, ongoing economic development will lead to a leveling and eventual decline in the environmental impact of societies. This inverted U-shaped curve, representing the relationship between economic development and environmental impacts, is known as the environmental Kuznets curve and follows the same formulation as Simon Kuznets's (1955) discussion of the relationship between economic growth and income inequality. While materialistic, in an economic reductionist sense, nature remains in the background as simply an entity taken for granted, as a machine to be manipulated as needed. The thinking in economic circles too often goes as follows: The market determines any importance that the material world has, so that a "problem" that has no substantial and immediate consequences for economic development is no problem at all. The processes and cycles of nature are not a concern, so long as the environment remains as a resource for production.

Ecological modernization continues along these lines, insisting that the only "possible way *out* of the ecological crisis is by going further *into* the process of modernization" (Mol, 1995, p. 42). The particular form of modernization embraced is not a radical break with the current economic system and institutions. Rather, the forces of modernization that are believed to lead human society from its past of environmental degradation and exploitation to environmental sustainability are the institutions of modernity, including the market, industrialism, and technology (Cohen, 1999; Hajer, 1995; Mol, 1995, 1996, 2001, 2002; Mol & Sonnenfield, 2000; Mol & Spaargaren, 2000; Spaargaren, 1997, 2000; Spaargaren & Mol, 1992). Ecological modernization theorists do not view environmental degradation as an inherent characteristic of capitalist development. Thus, they remain zealous socio-techno-optimists, believing that the forces of modernization will lead to the dematerialization of society and the decoupling of the economy from energy and material consumption, allowing human society, under capitalism, to transcend the environmental crisis (Mol, 1995; Spaargaren, 1997). Some proponents of this position, such as Leadbeater (2000), argue that as the economy develops, it is producing a weightless society that is more knowledge based and less reliant on natural resources.

Ecological modernization theorists contend that one of the primary forces driving these developments within the modern economy is rationality. By allowing the market to develop to its full potential, a new, modern rationality will percolate

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throughout all institutions of "advanced" societies (Mol, 1996, 2001). This process leads to the emergence of "ecological rationality," which focuses on the necessity of maintaining the resources and ecosystem functions upon which societies depend and shifts the focus away from the pure economic rationality that prevailed in the early stages of modernization. However, at base, ecological modernization theorists are proposing a more fine-tuned economic rationality, not an ecological counterforce to economic hegemony, in that their case is that more explicitly recognizing the inputs of the environment into the economy will lead to a more economically rational system. They expect that new technologies will be developed to resolve environmental problems and to enhance the environmental sustainability of society, without challenging the dominant position of the market. It is assumed that a green rationality will provide the knowledge of how to properly manipulate nature to meet the economic needs of production within the ongoing development of capitalism.

General Electric Company presented an example of the types of transformations that ecological modernization theorists posit when it announced recently that it is going to invest over a billion dollars in "greener technologies" within the next 5 years. GE's objective is to improve its energy efficiency as a company and to expand its environmental products for the market. Its public-relations spin frames the environment as a problem to be solved through "ecomagination." The General Electric Company believes that green products will provide a valuable product line along with it other commodities, as it continues to expand in the coming years, seeking to produce around $20 billion in revenues from environmental products (Speer, 2005). Thus, the drive to accumulate capital on a larger scale supposedly embraces an "eco-consciousness." Environmental problems, then, become a source of marketing to expand profit.

Within this perspective, nature remains undertheorized. It is a realm of material input for the economy and society in general. Although environmental degradation is recognized, it is merely a sociotechnical challenge, given that further development of the economy and social institutions will resolve the situation. The ecological modernization vision is to ecologize the economy and to economize ecology within the current economic system. Ecological modernization theory is, at base, a functionalist theory in that it does not see the emergence of ecological rationality as coming primarily from social conflict but rather from ecological enlightenment within the key institutions in societies (Mol, 1995). Ecological modernization theorists contend, then, that radical ecological reform does not require radical social reform—that is, the institutions of capitalist modernity can avert a global environmental crisis without a fundamental restructuring of the social order. Instead, they are focused on the continuity of the social order, with gradual change in its operations. Social production is simply a machine that interacts with the environment. Humans, in their productive apparatus and in their interactions with the environment, simply need to tinker with operations to tweak any dysfunction back into order. For them, nature will continue to exist for our rational exploits, once we overcome its barriers through our ingenuity. On the whole, nature remains trapped in the metaphor of a machine that simply needs fine-tuning from time to time.

Embracing the optimism of ecological modernization and the workings of the capitalist economic system, proponents of green capitalism, such as Paul Hawken, propose that the capitalist economy can and should be restructured along environmentally sustainable lines. Hawken argues that if the value of nature were properly accounted for, capitalism would develop in an ecologically benign direction

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(Hawken, 1995; Hawken, Lovins, & Lovins, 1999). Thus, ecological goods and services are not currently properly accounted for by the market, so nature needs to have a rational price structure applied to it. The environment is then broken down into various commodities, and through an analysis of their contribution to market value a price is assigned to them. Once nature is fully commodified, the operation of the market can take care of the environment. For instance, green capitalism proponents aim to establish whether any particular stand of trees has more value for society in terms of its recreational potential, habitat, and ecosystem services provided or as a source of timber and the profit that the sale of this commodity generates on the market.

Green capitalists, such as Hawken (1993), argue that achieving sustainability is simply a matter of balancing the accounting books and changing the ethics held by the people directing corporations. He asserts that business exists to service people, not simply to make money. Thus, if a change in ethics takes place, capitalism can be directed down the path of sustainable development. Advocates of green capitalism stress that through innovative technological development and appropriate reformist government policy, the economy can be dematerialized, reducing the throughput of raw materials and energy that the system requires (Hawken, 1997). When this is done, they contend, the continued growth of the economy, on whatever scale, poses no threat to the natural world.

Like other variations of economism, nature remains a realm of inputs for the continued operation of an expanding economy. Its degradation and natural cycles only matter to the extent that they serve or interrupt the functioning of the economy. For them, nature presents obstacles that must be overcome, problems to be solved. And it is assumed that the solution to the "nature problem" will be produced by the ongoing development of the market and an advance of "green ethics." Thus, any real attempt to fundamentally transform the social system to address the ecological crisis is not necessary.

The central problem with this perspective is that the reproduction of the environment does not act in accord with "the rules of the market" (Foster, 2002, p. 27; see also Perelman, 2003; Sweezy, 2004). A forest cannot be reproduced at the same pace that it can be cut and transformed into commodities. Furthermore, we cannot assume that once an ecosystem has been drastically altered, such as when a forest is cut down, it will simply return to the previous state. And the unity of social production and nature becomes mystified in the operation of capital by "the increasing domination of exchange value over use value" (Burkett, 1999, pp. 64-65). The contribution of nature to the production of use value and maintenance of labor disappears within the capitalist framework. Labor time becomes the measure of value under capitalism, as nature becomes a mere object of labor. The alienation of workers and nature, in a competitive, profit-driven system, increases the exploitation of nature as the natural world becomes increasingly organized for the capitalist economic system that requires increasing throughputs for production, given that it is inherently expansionary and continually reproduces itself on a larger scale (pp. 70-79).

Advocates of green capitalism have grafted an "eco-veneer" on an economic system that is driven by the accumulation of capital. It would be wise to reflect upon how embedded the exploitation of nature is in the operations of the capitalist system. As Marx (1993) noted in his characterization of how capital interacts with nature,

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> Thus capital creates the bourgeois society, and the universal appropriation of nature as well as of the social bond itself by the members of society. . . . For the first time, nature becomes purely an object for humankind, purely a matter of utility; ceases to be recognized as a power for itself; and the theoretical discovery of its autonomous laws appears merely as a ruse so as to subjugate it under human needs, whether as an object of consumption or as a means of production. In accord with this tendency, capital drives beyond national barriers and prejudices as much as beyond nature worship as well as . . . old ways of life. It is destructive towards all of this, and constantly revolutionizes it, tearing down all the barriers which hem in the development of the forces of production, the expansion of needs, the all-sided development of production, and the exploitation and exchange of natural and mental forces. (pp. 409-410)

Capitalism freely appropriates nature, as it organizes the environment and labor for the production of commodities for sale on the market. Given the global operations of capital and its short-term focus on profit, which excludes any serious consideration of the environment, there is no means within its operations to stop the ruin of ecosystems, short of global collapse (Burkett, 2003; Foster, 2002a).

It is worth noting that the expectations of ecological modernization theorists and green capitalism proponents about substantial ecological reform in modern societies have not to date been confirmed. In addition to the various logical and methodological flaws that have often been associated with this tradition (York & Rosa, 2003), empirical evidence supports the conclusion that the capitalist modernization project leads to environmental degradation, particularly at the global scale. Although some indicators of local environmental quality (e.g., air and water pollution) show improvements in some developed nations, the impact of societies on the global environment (e.g., greenhouse gas emissions, resource consumption) appears to consistently escalate as the modernization project advances (Cavlovic, Baker, Berrens, & Gawande, 2000; Rosa, York, & Dietz, 2004; Shi, 2003; York, Rosa, & Dietz, 2003, 2004). Thus, the economistic conceptualization of nature does not appear to be conducive to environmental sustainability.

Economistic approaches to the environment perpetuate an economic reductionistic understanding of nature. The natural world simply exists as an input, in the background of their considerations, and as a realm to be managed to meet the needs of business in pursuit of profit. Any environmental problems created by society can simply be fixed through technological ingenuity, as the economy surmounts any external obstacles to its functioning. Although materialist, economistic approaches remain mechanistic in their orientation to nature, disregarding the dynamic processes of the natural world. Their stated goal is simply to bring the economy and ecology into accord, where capitalism continues to operate. The earth continues to be converted into a variety of commodities. The market is the measure of all things.

THE BALANCE OF NATURE: IDEALIZED HARMONY

Idealistic conceptions of the world—its meaning, its organization, and its purpose—have long been part of social thought. The specific character of these conceptions is often in reaction to prevailing material conditions in the physical world, sometimes including a longing for a return to some previous idealized state. Within ecological thought, deep ecology and the Gaia hypothesis are representatives of this perspective. Like any other perspective, deep ecology includes a diversity of opinions, ranging from humans being seen as a virus attacking the earth to humans

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having the potential to live in a natural harmony with the environment. Nonetheless, a uniting theme for this perspective is the conception that if industrial civilization were removed, the world could return to its natural state, where a balance of nature exists. This perspective tends to idealize traditional societies and indigenous people as living in a harmonious state with nature prior to the intrusion of the "modern" world. The notion of an ordered world is an old theme, found both in natural theology and in mechanistic depictions of the world. Deep ecologists reject mechanistic accounts of nature. They also scuttle the hierarchy that was central to natural theology, by displacing humans from the position just below god. Instead, they insist upon an ecocentric conception, where humans are only one of the many species inhabiting the earth and deserving of no special privilege. Ideal Nature is assumed to be a place of harmony. The real world is measured against this ideal state.

In 1973, Arne Naess highlighted that there were two currents within environmental thought. One was a "shallow ecology" primarily concerned with fighting pollution and resource depletion. The other, deep ecology, included the objectives of shallow ecology but also entailed a shift in thought, where nature is seen and defined not as it relates to human interests but from its own position. A new point of view was required: ecocentrism, as opposed to anthropocentrism (Naess, 1973). The deep ecology position attempts to shift social perception away from the economistic understanding of the world. Nature is seen as having intrinsic worth rather than as simply being a resource for humans. Deep ecologists insist that the social forces that harm the environment must cease in order to preserve life in all of its forms and to seek a world of harmony. Industrial civilization is seen as being the primary enemy (Devall, 2001; Devall & Sessions, 1985). To transcend this imbalance, a revolution in values and thoughts is need. Thus, much of deep ecology focuses on establishing its philosophical moorings via Buddhism, strains of Christianity, Rachel Carson, Aldo Leopold, Thoreau, Muir, Darwin, and Gary Snyder. Drawing upon this smorgasbord of social thought, an ecocentric paradigm is counterposed to the dominant worldview of nature and is seen as a means of overcoming the current ecologically destructive social order. Rather than a society that stokes the fire of ever-increasing material needs and that views the world as simply an object, a world of simplicity and equality among all species is offered.

Lovelock's (1979) Gaia hypothesis, which posits that the earth is an organism in its own right, is based on intellectual foundations that are similar to those of deep ecology. First and foremost, the Gaia hypothesis is a highly functionalist view, strikingly paralleling Talcott Parsons's (1937, 1951) conception of society as a superorganism, and has all the attendant problems of such a view. In particular, the assumption that all components of the global ecosystem are interconnected in an ordained functional harmony requires the invocation of teleological forces. After all, unless some supernatural force mandates that it must be so, why should material forces lead to a natural state of harmony? In this, advocates of deep ecology and the Gaia hypothesis often slip into a spiritualist morass, denying the potential for rational inquiry.

Our concern here is not with deep ecology's emphasis on the subtle interconnections and complexity of nature, its distaste for human arrogance, or its argument for the ethical importance of recognizing that humans are but one among millions of species on earth and not the divinely (or self) appointed masters of Creation. Indeed, we are fully sympathetic with deep ecology's view on these matters. Rather, it is its philosophical idealism and its conception of nature as an ideal func-

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tional system, of the earth as a literal (rather than metaphorical) superorganism, existing in a grand state of balance if unmolested by humanity, that is our focus. Why would there be a grand balance in nature? Natural history is a record of drastic changes and discontinuities in the biophysical world. The assumption of a natural harmony is not consistent with a critical historical understanding of nature. Furthermore, deep ecology is based on an antimaterialist theory of causality—one that posits that our value system, particularly the one emerging with the birth of modernity and a scientific worldview, is, at base, the cause of the environmental crisis. Rather than a discussion of the social forces that drive social production, a critique of the dominant worldview—divorced from its social-material influences—becomes paramount. Change becomes a matter of adjusting values and developing the proper eco-ethics, and from there, it is assumed, changes in the social structure will follow.

Although values remain an important part of the social world, limiting discussion to this realm prevents a systematic understanding of the material forces that largely contribute to the organization of society and its interactions with nature, not to mention the forces that continue to contribute to the reproduction of the capitalist system (Bhaskar, 1979). Since the late 15th century, an economic system propelled by the accumulation of capital has been the dominant force shaping human society. Deep ecologists do not disagree that an economic system premised on growth leads to conflicts with natural processes and environmental degradation. But little of their analysis is situated to critique the workings of the economic system, as far as what forces drive it. Furthermore, a discussion of material processes is not at the forefront of their analyses. Thus, deep ecology's conceptualization of the interaction of society and nature is quite limited. If a sustainable society is only a matter of changing values and ethics, an analysis of environmental problems gets shortchanged. Measuring nature against an idealized notion of balance will hinder our ability to understand both natural processes and the ongoing interactions between society and the environment.

DIALECTICAL NATURE: STRUCTURAL CONSTRAINTS AND EMERGENT POTENTIAL (THE ONGOING DANCE OF LIFE)

In the following section, we argue that a full understanding of Nature is best realized through a materialistic and historical lens. Both the economistic and the deep ecology views just outlined tend to be ahistorical, and the economistic view, though materialist, neglects the complexity of processes in the natural world, whereas the deep ecology view, though concerned with the subtleties of nature, rejects materialism. A dialectical approach to understanding nature is needed—one that overcomes the limitations of economism and deep ecology. Rather than evaluating nature in terms of an idealized state, such as the abstract balance of nature assumed in deep ecology, the world is better understood and explained in terms of its history. A materialist and dialectical approach can account for the interactions that take place at all levels, the structural constraints on change and the forces that facilitate it, the emergence of new properties, and the periods of stasis and discontinuity in history. The dialectical materialist tradition, particularly the strain that developed in the natural sciences, provides a conception and measure of nature different from that proposed by neoclassical economists and deep ecologists.[1] This tradition recognizes that nature includes processes that operate on their

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own terms and that have no inherent "purpose." At the same time, this tradition recognizes that the production of human society involves a constant interaction with the natural world, which involves a continual transformation of nature and society. Such a recognition of this interaction and continual transformation does not serve as a justification for human efforts to subdue and control nature, but rather, it simply entails the acknowledgment of the inevitability of change and the interaction between elements of the material world—that is, long before humans evolved, nature was in a continual process of transformation due to the interaction of material forces and conditions, such as the origins of the biosphere (Vernadsky, 1998) and the emergence of life (Oparin, 1965).

For Marx, human history remains part of natural history but is not subsumed by it—that is, society is embedded in nature and dependent on it, although there are distinct social and natural processes (Colletti, 1972, pp. 13-14). A dialectical relationship exists between society and nature, as they continually transform each other in their coevolutionary development (Burkett, 1999; Foster, 2000b; Foster & Burkett, 2000; Haila & Levins, 1992; Marx 1974, p. 400). The direction of this relationship is not predetermined; the future remains open.

Natural scientists in the Marxist tradition have been at the forefront of developing a dialectical materialist position for understanding nature via an understanding of the development of life and natural history. The work of dialectical natural scientists, particularly that of Richard Levins, Richard Lewontin, and Stephen Jay Gould[2]—who follow in the tradition of Darwin and Marx, as well as that established by Lancelot Hogben, Hyman Levy, J. D. Bernal, J. B. S. Haldane, and Joseph Needham—provides a valuable foundation for understanding the natural world and the development of life. The work of these dialectical scientists dismantles the reification of essentialist and idealist conceptions of nature and avoids mechanical materialist presumptions that the world can be reduced to the workings of a machine and neatly molded to suit the demands of the market. The focus of these dialectical scientists is on interactions at various levels in the natural world—between genes and whole organisms, organisms and the environment—and the dynamic and contingent historical process of evolution. In opposition to the hyperreductionism of Dawkins (1976) and Dennett (1995), which tries to push the level of causation in evolutionary history and in society to the level of the gene, Levins, Lewontin, and Gould argue that causal forces operate at different levels of aggregation and that a comprehensive causal explanation cannot be reduced to a single level.

In regard to the development of an organism, Levins and Lewontin (1985) challenge the notion that life is simply the unfolding of a genetic blueprint that provides the design for our lives. They contend that life cannot be reduced to the mechanistic operations of genetic forces, where change is predetermined, following an ascribed path until death. Instead, organisms remain in a state of making, so long as they live, given that they are the consequence of the relationships and interactions between genes, themselves, and the environment. To gain a more comprehensive understanding of life, the relationship between the internal and external processes of life must be conceptualized as a whole. Failing to do so neglects the complexity of biological processes and the dynamic character of life. The organism is a site of interaction between the environment and genes (Lewontin, 2000, pp. 17-18). Its development is the unique consequence of the genes it carries, the conditions of the environments through which it passes, the historical context in which it resides,

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and random events (in the larger world, as well as at the molecular level). Simply stated, an organism does not compute itself from its genes; interactions and the environment must be considered.

Lewontin (2000) notes that Darwin took an important step in evolutionary science "by alienating the inside from the outside: by making an absolute separation between the internal processes that generate the organism and the external processes, the environment, in which the organism must operate" (p. 42). He made this distinction to free science from existing tendencies to collapse the entire world into a unified, indistinguishable whole that made life itself unanalyzable (p. 47). His materialist approach opposed the idealist explanations that life and the organization of the world were a reflection of an ordered plan at the hand of god (Foster, 2000b). Within evolutionary science, Darwin rejected the Lamarckian notion that variation itself was directed by the environment. He posited that the direction of variation was independent of the environment, effectively random. Changes through evolutionary history, then, were not seen as the product of trends in variation itself but rather in the nonrandom retention of traits produced through the independent process of variation—the key point of natural selection.

However, like Lamarck, Darwin constructed a functionalist theory—that is, he posited that the process of natural selection fitted organisms to their environments and that the environment, as the determinant of the selective regime, ultimately largely determined the organism. The Darwinian perspective sees diversity of species as a consequence of diverse environments "to which different species have become fitted by natural selection. The process of that fitting is the process of *adaptation*" (Lewontin, 2000, pp. 41-42). The interaction of the organism and the environment involved a selective process, where an organism fit into an ecological niche. The notion of a niche implies a predetermination, a hole in nature, which is filled by an organism, rather than a transformation on the part of either the environment or the organism (pp. 43-44).

Lewontin (2000) argues that while it is true that the internal process of heritable variation is not casually dependent on the environment in which organisms live, "the claim that the environment of an organism is casually independent of the organism, and that changes in the environment are autonomous and independent of changes in the species itself, is clearly wrong" (p. 48). Rather than adaptation, the process of evolution is best described as a process of construction. Organisms actively transform the environment through living (such as collecting food and constructing shelter), although the conditions of the environment are not wholly of their own choosing, given that previously living agents and inorganic forces historically shaped nature. Niches come into being in part as a result "of the nature of the organisms themselves" (p. 51).

The dialectical interchange between the environment and the organism becomes a central tenet of the coevolutionary perspective proposed by Lewontin and like-minded scholars. Levins and Lewontin (1985) explain that organisms are dependent on nature for their survival. Although a larger physical world exists, from which organisms receive benefit, such as the atmosphere, organisms make use of only a small part of nature in the creation of their immediate environment. Independent forces and processes operate in nature. Volcanic eruptions can occur independently, but these are physical conditions beyond any individual organism. They shape the physical world that life confronts. At the same time, the life activities of organisms—for example, gathering food—determine what parts of the world become an immediate part of their environment. In the process of obtaining

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sustenance, organisms transform the world for themselves and other species. This dynamic holds for all life. Thus, organisms confront a physical world that has been shaped by natural processes and past life, while it is also being transformed by coexisting species (Levins & Lewontin, 1985, pp. 89-106; Lewontin, 2000, pp. 48-55).

The characteristics of an organism, such as its metabolism, sense organs, shape, and nervous system, influence how it responds to signals in nature and how it processes materials. For example, ultraviolet light helps to lead bees to food, whereas for humans, it can cause skin cancer. Thus, the biology of a species influences interactions with nature. In the process of consumption, interacting with the larger physical world, life is engaged in a process of production, as the physical conditions are changed to meet the needs of organisms. Thus, new environments are created for life, influencing the conditions that all organisms will confront (Lewontin, 2000, p. 55). Organisms are both a subject and an object in the physical world, creating in part their own environment, given the existing conditions, as well as facilitating their own construction. A dialectical materialist approach provides the means to understand the complex interactions between organisms and the environment (Levins & Lewontin, 1985; Lewontin, 2001).

Although organisms do not perceive all the autonomous processes of the larger world, in their interactions with and transformations of nature, they respond to these conditions. Lewontin (2000, pp. 62-64) explains that in their responsive abilities, such as the rates and forms of reproduction, which vary in invertebrate animals according to changes in space and time (including temperature, weather, etc.) of the world surrounding them, organisms are influenced by external nature. Life remains immersed in external conditions that are the consequence of the biological activities of contemporary life and all life that has preceded it (p. 66).

Life, by necessity, involves interaction, which leads to change that is not entirely predictable. Organic processes are historically contingent and, thus, defy deterministic universal explanations of their particulars (Lewontin, 2000, p. 76). Lewontin (2000) rejects teleological conceptions of evolution:

> All species that exist are the result of a unique historical process from the origins of life, a process that might have taken many paths other than the one it actually took. Evolution is not an unfolding but an historically contingent wandering pathway through the space of possibilities. Part of the historical contingency arises because the physical conditions in which life has evolved also have a contingent history, but much of the uncertainty of evolution arises from the existence of multiple possible pathways even when external conditions are fixed. (p. 88)

Organisms are emergent, involving both internal and external dynamics. So long as genes, organisms, and environments are studied separately, the advance of our knowledge of the living world will be hindered. Given that life is both a subject and an object in its own historical development, the reductionistic notion that DNA is the sole secret to life is misleading. As Barry Commoner (2002) states, "DNA did not create life; life created DNA" (p. 47).

A key feature of the Marxist view of history is that change is not typically smooth and continuous but rather often occurs very rapidly following periods of stasis (temporary periods, of indeterminate length, of counterbalancing opposing forces leading to relative stability). Throughout history, the worldview of the ruling class has typically been quite different from this, either identifying eternal stasis as

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the natural condition or change as inevitably smooth and gradual. This is a view, obviously, comforting to those in power because it undermines the idea that revolutions are likely. The discovery of "deep time" by geologists and of organic evolution by naturalists undermined the eternal-stasis perspective, but the notion of slow, continuous change was a key facet of the thinking of Victorian scholars, reflected in Charles Lyell's uniformitarianism and Darwin's gradualism. Of course, neither view, rapid change or gradual change, is absolutely correct; the complexity of human and natural history has ensured that both types of change occur (it goes without saying that the rate of change is not binary, either necessarily rapid or gradual, but this dichotomy is heuristically useful). Furthermore, the rate of change of any particular phenomenon is a factual question and cannot be determined by ideology. However, a key point of scientists in the Marxist tradition is that the ideology of the ruling class often distorts one's perceptions of the world. The Marxist tradition, therefore, emphasizes the necessity of being particularly skeptical of assertions about the natural world when they conform to ruling-class ideology (Gould, 1981; Levins, 1990, 1998; Lewontin, Rose, & Kamin, 1984).

The Marxist view of historical change in the natural world is perhaps best expressed in Eldredge and Gould's (1972; Gould & Eldredge, 1977) argument that the evolutionary history of organisms is best characterized as "punctuated equilibria," long periods of stasis, punctuated with (geologically) brief periods of rapid change. This is based in part on a literal interpretation of the fossil record, which generally shows fossils of a species remaining quite similar over extended stretches of time and then suddenly (in the geological sense) being replaced by a substantially different, although apparently related, type. Their argument is in no way a rejection of Darwinism in general, only a challenge to Darwin's strong preference for gradualism. They invoke no special mechanisms for change. Rather, they argue that speciation typically happens when a subset of a species becomes isolated. In a small isolated population, mutations can spread rapidly throughout all members of the species, and the rate of change can be further accelerated if the population faces different selection pressures than the parent species. In large populations that are geographically widespread, although connected through breeding, mutations spread slowly, and any mutations that are favorable to organisms in one part of the range are not necessarily retained, because they become watered down by genes from the larger population. For these reasons, Eldredge and Gould proposed that widespread species will generally change little over most stretches of time but may change rapidly around the point of speciation, when a subpopulation becomes isolated.

Gould (2002) has also argued that organisms are not mere putty to be sculpted over the course of their phylogeny (evolutionary history) by external environmental forces, but rather, their structural integrity constrains and channels the variation on which natural selection operates. In this, Gould is challenging the notion that variation is isotropic, effectively random in all directions. He notes that the structural nature of the development of an organism throughout its life course (ontogeny) limits the types of phenotypic variation that are possible because changes at one stage of the developmental process have consequences for later stages. Therefore, many characteristics of an organism cannot simply be modified without having substantial ripple effects throughout the whole organism. The inherited patterns of development, therefore, do not readily allow for all types of modification. Therefore, the evolutionary process is a dialectical interaction between the internal (inherited structural constraints) and the external (environmental selection pres-

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sure), just as the ontogeny (individual development) of individual organisms is a dialectical interaction between their genes and the environment.

The structural nature of development has consequences for patterns of change. To illustrate this point, Gould (1993) makes use of a metaphor, Galton's polyhedron. In true fashion, Gould draws upon the arguments of various historic figures involved in the evolutionary debate to build his own. Francis Galton, who was Darwin's cousin (Erasmus Darwin was grandfather to both), who helped lay the foundations for much of modern statistics, and who is regarded as the father of eugenics, was deeply impressed by his cousin's work on evolution, but he disagreed with Darwin's assumptions about the nature of variation.[3] He developed an analogy to challenge Darwin. While Galton did not appreciate the dialectical position within his own analogy, Gould was never one to miss a conceptual gem even in the most unlikely of places and was always able to bring out the potential of a concept. Gould explains that in Darwin's idealized formulation, species are metaphorical spheres that roll freely on any phylogenic course the external world pushes them along—that is, their structure offers no resistance to pressure from the external environment, and thus, they move readily wherever environmental forces direct them. Alternatively, in Galton's metaphor, species are polyhedrons, multisided solid objects that have flat faces (such as dice), whose structure prevents them from rolling freely when only slightly perturbed and limits the paths they can follow after receiving a sufficient push from the external world. They can switch the facet on which they rest, but they cannot simply rest in any given position. In contrast with a sphere, which may roll smoothly with a light tap, the polyhedron will resist minor perturbations but, given sufficient force, will switch facets abruptly. Thus, species cannot perfectly track changing environments, because of the structural interconnections they develop over the course of their phylogeny, which limit and, potentially, direct the type of change that is possible. Note that this metaphor also points to another concept common in the historical materialist tradition: Change does not necessarily happen smoothly but rather can happen rapidly, preceded and followed by periods of relative stability, shaped by opposing forces (Gould, 1993, pp. 384-385). The polyhedron contains both structural constraints and the potentiality for new states. Hence, it has an affinity with the theory of punctuated equilibria.

This metaphor can also serve as an illustration of the global environment. Ecosystems have resiliency within certain bounds. Their natural cycles and processes continue to operate within certain states. Complex systems, such as the global climate, can maintain a stable state for extended periods, but if sufficiently disturbed, such as by the anthropogenic emission of greenhouse gases, they can change abruptly. The recognition of thresholds and the potential for sudden change in the natural world is central to a dialectical and historical understanding of nature. Natural thresholds can be surpassed, creating a sudden change in the global ecosystem (Falkowski et al., 2000; Muradian, 2001; Scheffer, Carpenter, Foley, Folke, & Walker, 2001; Vitousek, 1994). The polyhedron, in this case the global environment, could be pushed so hard that the changing of the facets results in conditions that cannot sustain societies. A proper understanding of this point undermines economistic approaches to quantifying the value of nature's services to society, because there is no directly linear correspondence between human-generated pressure on the environment and changes in the environment. For example, the "cost" to society and the other creatures that inhabit the earth may be modest for the first several billion metric tons of carbon emitted by societies, but when a natural

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threshold is approached, the cost may escalate dramatically and in an effectively unpredictable manner (Alley, 2000; Broecker, 2003; Foster, Magdoff, & McChesney, 2004; Houghton et al., 2001; National Research Council, 2002). The program to assign economic value to natural processes fails to appreciate both the inherent complexity and unpredictability of natural systems and the lack of a direct correspondence between ecological dynamics and economic dictates.

CONCLUSION AND CONCERNS: THE ENDURING STRUGGLE AND THE THREAT OF EXTINCTION

A dialectical materialist approach to nature provides the means for understanding the complex interactions throughout the natural world, the ability to explain the world in terms of itself, the perception to recognize that contingency and emergence are inherent aspects of a living world, and the capability to study the structural constraints and the inherent potential for change. In this, a materialist dialectic avoids the mechanistic reductionism of economistic approaches, where nature exists in the background, as simply an input to the economic system. It also avoids the idealized notion that nature exists in a state of balance and that a return to such a state is simply a matter of developing the appropriate moral-ethical system.

The dialectical materialist perspective recognizes that the world is one of constant change but not one where anything goes. Constraints and possibilities remain in the structural conditions of the world. Abrupt, punctuated change can radically shift life to new pathways or the environment to conditions that present serious challenges to existing life. It is of utmost importance that nature is understood in terms of itself. Human society is dependent upon the environment and must interact with it to continually reproduce itself. This interaction involves the transformation of the world. The dialectical materialist approach highlights how history involves change. But all change and any change is not good. The interaction between humans and the environment is an enduring struggle to live within a finite world, under emerging conditions. There are social interactions that threaten to push the polyhedron of the global environment toward states of radical change that threaten the world we know with global mass extinction.

The previous five mass extinctions are not fully understood as far as what the causes were, but the mass extinction taking place today is being driven by *Homo sapiens* (Hooper et al., 2005; Leakey & Lewin, 1996) via an economic system that operates at the global level (Broswimmer, 2002; Eldredge, 1995, 1991). The constant expansion of the capitalist system has pushed environmental degradation to the planetary level, as habitat destruction decimates the living conditions of species and as ecosystems are radically transformed (Broswimmer, 2002). Human civilization, under capitalism, is engaged in a process of destroying the future, as "we suck our sustenance from the rest of nature in a way never before seen in the world, reducing its bounty as ours grows" (Leakey & Lewin, 1996, p. 233).

Eldredge (1995) points out that as humans moved beyond isolated ecosystems, to operate at the planetary level, our alienation from nature increased. We developed the illusion that we were not dependent upon the environment. Eldredge warns that the current global mass extinction is quite different from previous ones, in that the source of the extinction remains on the scene: humans destroying habitat for the sake of profit (Eldredge, 1995, pp. 125-132). Thus, recovery of ecosystems is not possible so long as the same forces continue to act and change the world as

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has been the practice. For example, forests continue to be cleared to make room for urban growth and crops. As the environment is simplified and biodiversity declines, the operation of ecosystems is hindered as resource capture through energy, water, and nutrients is diminished. The resiliency of an ecosystem is also hampered, reducing its ability to purify water and its integrity to mitigate floods (Ceballos & Ehrlich, 2002; Hughes, Daily, & Ehrlich, 1997; Primm & Raven, 2000; United Nations Environment Programme, 2002). Furthermore, given the interdependency of species and the complexity of interactions among species, the remaking of the environment through habitat destruction poses the threat of cascading extinctions. The loss of a specific larval host plant in Singapore led to the loss of tropical butterfly species. Hummingbird flower mites are dependent upon both the hummingbirds that provide transportation to other flowers and the flowers from which they "depend for nectar and pollen." If either the flowers or the hummingbirds are threatened with extinction, so are the flower mites. The potential loss of "irreplaceable evolutionary and coevolutionary history" is very grave, as "species coextinction is a manifestation of the interconnectedness of organisms in complex ecosystems" (Koh et al., 2004, pp. 1632-1634).

The rate of speciation is caught in a time conflict, as the current rate of extinction is faster than the rate of evolution (Eldredge, 1995). The mass extinction being orchestrated today is a unique historic event, given that it is being driven by anthropogenic forces that continue to operate. Since 1600, the extinction rate has been 50 to 100 times the average estimated rate of extinction during previous epochs, but the rate "is expected to rise to between 1,000 and 10,000 times the natural rate" (United Nations Environment Programme, 1997, chap. 4). Thus, a radical change in the operations of human society and its interactions with nature is necessary to stop the ecological crisis that is taking place (Buell, 2003).

The interaction between human society and nature is a never-ending dance, which always presents a challenge. Because change is the law of life, this does not mean that we are helpless or that we should not try to positively influence the conditions of the world. In fact, given the current state of the environment and the ecological crisis in which we live, not to mention the potential for an ecological discontinuity that both is created by humans and would threaten human survival, monitoring and directing how humans interact with nature is a priority. Humans must establish a form of social production that does not alienate people from nature and that interacts with nature in a manner that does not undermine the environment's ability to regenerate. This requires constant vigilance and flexibility to respond to contingency, as the world continues to change. So long as society is driven by short-term goals, such as the drive to accumulate capital, the longevity of the current global environment and humans is threatened.

As Lewontin (2000) explains, there is no evidence that organisms are becoming more adapted to the environment. Evolution does not entail a drive toward perfection. All elements of life are changing. Around 99.99% of all species that ever existed are extinct (p. 68). Likewise, there is no evidence for claims of harmony and balance with the external world. Environmental change will continue. Natural and social history are in constant motion. Chance is always present. "What we can do," Lewontin emphasizes, "is to try to affect the rate of extinction and direction of environmental change in such a way as to make a decent life for human beings possible. What we cannot do is to keep things as they are" (p. 68). A dialectical materialist approach provides the means to grapple with an emerging world and helps to fur-

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ther our understanding of the human-environment interaction, pointing the way to a more accurate measure and understanding of nature.

NOTES

1. The term *dialectical materialism* is often used derisively within contemporary Western Marxism and has come to symbolize Stalinist dogma. Our intention here is to rehabilitate the term by using it to refer exclusively to those inquiries that can be seen as genuine attempts to employ both dialectical and materialist methodologies in both the natural and the social realms. Materialism without dialectics tends toward mechanism and reductionism. Dialectics without materialism tends toward idealism and vitalism. Genuine dialectical materialism seeks to transcend these antinomies. It thus stands for a critical realism sorely lacking in conventional thought (see Clark & York, 2005; also Foster, 2000b).

2. For discussions of the intellectual perspectives of Gould, Lewontin, and Levins, particularly as they relate to nature, science, and society, see Clark (2002), Clark and York (2005), York (2005), and York and Clark (2005).

3. See Black (2003) for a discussion of eugenics, which includes important comments regarding Galton. For a biography of Galton that includes a presentation of both his "dark visions and bright ideas," see Brookes (2004).

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