

ESSAY

Socialism - Marxism and Ecology: Common Fonts of a Great Transition

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Socialist thought is re-emerging at the forefront of the movement for global ecological and social change. In the face of the planetary emergency, theorists have unearthed a powerful ecological critique of capitalism at the foundations of Marx's materialist conception of history. This has led to a more comprehensive conception of socialism rooted in Marx's analysis of the rift in "the universal metabolism of nature" and his vision of sustainable human development. This work resonates with other approaches for understanding and advancing a Great Transition. Such a social and ecological transformation will require a two-step strategy. First, we must mount struggles for radical reforms in the present that challenge the destructive logic of capital. Second, we must build the broad movement to carry out the long revolutionary transition essential for humanity's continued development and survival.

Introduction

To link Marxism and ecological transition may seem at first like trying to bridge two entirely different movements and discourses, each with its own history and logic: one having mainly to do with class relations, and the other, the relation between humans and the environment. Historically, however, socialism has influenced the development of ecological thought and practice, while ecology has informed socialist thought and practice. Since the nineteenth century, the relationship between the two has been complex, interdependent, and dialectical.

Marxian approaches to the planetary ecological crisis and the socio-ecological transformation necessary for its resolution have evolved rapidly in recent decades. This has created the basis for a much more powerful, collective struggle for a Great Transition, in which values of "consumerism, individualism, and domination of nature" are replaced with "a new triad: quality of life, human solidarity, and ecological sensibility."¹ The demands for a society dedicated to need rather than profit and to human equality and solidarity have long been associated with socialism. More recently, socialist thinkers have given equal importance to ecological sustainability, building on Karl Marx's environmental critique of capitalism and his pioneering vision of sustainable human development.²

This essay unearths the deep ecological roots of Marx's thought, showing how he brought an environmental perspective to bear on the overarching question of social transformation. From there, it traces the evolution of Marxian ecology, illuminating its profound, formative link to modern ecological economics and systems ecology. It concludes by discussing the wider project of building a social movement broad and deep enough to halt and reverse ecological and social destruction.

For the first time in human history, our species faces a dire existential choice. We can continue on the path of business as usual and risk catastrophic Earth-system change (what Frederick Engels metaphorically referred to as "the revenge" of nature"), or we can take the transformative route of social-system change aimed at egalitarian human development in coevolution with the vital parameters of the earth.³ This constitutes the epochal challenge of our time: to advance radical reform measures that oppose the logic of capital in the historical present while coalescing with a long revolution to construct a new social and ecological formation that promotes sustainable human development.

Socialism and the Origins of Systems Ecology

Ecology as understood today came into its own only with the rise of systems ecology and the concept of ecosystem. Although Ernst Haeckel, who promoted and popularized Charles Darwin's work in Germany, coined the word ecology in 1866, the term was originally used merely as an equivalent for Darwin's loose concept of the "economy of nature."⁴ This view of ecology would later gain currency as a way to address complex plant communities in botanical studies in the early twentieth century.

Yet ecology had other roots, closer to our current conception, in early work on nutrient cycling and the extension of the concept of metabolism to ecological system processes. A key figure in this respect, the great German chemist Justus von Liebig, launched a major ecological critique of British industrial agriculture in the late 1850s and early 1860s.⁵ Liebig accused the British of developing a robbery culture, systematically leaching the soil of nutrients and thereby requiring that bones be imported from the Napoleonic battlefields and catacombs of Europe (and guano from Peru) to replenish English fields. Liebig's analysis itself was a product of revolutions then taking place in nineteenth-century physics and chemistry. In 1845, Julius Robert von Mayer, one of the co-discoverers of the conservation of energy, had described the metabolism of organisms in thermodynamic terms. The new physiochemical thinking stressed the interrelationship between the inorganic and organic (abiotic and biotic), providing the initial basis for what was eventually to become a wider ecological systems theory.⁶

Drawing on the work of Liebig, and that of the socialist physician Roland Daniels, Karl Marx introduced the concept of "social metabolism," which from the late 1850s occupied a central place in all his economic works.⁷ Marx defined the labor process itself as a way in which "man, through his own actions, mediates, regulates and controls the metabolism between himself and nature." Human production operated within what he called "the universal metabolism of nature." On this basis, he developed his theory of ecological crisis proper, now known as the theory of metabolic rift, pointing to the "irreparable rift in the interdependent process of social metabolism, a metabolism prescribed by the natural laws of life itself."⁸ As economist Ravi Bhandari has recently written, Marxism was "the first systems theory."⁹ This is true not only in political-economic terms, but also in terms of the incorporation of thermodynamics and the wider metabolic relationship between nature and society into its analysis.

These two strands of ecological analysis—Haeckel's notion of "ecology" and Liebig and Marx's concept of a metabolic relationship between society and nature—evolved during the late nineteenth

and early twentieth centuries. Beginning in the 1880s, the leading British zoologist E. Ray Lankester (Charles Darwin and Thomas Huxley's protégé and Marx's close friend) put forward a strong ecological critique of capitalism and the Victorian concept of progress.¹⁰ Botanist Arthur George Tansley, Lankester's student and—like him—a Fabian-type socialist, founded the British Ecological Society. He introduced the ecosystem concept in 1935 in a theoretical polemic against the racist ecological “holism” of General Jan Smuts and his followers in South Africa. In the process, he developed a broad, materialist approach to ecology that incorporated both inorganic and organic processes.¹¹

Ecology as we know it today thus represents the triumph of a materialist systems theory. Tansley's ecosystem concept focused on natural complexes in a state of dynamic equilibrium. Ecosystems were seen as relatively stable (resilient) complexes that were nonetheless vulnerable and subject to change. In developing this analysis, he drew on the systems perspective of the British Marxist mathematician and physicist Hyman Levy. In Tansley's framework, humanity was viewed as an “exceptionally powerful biotic factor” that disrupted and transformed natural ecosystems.¹² Correspondingly, ecology in our time is increasingly centered on the human disruption of ecosystems from the local to the global.

Related developments occurred in the Soviet Union. In his 1926 work *The Biosphere*, V. I. Vernadsky argued that life existed on the thin surface of a self-contained planetary sphere, was itself a geological force affecting the earth as a whole, and had an impact on the planet that grew more extensive over time.¹³ These insights induced Nikolai Bukharin, a leading figure in the Russian Revolution and Marxian theory, to reframe historical materialism as the problem of “man in the biosphere.”¹⁴ Despite the purge under Stalin of Bukharin and other ecologically oriented thinkers, Vernadsky's work remained central to Soviet ecology, and later helped inspire the development of modern Earth system analysis.

With the rise of systems ecology, Marx's concepts of the “universal metabolism of nature,” the “social metabolism,” and the metabolic rift have proven invaluable for modeling the complex relation between social-productive systems, particularly capitalism, and the larger ecological systems in which they are embedded. This approach to the human-social relation to nature, deeply interwoven with Marx's critique of capitalist class society, gives historical materialism a unique perspective on the contemporary ecological crisis and the challenge of transition. Marx wrote of a rift in the soil metabolism caused by industrialized agriculture. Essential soil nutrients, such as nitrogen, phosphorus, and potassium contained in food or fiber were shipped for hundreds, even thousands, of miles to densely populated cities, where they ended up as waste, exacerbating urban pollution while being lost to the soil. He went on to emphasize the need for rational regulation of the metabolism between human beings and nature as fundamental to creating a rational society beyond capitalism. Socialism was defined in ecological terms, requiring that “socialized man, the associated producers, govern the human metabolism of nature in a rational way...accomplishing it with the least expenditure of energy and in conditions most worthy and appropriate for their human nature.” The earth or land constituted “the inalienable condition for the existence and reproduction of the chain of human generations.” As he declared in *Capital*, “Even an entire society, a nation, or all simultaneously existing societies taken together, are not owners of the earth. They are simply its possessors, its beneficiaries, and have to bequeath it in an improved state to succeeding generations as *boni patres familias* [good heads of the household].”¹⁵

Marxism's Great Divide and the Ecological Problem

Yet, if classical historical materialism embodied a powerful ecological critique, why was this

forgotten for so long within the main body of Marxist thought? One partial answer can be found in the observation of the early twentieth century revolutionary socialist Rosa Luxemburg that many aspects of Marx's vast theoretical framework extending beyond the immediate needs of the working-class movement would be discovered and incorporated much later, as the socialist movement matured and new historical challenges arose.¹⁶ A more direct explanation, however, is the fact that Marx's ecological ideas fell victim to the great split that opened in the 1930s between Western Marxism and Soviet Marxism.

Intellectually, the schism within Marxism centered on the applicability of dialectics to the natural realm, and the position on this of Marx and Engels. The concept of the "dialectics of nature" was more closely identified with Engels than Marx. Engels argued that dialectical reasoning—focusing on the contingent character of reality, contradictory (or incompatible) developments within the same relation, the interpenetration of opposites, quantitative change giving rise to qualitative transformation, and processes of historical transcendence—was essential to our understanding of the complexity and dynamism of the physical world. This, however, raised deep philosophical problems (both ontological and epistemological) within Marxian discourse.

Soviet thinkers continued to see complex, historical, interconnected views of development, associated with dialectical reasoning, as essential to the understanding of nature and science. Yet, while Marxism in the Soviet Union continued to embrace natural science, its analysis often assumed a dogmatic character, combined with an exaggerated technological optimism. This rigidity was reinforced by Lysenkoism, which criticized Darwinian natural selection and Mendelian genetics, and took on a politically repressive role during the purges of the scientific community in the Stalin period.¹⁷

In contrast, the philosophical tradition known as Western Marxism dissociated Marxism and the dialectic from questions of nature and science, claiming that dialectical reasoning, given its reflexive character, applied to human consciousness (and human society) only and could not be applied to the external natural world.¹⁸ Hence, Western Marxists, as represented most notably in this respect by the Frankfurt School, developed ecological critiques that were largely philosophical and abstract, closely related to ethical concerns that were later to dominate Green philosophy, but distant from ecological science and issues of materialism. Neglect of natural-scientific developments and a strong anti-technology bent placed sharp limits on the contributions of most Western Marxists to an ecological dialogue.

From the 1950s to 1970s, when the modern environmental movement first developed, some pioneering environmental thinkers, such as radical ecological economist K. William Kapp and socialist biologist Barry Commoner, reached back to Marx's idea of metabolic rift in explaining ecological contradictions.¹⁹ However, in the 1980s, a distinct tradition of ecosocialism arose in the work of major New Left figures, including British sociologist Ted Benton and French social philosopher André Gorz. These important, early ecosocialist thinkers employed the new ecologism of Green theory to criticize Marx for allegedly failing to address questions of sustainability. In Benton's view, Marx, in his critique of Thomas Malthus, had thrown the baby out with the bathwater, downplaying and even denying natural limits.²⁰ The response these thinkers offered was to graft the general assumptions of mainstream Green thought (including Malthusian notions) onto Marxian class analysis. The journal *Capitalism Nature Socialism*, founded by Marxian economist James O'Connor in the late 1980s, generally denied any meaningful relation to ecology in Marx's work itself, insisting that prevailing ecological concepts should simply be joined, in a centaur-like fashion, with Marxian class-based perspectives—a position known today as "first-stage ecosocialism."²¹

The hybrid approach changed in the late 1990s when others, most notably Paul Burkett, demonstrated the deep ecological context in which Marx's original critique had been constructed.

The new analysis included the systematic reconstruction of Marx's argument on social metabolism. The result was the development of important Marxian ecological concepts, together with a reunification of Marxian theory. Hence, "second-stage ecosocialists," or ecological Marxists, like Burkett have reincorporated Engels's major contributions to ecological thought, associated with his explorations of the dialectics of nature, into the core of Marxian theory, seeing Marx and Engels's work as complementary.²²

More recently, the importance of late Soviet ecology has come to light. Despite its tortuous history, Soviet science, particularly in the post-Stalin period, continued to give rise to a dialectical understanding of interdependent natural and historical processes. A key innovation was the concept of biogeocoenosis (equivalent to ecosystem but emerging from the Vernadsky tradition of the impact of life on the earth), developed in the early 1940s by the botanist and silviculturalist Nikolaevich Sukachev. Another critical systemic insight was Soviet climatologist Michael Budyko's discovery in the early 1960s of the albedo-ice feedback, which made climate change a pressing issue for the first time. By the 1970s, recognition of "global ecology" as a distinct problem related to the Earth system grew in the Soviet Union—in some respects, ahead of the West. It is not by chance that the word "Anthropocene" first appeared in English in the early 1970s in *The Great Soviet Encyclopedia*.²³

Marxism and Ecological Economics

By the dawn of the twenty-first century, awareness of Marx's ecological analysis inspired a radical reappraisal of Marxism in line with classical foundations of historical materialism and its underlying ecological framework. For a long time, Marxian thinkers, particularly in the West, had lamented that Marx had wasted much time and energy on what then seemed to be esoteric topics related to science and unrelated to the presumed narrow social-scientific bases of his own theory. Marx attended with great interest some of the lectures on solar energy by British physicist John Tyndall, over the course of which Tyndall reported on his experiments demonstrating for the first time that carbon dioxide emissions contributed to the greenhouse effect. Marx also took detailed notes on how the shifting isotherms on the earth's surface due to climate change led to species extinction over the course of earth history. He noted how anthropogenic regional climate change in the form of desertification contributed to the fall of ancient civilizations, and considered the way this would likely play out within capitalism.²⁴ Today, the rise of socialist ecology in response to changing conditions has led to a growing appreciation—as Luxemburg anticipated—of such wider aspects of Marx's science and their essential role in his system of thought.

Marx's (and Engels's) approach to ecological economics took shape from a critique of production, and particularly capitalist commodity production. All commodities were conceived as having the dual forms of use value and exchange value, related respectively to natural-material conditions and monetary-exchange valuations. Marx saw the antagonistic tension between use value and exchange value as key to both the internal contradictions of capitalism and its conflict with its external natural environment. He insisted that nature and labor together constituted the dual sources of all wealth. By incorporating only labor (or human services) into economic value calculations, capitalism ensured that the ecological and social costs of production would be excluded from the bottom line. Indeed, classical liberal political economy, Marx argued, treated the natural conditions of production (raw materials, energy, the fertility of the soil, etc.) as "free gifts of nature" to capital. He based the critique on an open-system thermodynamics, in which production is constrained by a solar budget and by limited supplies of fossil fuels—referred to by Engels as "past solar heat"—that was being systematically "squandered."²⁵

In Marx's critique, the social metabolism, i.e., the labor-and-production process, necessarily drew its

energy and resources from the larger universal metabolism of nature. However, the antagonistic form of capitalist production—treating natural boundaries as mere barriers to be surmounted—led inexorably to a metabolic rift, systematically undermining the ecological foundations of human existence. “By destroying the circumstances of this metabolism” related to “the eternal natural condition” governing human production, this same process, Marx wrote, “compels its systematic restoration as a regulative law of social production, and in a form adequate to the human race”—albeit in a future society transcending capitalist commodity production.²⁶

Central to the destructive dynamic was capital’s inherent drive to accumulate on an ever greater scale. Capital as a system was intrinsically geared to the maximum possible accumulation and throughput of matter and energy, regardless of human needs or natural limits.²⁷ In Marx’s understanding of the capitalist economy, the correlation of material flows (related to use value) and labor-value flows (related to exchange value) leads to an intensifying contradiction between the imperatives of environmental resilience and economic growth.

Burkett delineates two different sources of such imbalance underpinning ecological crisis theory in Marx. One of these takes the form of economic crises associated with resource scarcities and the concomitant increases in costs on the supply side, which squeeze profit margins. Ecological crises of this kind have a negative effect on accumulation, and naturally lead to responses on the part of capital, e.g., energy conservation as an economizing measure.

The other type, the ecological crisis proper, is quite different, and is most fully developed in Marx’s conception of the metabolic rift. It concerns the interplay between the degradation of the environment and human development in ways not accounted for in standard economic metrics like GDP. For example, the extinction of species or the destruction of whole ecosystems is logically compatible with the expansion of capitalist production and economic growth. Such negative ecological impacts are designated as “externalities” since nature is treated as a free gift. As a result, no direct feedback mechanism intrinsic to the capitalist system prevents environmental degradation on a planetary scale.

A distinctive characteristic of Marxian ecological theory has been an emphasis on unequal ecological exchange, or ecological imperialism, in which it is understood that one country can ecologically exploit another. This can be seen in Marx’s famous reference to how, for more than a century, England had “indirectly exported the soil of Ireland,” undermining the long-term fertility of Irish agriculture. In recent years, Marxian theorists have extended this analysis of ecological imperialism, coming to see it as integral to all attempts to address the ecological problem.²⁸

Marxian Rift Analysis and Planetary Boundaries

As described above, Marx’s theory of metabolic rift grew out of a response to this nineteenth century crisis of soil fertility. The problems of accelerated tempo, increasing scale, and spatial disjuncture (separation of town and country) in capitalist production were already systematically stressed by Marx in the mid-nineteenth century. In recent years, Marxian theorists have built on this perspective to explore the global rift in the carbon metabolism and a host of other sustainability issues.²⁹ For several decades, socialist ecologists have argued that capitalism has generated an acceleration of the human transformation of the Earth system, occurring in two major phases: (1) the industrial revolution beginning at the end of the eighteenth century and (2) the rise of monopoly capitalism, particularly in its mature stage following the Second World War—including the post-war scientific-technical revolution marked by the development of nuclear power and widespread commercial use of synthetic chemicals.³⁰

Thus, socialist ecological theorists were quick to embrace the explanatory power of the Anthropocene, which highlights the epoch-making emergence of modern human society as the major planetary geological force governing changes in the Earth system. Closely related to this rich insight, leading Earth System scientists introduced the planetary boundaries framework in 2009 to delineate a safe space for humanity defined by nine planetary boundaries, most of which are currently in the process of being crossed. In our 2010 book *The Ecological Rift*, Brett Clark, Richard York, and I integrated the Marxian metabolic rift analysis with the planetary-boundaries framework, describing it as rifts in the Earth system. In this view, today's planetary emergency could be called "the global ecological rift," encapsulating the disruption and destabilization of the human relationship to nature on a planetary scale which arises from the process of capital accumulation without end.³¹

The Great Convergence

The integrative concept of "the global ecological rift" represents a growing convergence of Marxian ecological analysis with Earth system theory and the Great Transition perspective, which share a complex, interconnected evolution. Marxian ecologists today start with the critique of economic growth (in its more abstract characterization) or capital accumulation (viewed more concretely). Continued exponential economic growth cannot occur without expanding rifts in the Earth system. Therefore, society, particularly in rich countries, must move towards a stationary state or steady-state economy, which requires a shift to an economy without net capital formation, one that stays within the solar budget. Development, particularly in the rich economies, must assume a new form: qualitative, collective, and cultural—emphasizing sustainable human development in harmony with Marx's original view of socialism. As Lewis Mumford argued, a stationary state, promoting ecological ends, requires for its fulfillment the egalitarian conditions of "basic communism," with production determined "according to need, not according to ability or productive contribution."³² Such a shift away from capital accumulation and towards a system of meeting collective needs based on the principle of enough is obviously impossible in any meaningful sense under the regime of capital accumulation. What is required, then, is an ecological and social revolution that will facilitate a society of ecological sustainability and substantive equality.

If the objective necessity of such an ecological revolution is now clear, the more difficult question of how to carry out the necessary social transformations remains. The ecosocialist movement has adopted the slogan System Change Not Climate Change, but a capitalist system deeply entrenched worldwide infuses the current omnipresent reality. The dominance of the capitalist mode of production means that revolutionary change on the scale needed to confront the planetary environmental emergency remains beyond the immediate social horizon.

However, we need to take seriously the nonlinear, contingent relation of everything related to human development. The conservative nineteenth-century cultural theorist Jacob Burckhardt used the term "historical crisis" to refer to situations in which "a crisis in the whole state of things is produced, involving whole epochs and all or many peoples of the same civilization." He explained, "The historical process is suddenly accelerated in terrifying fashion. Developments which otherwise take centuries seem to flit by like phantoms in months or weeks, and are fulfilled."³³ That revolutionary accelerations of the historical process have occurred in the past around the organization of human society itself is not to be doubted. We can point not only to the great political revolutions, but also beyond, to such fundamental transformations in production as the original Agricultural Revolution and the Industrial Revolution. Today, we need an Ecological Revolution equivalent in depth and scope to these earlier transformations.

The obvious difficulty is the speed—and, in some respects, irreversibility—of encroaching environmental havoc. The concomitant acceleration of the historical process to address the crisis must therefore start now. Underestimating the scale of the problem will prove fatal. In order to avoid hitting the trillionth cumulative tonne of combusted carbon, equivalent to a 2° C increase in global temperature, carbon emissions must fall by a rate of around 3 percent per annum globally. This would require rich nations to cut their emissions by more than twice that rate, a truly daunting challenge. As always, we must act with the tools we have, and remember that no mere technical fix can solve a problem based in the systematic maximization of exponential economic growth ad infinitum. Hence, “a revolutionary reconstitution of society at large,” altering the system of social-metabolic reproduction, provides the only alternative to the impending “common ruin of the contending classes.”³⁴

For Marxist ecological thinkers, this dire state of affairs has led to the development of a two-stage strategy for ecological and social revolution. The first stage focuses on “What Can Be Done Now?”—that is, on what is realistic in the short term under present-day conditions, while necessarily going against the logic of capital accumulation. This could be considered the ecodemocratic phase in the worldwide ecological revolution. Under prevailing conditions, a wide array of drastic changes needs to be fought for within a broad-based radical movement.³⁵ Such an effort would need to include measures like the following: a carbon-fee-and-dividend system, with 100 percent of the revenue being redistributed back to the population on a per capita basis; a ban on coal fired plants and unconventional fossil fuels (such as tar sands oil); a vast shift to solar and wind power and other sustainable energy alternatives, such as energy efficiency, financed by cutbacks in military spending; a moratorium on economic growth in the rich economies in order to reduce carbon emissions, coupled with radical redistribution (and measures to protect the less well-off); and a new international climate negotiation process modeled on the egalitarian and ecocentric principles of the Peoples’ Agreement of the World Peoples’ Conference on Climate Change in Bolivia in 2010.³⁶

These emergency measures all run against the prevailing logic of capital accumulation, but nevertheless can conceivably be advanced under present conditions. Along with a wide array of similar initiatives, such measures constitute the rational and realistic starting point for an ecological and social revolution, and a means with which to mobilize the general public. We cannot replace the whole system overnight. The battle must start in the present and extend into the future, accelerating in the mid-term and ending with a new social metabolism geared to sustainable human development.

The long term goal of systemic transformation raises the issue of a second stage of ecological revolution, or the ecosocialist phase. The primary question, of course, is the historical conditions under which this change can come about. Marx referred to the environmental pressures of his day as an “unconscious socialist tendency,” which would require associated producers to regulate the social metabolism with nature in a rational way.³⁷ This tendency, however, can only be realized as the result of a revolution carried out by the greater part of humanity, establishing more egalitarian conditions and processes for governing global society, including the requisite ecological, social, and economic planning.

In the not-too-distant future, an “environmental proletariat”—signs of which are already present—will almost inevitably emerge from the combination of ecological degradation and economic hardship, particularly at the bottom of society. In these circumstances, the material crises affecting people’s lives will become increasingly indistinguishable in their manifold ecological and economic effects (e.g., food crises). Such conditions will compel the working population of the earth to revolt against the system. What we often misleadingly call the “middle class”—those above the working poor but with little vested interest in the system—will doubtless be drawn into this struggle too. As in all revolutionary situations, some of the more enlightened elements of the ruling class will surely abandon their class interests in favor of humanity and the earth. Since the challenge of

maintaining a resilient earth will face the younger generations the most, we can expect that youth will become disenchanted and radicalized as the material conditions of existence deteriorate. Historically, women have been especially concerned with issues of natural and social reproduction and will undoubtedly be at the forefront of the struggle for a more ecologically oriented global society as well.

In this Great Transition, I believe socialists will play the leading role, even as the meaning of socialism evolves, taking on a wider connotation in the course of the struggle. The great artist, writer, and socialist William Morris famously declared, "Men fight and lose the battle, and the thing they fought for comes about in spite of their defeat, and when it comes turns out not to be what they meant, and other men have to fight for what they meant under another name."³⁸ Today, the age-old struggle for human freedom and meaning has reached an endgame. In the new epoch before us, our task is clear: to fight for equitable and sustainable human development in lasting accord with the earth.

John Bellamy Foster, October 2015

Endnotes

1. Paul Raskin, *The Great Transition Today: A Report from the Future* (Boston: Tellus Institute, 2006), http://www.greattransition.org/archives/papers/The_Great_Transition_Today.pdf
2. See Paul Burkett, "Marx's Vision of Sustainable Human Development," *Monthly Review* 57, no. 5 (October 2005): 34-62.
3. Frederick Engels, *The Dialectics of Nature*, in Karl Marx and Frederick Engels, *Collected Works*, vol. 25 ([1873-1882]; New York: International Publishers, 1975), 460-461.
4. Frank Benjamin Golley, *A History of the Ecosystem Concept in Ecology* (New Haven, CT: Yale University Press, 1993), 2, 207.
5. On Liebig's ecological critique, see John Bellamy Foster, *Marx's Ecology: Materialism and Nature* (New York: Monthly Review Press, 2000), 149-154.
6. Julius von Mayer, "The Motions of Organisms and Their Relation to Metabolism," in Julius Robert Mayer: *Prophet of Energy*, ed. Robert B. Lindsey ([1845]; New York: Pergamon Press, 1973), 75-145.
7. Roland Daniels, *Mikrokosmos* ([1851]; New York: Verlag Peter Lang, 1988), 49.
8. Karl Marx, *Capital*, vol. 3 ([1863-1865]; London: Penguin, 1981), 949; Karl Marx, *Economic Manuscript of 1861-1863*, in Karl Marx and Frederick Engels, *Collected Works*, vol. 30 ([1861-1863]; New York: International Publishers, 1975), 54-66.
9. Ravi Bhandari, "Marxian Economics: The Oldest Systems Theory is New Again (or Always)?" *Institute for New Economics*, April 9, 2015, <http://ineteconomics.org/ideas-papers/blog/marxian-economics-the-oldest-systems-theory-is-new-again-or-always>.
10. E. Ray Lankester, *Science from an Easy Chair* (New York: Henry Holt & Co., 1913), 365-379; Joseph Lester, *E. Ray Lankester and the Making of Modern British Biology* (Oxford: British Society for the History of Science, 1995).
11. Arthur G. Tansley, "The Use and Abuse of Vegetational Concepts and Terms," *Ecology* 16, no. 3

- (July 1935): 284-307; Peder Anker, *Imperial Ecology: Environmental Order in the British Empire, 1895-1945* (Cambridge, MA: Harvard University Press, 2001).
12. Tansley, "Use and Abuse," 303-304; Hyman Levy, *The Universe of Science* (London: Watts & Co., 1932).
13. Lynn Margulis, et. al., "Foreword," in Vladimir I. Vernadsky, *The Biosphere*, trans. D.B. Langmuir ([1926]; New York: Springer-Verlag, 1998), 15.
14. Nikolai Bukharin, "Theory and Practice from the Standpoint of Dialectical Materialism," in Bukharin, et. al, *Science at the Crossroads: Papers Presented to the International Congress of the History of Science and technology Held in London from June 29th to July 3rd, 1931 by the delegates of the U.S.S.R* (London: Frank Cass & Co., 1931), 17.
15. Karl Marx, *Capital*, vol. 1 ([1867]; London: Penguin, 1976), 637; *Capital*, vol. 3, 754, 911, 949, 959.
16. Rosa Luxemburg, "Stagnation and Progress of Marxism," in Luxemburg, Rosa Luxemburg *Speaks* ([1903]; New York: Pathfinder Press, 1970), 111.
17. For an informed and balanced discussion of Lysenkoism, see Richard Levins and Richard Lewontin, *The Dialectical Biologist* (Cambridge, MA: Harvard University Press, 1985), 163-196.
18. See Russell Jacoby, "Western Marxism," in *A Dictionary of Marxist Thought*, ed. Tom Bottomore (Oxford, UK: Blackwell, 1983), 523-526.
19. K. William Kapp, *The Social Costs of Private Enterprise* (Cambridge, MA: Harvard University Press, 1950), 35-36; Barry Commoner, *The Closing Circle: Nature, Man, and Technology* (New York: Alfred A. Knopf, 1971), 280.
20. Ted Benton, "Marxism and Natural Limits," *New Left Review* no. 178 (December 1989): 51-86; André Gorz, *Capitalism, Socialism, Ecology* (London: Verso, 1994).
21. See John Bellamy Foster, "Foreword," in Paul Burkett, *Marx and Nature: A Red and Green Perspective* (New York: St. Martin's Press, 1999; Chicago: Haymarket, 2014), vii-xiii.
22. Burkett, *Marx and Nature*.
23. John Bellamy Foster, "Late Soviet Ecology," *Monthly Review* 67, no. 2 (June 2015): 20; M.I. Budyko, *Global Ecology* ([1977]; Moscow: Progress Publishers, 1980); E.V. Shantser, "The Anthropogenic System (Period)," *Great Soviet Encyclopedia*, vol. 2 (New York: Macmillan, 1973; translation of third edition), 140.
24. On these aspects of Marx's thought, see John Bellamy Foster, "Capitalism and the Accumulation of Catastrophe," *Monthly Review* 63, no. 7 (December 2011): 1-17.
25. Frederick Engels, "Engels to Marx, December 19, 1882," in Marx and Engels, *Collected Works*, vol. 46, 411; John Bellamy Foster, Brett Clark, and Richard York, *The Ecological Rift: Capitalism's War on the Earth* (New York: Monthly Review Press, 2010), 61-64.
26. Marx, *Capital*, vol. 1, 637-638; Karl Marx, *Grundrisse: Outlines of the Critique of Political Economy* ([1857-1858]; London: Penguin, 1973), 334-335.

27. Marx, *Capital*, vol. 1, 742; Foster, Clark, and York, *The Ecological Rift*, 207-11.
28. Marx, *Capital*, vol. 1, 860; Foster, Clark, and York, *The Ecological Rift*, 345-72; John Bellamy Foster and Hannah Holleman, "The Theory of Unequal Ecological Exchange: A Marx-Odum Dialectic," *The Journal of Peasant Studies* 41, no. 1-2 (March 2014): 199-233.
29. See, for example, Stefano Longo, Rebecca Clausen, and Brett Clark, *The Tragedy of the Commodity: Oceans, Fisheries, and Aquaculture* (New Brunswick, NJ: Rutgers University Press, 2015). See also Ryan Wishart, Jamil Jonna, and Jordan Besek, "The Metabolic Rift: A Select Bibliography," *Monthly Review*, October 16, 2013, <http://monthlyreview.org/commentary/metabolic-rift>.
30. See Ian Angus, "When Did the Anthropocene Begin...and Why Does It Matter?" *Monthly Review* 67, no. 4 (September 2015): 1-11; John Bellamy Foster, *The Vulnerable Planet: A Short Economic History of the Environment* (New York: Monthly Review Press, 1994), 108.
31. Foster, Clark, and York, *The Ecological Rift*, 14-15, 18; Johan Rockström, et. al., "A Safe Operating Space for Humanity," *Nature* 461, no. 24 (September 2009): 472-475.
32. Lewis Mumford, *The Condition of Man* (1944; New York: Harcourt Brace Jovanovich, 1973), 411. Mumford, interestingly, was drawing here on both Mill's *Principles of Political Economy* (1848) and Marx's *Critique of the Gotha Programme* (1875).
33. Jacob Burckhardt, *Reflections on History* ([1869]; Indianapolis: Liberty Press, 1979), 214.
34. Karl Marx and Frederick Engels, *The Communist Manifesto* (London, 1848; New York: Monthly Review Press, 1964), 2. On the concept of socio-metabolic reproduction, see István Mészáros, *Beyond Capital: Toward a Theory of Transition* (New York: Monthly Review Press, 1995), 170-187.
35. These and other proposals are developed in Fred Magdoff and John Bellamy Foster, *What Every Environmentalist Needs to Know About Capitalism: A Citizen's Guide to Capitalism and the Environment* (New York: Monthly Review Press, 2011), 124-33.
36. *Ibid.*
37. Karl Marx, "Marx to Engels, March 25, 1868," in Marx and Engels, *Collected Works*, vol. 42, 558-59.
38. William Morris, *A Dream of John Ball* in Morris, *Three Works* ([1888]; London: Lawrence and Wishart, 1986), 53.

P.S.

* "Marxism and Ecology: Common Fonts of a Great Transition":
<http://www.greattransition.org/publication/marxism-and-ecology>