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Marx's Ecological Notebooks

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Karl Marx has long been criticized for his so-called ecological "Prometheanism"—an extreme commitment to industrialism, irrespective of natural limits. This view, supported even by a number of Marxists, such as Ted Benton and Michael Löwy, has become increasingly hard to accept after a series of careful and stimulating analyses of the ecological dimensions of Marx's thought, elaborated in *Monthly Review* and elsewhere. The Prometheanism debate is not a mere philological issue, but a highly practical one, as capitalism faces environmental crises on a global scale, without any concrete solutions. Any such solutions will likely come from the various ecological movements emerging worldwide, some of which explicitly question the capitalist mode of production. Now more than ever, therefore, the rediscovery of a Marxian ecology is of great importance to the development of new forms of left strategy and struggle against global capitalism.

Yet there is hardly unambiguous agreement among leftists about the extent to which Marx's critique can provide a theoretical basis for these new ecological struggles. "First-stage ecosocialists," in John Bellamy Foster's categorization, such as André Gorz, James O'Connor, and Alain Lipietz, recognize Marx's contributions on ecological issues to some extent, but at the same time argue that his nineteenth-century analyses are too incomplete and dated to be of real relevance today. In contrast, "second-stage ecosocialists," such as Foster and Paul Burkett, emphasize the contemporary methodological significance of Marx's ecological critique of capitalism, based on his theories of value and reification.[1]

This article will take a different approach, and investigate Marx's natural-scientific notebooks, especially those of 1868, which will be published for the first time in volume four, section eighteen of the new *Marx-Engels-Gesamtausgabe* (MEGA).[2] As Burkett and Foster rightly emphasize, Marx's notebooks allow us to see clearly his interests and preoccupations before and after the publication of the first volume of *Capital* in 1867, and the directions he might have taken through his intensive research into disciplines such as biology, chemistry, geology, and mineralogy, much of which he was not able fully to integrate into *Capital*.[3] While the grand

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project of *Capital* would remain unfinished, in the final fifteen years of his life Marx filled an enormous number of notebooks with fragments and excerpts. In fact, a third of his notebooks date to this period, and almost one half of them deal with natural sciences. The intensity and scope of Marx's scientific studies is astonishing. Thus it is simply invalid to conclude, as some critics have, that Marx's powerful ecological arguments in *Capital* and other writings were mere asides, while ignoring the mass of contrary evidence to be found in his late natural-scientific researches.

Looking at the notebooks after 1868, one can immediately recognize the rapid expansion of Marx's ecological interests. I will argue that Marx's critique of political economy, if completed, would have put a much stronger emphasis on the disturbance of the "metabolic interaction" (*Stoffwechsel*) between humanity and nature as the fundamental contradiction within capitalism. Furthermore, the deepening of Marx's ecological interests serves to complicate Liebig's critique of the modern "robbery system," which I discuss below. The centrality of ecology to Marx's late writings remained hard to discern for a long time because he was never able to complete his *magnum opus*. The newly published notebooks promise to help us comprehend these hidden but vital aspects of Marx's lifelong project.

Marx and Liebig in Different Editions of *Capital*

It is by now a well-known fact that Marx's critique of the irrationality of modern agriculture in *Capital* is deeply informed by Justus von Liebig's *Agricultural Chemistry* and James F. W. Johnston's *Notes on North America*, works which argue that neglect of the natural laws of soils inevitably leads to their exhaustion.[4] After intensive study of these books in 1865–66, Marx integrated Liebig's central ideas into volume one of *Capital*. In a section called "Modern Industry and Agriculture," Marx wrote that the capitalist mode of production

> collects the population together in great centres, and causes the urban population to achieve an ever-growing preponderance…. [It] disturbs the metabolic interaction between man and the earth, i.e., it prevents the return to the soil of its constituent elements consumed by man in the form of food and clothing; hence it hinders the operation of the eternal natural condition for the lasting fertility of the soil. Thus it destroys at the same time the physical health of the urban worker, and the intellectual life of the rural worker.[5]

This justly famous passage has become the cornerstone of recent "metabolic rift" analyses.[6] In a footnote to this section, Marx openly expresses his debt to the seventh edition of Liebig's *Agricultural Chemistry*, published in 1862: "To have developed from the point of view of natural science the negative, i.e., destructive side of modern agriculture, is one of Liebig's

immortal merits." Such remarks are the reason the "metabolic rift" approach has focused on Liebig's critique of modern agriculture as an intellectual source for Marx's ecological critique of capitalism.

However, it is hardly known that in the first German edition of *Capital* (1867), which is unfortunately not available in English, Marx went on to state that Liebig's "brief comments on the history of agriculture, although not free from gross errors, contain more flashes of insight than all the works of modern political economists put together [*mehr Lichtblicke als die Schriften sämmtlicher modernen politischen Oekonomen zusammengenommen*]."[7] A careful reader may immediately notice a difference between this version and later editions, although it was pointed out only recently by a German MEGA editor, Carl-Erich Vollgraf.[8] Marx modified this sentence in the second edition of *Capital* published in 1872–73. Consequently, we usually only read: "His brief comments…although not free from gross errors, *contain flashes of insight*."[9] Marx has deleted the statement that Liebig was more insightful "than all the works of modern political economists put together." Why did Marx soften his endorsement of Liebig's contributions relative to classical political economy?

One might argue that this elimination is only a trivial change, meant to clarify Liebig's original contributions in the field of agricultural chemistry and separate them from political economy, where the great chemist made some "gross errors." Also Marx, as these pages show, was very enthusiastic about one particular political economist's understanding of the soil problem, namely James Anderson, who, unlike other classical political economists, examined issues of the destruction of the soil. It was Liebig's own recognition of "the destructive side of modern agriculture," which Marx characterized as "one of Liebig's immortal merits." Hence, Marx might have thought that his expression in the first edition of *Capital* was rather exaggerated.

Nonetheless, it should also be noted that Liebig's *Agricultural Chemistry* was eagerly discussed by a number of political economists at the time, precisely because of his alleged contributions to political economy, especially ground-rent theory and population theory.[10] For example, the German economist Wilhelm Roscher recognized the relevance of Liebig's mineral theory to political economy even before Marx, and added some passages and notes dedicated to Liebig in his fourth edition of *National Economy of Agriculture and the Related Branches of Natural Production* [*Nationalökonomie des Ackerbaues und der verwandten Urproductionen*] (1865), in order to integrate Liebig's new agricultural findings into his own system of political economy. Notably, Roscher praises Liebig in similar terms: "Even if many of Liebig's historical assertions are highly disputable…even if he misses

some important facts of national economy, the name of this great natural scientist will always maintain a place of honor comparable to the name of Alexander Humboldt in the history of national economy as well."[11] In fact, it is very likely that Roscher's book prompted Marx to reread Liebig's *Agricultural Chemistry* in 1865–66. Both authors' similar remarks reflect a widespread opinion about Liebig's *Agricultural Chemistry* at the time.

Furthermore, it is reasonable to assume that Marx in the first edition of *Capital* was intentionally comparing Liebig to those political economists who postulated a trans-historical and linear development of agriculture, whether from more productive to less productive soils (Malthus, Ricardo, and J. S. Mill), or from less productive to more productive (Carey and later Dühring). Liebig's critique of the "robbery system" of cultivation instead denounces precisely the *modern form* of agriculture and its decreasing productivity as a result of the irrational and destructive use of the soil. In other words, Liebig's historicization of modern agriculture provides Marx with a useful natural scientific basis for rejecting abstract and linear treatments of agricultural development.

Yet as seen earlier, Marx somewhat relativizes Liebig's contribution to political economy between 1867 and 1872–73. Could it be that Marx had doubts about Liebig's chemistry as well as his economic errors? In this context, close study of Marx's letters and notebooks helps us comprehend the larger aims and methods of his research after 1868.

Debates on Liebig's Agricultural Chemistry

Looking at the letters and notebooks from this period, it seems more probable that the change regarding Liebig's contribution in the second edition represented more than a mere correction. Marx was well aware of the heated debates surrounding Liebig's *Agricultural Chemistry*, so after the publication of the first volume of *Capital*, he thought it necessary to follow up on the validity of Liebig's theory. In a letter to Engels dated January 3, 1868, Marx asked him to seek some advice from a long-time friend and chemist, Carl Schorlemmer:

> I would like to know from Schorlemmer what is the latest and best book (German) on agricultural chemistry. Furthermore, what is the present state of the argument between the mineral-fertilizer people and the nitrogen-fertilizer people? (Since I last looked into the subject, all sorts of new things have appeared in Germany.) Does he know anything about the most recent Germans who have written *against* Liebig's soil-exhaustion theory? Does he know about the alluvion theory of Munich agronomist Fraas (Professor at Munich University)? For the chapter on ground rent I shall have to be aware of the latest state of the question, at least to some extent.[12]

Marx's remarks in this letter clearly indicate his aim at the beginning of 1868 to study books on agriculture. He is not just looking for the recent literature on agriculture in general, but pays particular attention to debates and critiques of Liebig's *Agricultural Chemistry*. It is important to note that in the manuscript for volume three of *Capital*, Marx uncharacteristically points to the importance of Liebig's analysis while essentially indicating that this needs to be filled-in in the future. That is, this was part of the argument that he was continuing to research—and in such basic areas as "the declining productivity of the soil" related to discussions of the falling rate of profit.[13]

Liebig, often called the "father of organic chemistry," convincingly demonstrated that the healthy growth of plants requires both organic and inorganic substances, such as nitrogen, phosphoric acid, and potassium. He claimed, against dominant theories centered on humus (an organic component of soil made up of decayed plant and animal matter) or nitrogen, that *all* necessary substances must be provided in more than a "minimum amount," a proposition known as Liebig's "law of the minimum."[14] Although Liebig's insight into the role of inorganic substances remains valid today, two theses derived from it, the theories of mineral fertilization and of soil exhaustion, sparked immediate controversy.

According to Liebig, the amount of inorganic substances in soils remains limited without constant replenishment. It is thus necessary regularly to return to the soil those inorganic substances that plants have absorbed if one is to grow crops sustainably. (These can be returned in either inorganic forms or organic forms, which are converted [mineralized] into inorganic forms.) Liebig calls this necessity the "law of replacement," and holds that the full replacement of inorganic substances is the fundamental principle of sustainable agriculture. Since nature alone could not provide enough inorganic material when such a large quantity of nutrients was being removed annually, Liebig argued for the use of chemical mineral fertilizer. He maintained that not only the humus theory of Albrecht Daniel Thaer's *Principles of Practical Agriculture*, but also the nitrogen theory of John Bennett Lawes and Joseph Henry Gilbert were seriously flawed, because they gave no attention to the limited quantity of available inorganic substances in soil.

Based on his theory, Liebig warned that violations of the law of replacement and consequent soil exhaustion threatened the whole of European civilization. According to Liebig, modern industrialization created a new division of labor between town and countryside, so that foods consumed by the working class in large cities no longer return to and restore the original soils, but instead flow out into the river through water toilets

without any further use. In addition, through the commodification of agricultural products and fertilizer (bone and straw), the aim of agriculture diverges from sustainability and becomes the mere maximization of profits, squeezing soil nutrients into crops in the shortest possible period. Disturbed by these facts, Liebig denounced modern agriculture as a "robbery system," and warned that the disruption of the natural metabolic interaction would ultimately cause the decay of civilization. Shifting from his rather optimistic belief in the early to mid-1850s in the cure-all of chemical fertilization, Liebig's 1862 edition of *Agricultural Chemistry*, especially its new introduction, emphasized the destructive aspects of modern agriculture much more fervently.

As Liebig strengthened his critique of this robbery system in 1862 and corrected his earlier optimism, Marx understandably felt a need to review the debate on soil fertility from a new perspective. At the same time, Liebig's critique of the robbery system and soil exhaustion inspired a number of new arguments among scholars and agronomists. Marx's letter to Engels makes clear that even after the publication of volume one of *Capital*, he tried to examine the validity of Liebig's theory from a more critical perspective.

Notably, various political economists other than Marx and Roscher also joined in this debate. As described by Foster, Henry Charles Carey had already referred to wasteful agricultural production in the United States and claimed that the irresponsible "robbery from the earth" constituted a serious "crime" against future generations.[15] Liebig was also interested in Carey and cited his work extensively, but Marx may not have been entirely clear about their relationship when he read *Agricultural Chemistry* in 1865–66. Marx had corresponded with Carey, who had sent him his book on slavery, which contained some of his arguments about soil exhaustion, and Marx studied Carey's economic works.[16] However, Carey's role in the overall soil debate likely became more apparent when Marx encountered Eugen Dühring's work. Marx started studying Dühring's books in January 1868, after Louis Kugelmann sent him Dühring's review of *Capital*—the first review of the book anywhere—published in December 1867.

Dühring, a lecturer at the University of Berlin, was an enthusiastic supporter of Carey's economic system. He also integrated Liebig's theory into his economic analysis as further validation of Carey's proposal to establish autarchic town-communities in which producers and consumers live in harmony, without wasting plant nutrients and thus without exhausting soils. Dühring maintained that Liebig's theory of soil exhaustion "builds a pillar on [Carey's] system," and claimed that

> soil exhaustion, which has already become quite threatening in North America, for example, will…be halted in the long run only through a commercial policy built upon the protection and education of domestic labor. For the harmonious development of the various facilities of one nation…promotes the natural circulation of materials [*Kreislauf der Stoffe*] and makes it possible for plant nutrients to be returned to the soil from which they have been taken.[17]

In the manuscript for volume three of *Capital*, Marx envisioned a future society beyond the antagonism between town and country in which "the associated producers rationally regulat[e] their metabolic interchange with nature." He must have been surprised to learn that Dühring similarly demanded, as the "only countermeasure" against wasteful production, the "conscious regulation of material distribution" by overcoming the division between town and country.[18] In other words, Marx's claim, together with Dühring's, reflects a popular tendency of the "Liebig school" at the time. In subsequent years Marx's view of Dühring grew more critical, as Dühring began to promote his own system as the only true foundation of social democracy. This likely reinforced Marx's suspicion of Dühring's interpretation of soil exhaustion and its advocates, even if he continued to recognize the usefulness of Liebig's theory. In any case, at the beginning of 1868, the discursive constellation already prompted Marx to study books "*against* Liebig's soil-exhaustion theory."

Liebig's Malthusianism?

Marx was particularly concerned that Liebig's warnings about soil exhaustion carried a hint of Malthusianism. They rehabilitated, to borrow Dühring's expression, "Malthus's ghost," as Liebig appeared to provide a new "scientific" version of old Malthusian themes of food scarcity and overpopulation.[19] As noted above, the general tone of Liebig's argument shifted from one of optimism in the 1840s up through the mid-1850s to a quite pessimistic one in the late 1850s and 1860s. Sharply critical of British industrial agriculture, he predicted a dark future for European society, full of war and hunger, if the "law of replacement" continued to be ignored:

> In a few years, the guano reserves will be depleted, and then no scientific nor, so to speak, theoretical disputes will be necessary to prove the law of nature which demands from man that he cares for the preservation of living conditions.… For their self-preservation, nations will be compelled to slaughter and annihilate each other in never-ending wars in order to restore an equilibrium, and, God forbid, if two years of famine such as 1816 and 1817 succeed each other again, those who survive will see hundreds of thousands perish in the streets.[20]

Liebig's new pessimism appears quite distinct in this passage. While his view of modern agriculture as a "robbery system" shows its superiority over the widespread ahistorical "law of diminishing returns" of Malthus and Ricardo, his conclusion leaves his relation to Malthusian ideas ambiguous. Indeed, Marx was particularly concerned about Liebig's references to the Ricardian theory. Liebig in fact personally knew John Stuart Mill and may have been directly influenced by the latter. Ironically, however, as Marx points out, Ricardian rent theory originated not with Ricardo or even with Malthus—and certainly not with John Stuart Mill, as Liebig mistakenly supposes—but with James Anderson, who had given it a historical basis in the degradation of the soil. What worried Marx, then, was the frequent linking in his day of Liebig with Malthus and Ricardo—representing a logic opposed to Marx's own analysis, and which, in contrast to Malthus and Ricardo, emphasized the historical nature of the soil problem.[21]

The question of Liebig's Malthusianism may seem like an arcane detail in the larger debate over soil exhaustion, but it is one of the main reasons why his *Agricultural Chemistry* became so popular in 1862.[22] For Dühring, this Malthusianism was not so problematic because he believed that Carey's economic system had already dispelled "Malthus's ghost," showing that the development of society made it possible to cultivate better soils.[23] Of course, Marx could hardly accept this naïve presupposition, as he wrote to Engels in November 1869: "Carey ignores even the most familiar facts."[24]

Thus in 1868 Marx began reading the work of authors who took a more critical stance toward Liebig's *Agricultural Chemistry*. He was already familiar with arguments such as Roscher's, which held that the robbery system should be criticized from the point of view of "natural science" but could be *justified* from an "economic" standpoint insofar as it was more profitable.[25] According to Roscher, it was only necessary to stop the robbery just before it became too expensive to recover the original fertility of the soil—but market prices would take care of that. Adopting Roscher's arguments, Friedrich Albert Lange, a German philosopher, argued against Dühring's reception of Liebig and Carey in his *J. St. Mill's Views of the Social Question* [*J. St. Mills Ansichten über die sociale Frage*] published in 1866. Marx read Lange's book at the beginning of 1868, and it is no coincidence that his notebook focuses on its fourth chapter, where Lange discusses the problems of rent theory and soil exhaustion. Specifically, Marx noted Lange's observation that Carey and Dühring denounced "trade" with England as a cause of all evils and regarded a "protective tariff" as the ultimate "panacea," without Lange's recognizing that "industry" possesses a "centralizing tendency," which creates

not only the division of town and country but also economic inequality.[26] Similar to Roscher, Lange argued that "despite the natural scientific correctness of Liebig's theory," robbery cultivation can be justified from a "national economic" perspective.[27]

Related ideas can be also found in the work of the German economist Julius Au. Marx owned a copy of Au's *Supplementary Fertilizers and their Meaning for National and Private Economy* [*Hilfsdüngermittel in ihrer volks- und privatwirtschaftlichen Bedeutung*] (1869), which he marked up with marginal notes and comments.[28] Although he recognized the scientific value of Liebig's mineral theory, Au doubted that the theory of soil exhaustion could be regarded as an "absolute" natural law. It was instead, Au argued, a "relative" theory with little meaning for the economies of Russia, Poland, or Asia Minor, because in these areas agriculture could be sustained, presumably through extensive development, without following the "law of replacement."[29] Yet Au seemingly forgot that Liebig's main concern was Western European countries. Moreover, Au ended up uncritically accepting the price-regulation mechanisms of the market, which he, like Roscher, expected to hinder excessive exploitation of soil power because it would simply cease to be profitable. What remains of Liebig's theory for Lange and Au is the simple fact that soil could not be improved infinitely. They were, after all, neo-Malthusian supporters of overpopulation theory and the law of diminishing returns.

Reacting to all this, Marx comments "Idiot!" [*Asinus*!] and writes many incredulous question marks in his copy of Au's book.[30] His evaluation of Lange's books is similarly hostile, as he ironically comments on Lange's Malthusian explanation of history in his letter to Kugelmann dated July 27, 1870.[31] In addition, it is safe to assume that Marx was not attracted to the idea of realizing sustainable agriculture through fluctuations in market prices. Since Marx was also unable to support Carey and Dühring, he set out to study the problem of soil exhaustion more intensively in order to articulate a sophisticated critique of the modern robbery system.

To sum up: Marx thought at first that Liebig's description of the destructive effects of modern agriculture could be used as a powerful argument against Ricardo and Malthus's abstract law of diminishing returns, but began to question Liebig's theory after 1868, as the debates over soil exhaustion increasingly took on a Malthusian tone. Marx therefore backed off from his somewhat uncritical and exaggerated claim that Liebig's analyses "contain more flashes of insight than all the works of modern political economists put together," in preparation for the more extensive research into the problem that he clearly intended for volumes two and three of *Capital*.

Marx and Fraas's Theory of Metabolic Interaction

If Liebig's Malthusian tendencies constituted a negative reason for Marx's alteration of the sentence on Liebig in the second edition of *Capital*, there was also a more positive one: Marx encountered a number of authors who became as important as Liebig to his ecological critique of political economy. Carl Fraas was one of them. In a letter from January 1868, Marx asks Schorlemmer about Fraas, a German agriculturist and professor at the University of Munich. Although Shorlemmer could not offer any specific information about Fraas's "alluvion theory," Marx nevertheless began reading several books by Fraas in the following months.

Fraas's name first appears in Marx's notebook between December 1867 and January 1868, when he notes the title of Fraas's 1866 book *Agrarian Crises and Their Solutions* [*Die Ackerbaukrisen und ihre Heilmittel*], a polemic against Liebig's theory of soil exhaustion.[32] When Marx wrote in a letter to Engels in January 1868 that "since I last looked into the subject, all sorts of new things have appeared in Germany," he was likely thinking of Fraas's book.

Just as Fraas's book was published, his relations with Liebig grew very strained, after Liebig criticized the scientific ignorance of agricultural educators and practical farmers in Munich, where Fraas taught as a professor for many years. In response, Fraas defended the agrarian praxis in Munich, and argued that Liebig's theory had been oversold and represented a retreat into Malthusian theory—one that ignored various historical forms of agriculture that maintained and even increased productivity without causing soil exhaustion. According to Fraas, Liebig's pessimism arose from his tacit presupposition that *humans* must be able to return inorganic substances and thus the soil demanded—if the division between town and country is not to be dissolved—the introduction of artificial fertilizers, which, however, would turn out to be too costly. In contrast, Fraas suggests a more affordable method, using the power of *nature itself* in order to sustain the fertility of the soil, as represented in his "theory of alluvion."[33]

In Charles Lyell's definition, alluvion is "earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not permanently submerged beneath the waters of lakes or seas."[34] Alluvial materials contain large quantities of the mineral substances vital for plant growth. Consequently, soils developed from regular deposition of such materials—usually adjacent to rivers in valleys—produce rich crops year after year without fertilizer, as in the sandbanks of the Danube, the deltas of the Nile or the Po, or the tongues of land of the Mississippi. The rejuvenating sediments in floodwater are derived from erosion further up the watershed. Hence, the

richness of the alluvial soil is a result of the impoverishment of upriver soils, most likely from slopes of hills and mountains. Inspired by these examples in nature, Fraas suggests constructing an "artificial alluvion" by regulating river water through the building of temporary dams over agrarian fields, cheaply and almost eternally providing them with essential minerals. Marx's notebook confirms that he carefully studied Fraas's arguments for the practical merits of alluvion in agriculture.[35]

What interested Marx most about Fraas, however, was probably not the theory of alluvion. After reading Fraas eagerly, documenting various passages in his notebooks, Marx writes to Engels in a letter dated March 25, 1868, praising Fraas's book *Climate and the Plant World Over Time* [*Klima und Pflanzenwelt in der Zeit*]:

> Very interesting is the book by Fraas (1847): *Klima und Pflanzenwelt in der Zeit, eine Geschichte beider* [*Climate and the Plant World Over Time*], namely as proving that climate and flora change in *historical* times.… He claims that with cultivation—depending on its degree—the "moisture" so beloved by the peasants gets lost (hence also the plants migrate from south to north), and finally steppe formation occurs. The first effect of cultivation is useful, but finally devastating through deforestation, etc.… The conclusion is that cultivation—when it proceeds in natural growth and is not *consciously controlled* (as a bourgeois he naturally does not reach this point)—leaves deserts behind it, Persia, Mesopotamia, etc., Greece. So once again an unconscious socialist tendency![36]

It might seem surprising that Marx found even "an unconscious socialist tendency" in Fraas's book, despite Fraas's harsh critique of Liebig. *Climate and the Plant World Over Time* elaborated how ancient civilizations, especially ancient Greece—Fraas had spent seven years as an inspector of the court garden and professor of botany at the University of Athens—collapsed after unregulated deforestation caused unsustainable changes in the local environment. As indigenous plants could no longer adapt to the new environment, steppe formation or, in the worst case, desertification set in. (Although Fraas's interpretation was influential, some would argue today that what occurred was not "desertification" as such, but rather the growth of plants that required less moisture—because so much of the rainfall was lost as runoff instead of infiltrating into soil.)

In our context, it is first of all interesting to note that Fraas emphasized the significance of a "natural climate" for plant growth, because of its great influence on the weathering process of soils. It is therefore not enough simply to analyze the chemical composition of soil alone, because mechanical and chemical reactions in the soil, which are essential for the weathering process, depend heavily on climatic factors such as

temperature, humidity, and precipitation. This is why Fraas characterized his own research field and method as "agricultural physics," in clear contrast to Liebig's "agricultural chemistry."[37] According to Fraas, in certain areas where climatic conditions are more favorable and the soils are adjacent to rivers and flood regularly with water containing sediments, it is possible to produce large amounts of crops without fear of soil exhaustion, as nature automatically fulfills the "law of replacement" through alluvial deposits. This, of course, would apply to only some of the soils in any particular country.

After reading Fraas's books, Marx grew more interested in such "agricultural physics," as he told Engels: "We must keep a close watch on the recent and very latest in agriculture. The *physical* school is pitted against the *chemical*."[38] Here it is possible to discern a clear shift in Marx's interests. In January 1868, Marx was mainly following debates *within* the "chemical school," in terms of whether mineral or nitrogen fertilizer was more effective. As he had already studied the issue in 1861, he now thought it necessary to study recent developments "to some extent." After two and a half months and intensive examination of Fraas's works, however, Marx grouped both Liebig and Lawes into one and the same "chemical school" and treated Fraas's theory as an independent "physical" school. Notably, this categorization reflects Fraas's own judgment, for he complained that both Liebig and Lawes made abstract, one-sided arguments about soil exhaustion by putting too much emphasis on only the chemical component of plant growth.[39] As a result, Marx came to believe that he "must" study the newest developments in the field of agriculture much more carefully.

Fraas's uniqueness is also evident in his attention to the *human impact* on the process of historical climate change. Indeed, Fraas's book offers one of the earliest studies on the topic, later praised by George Perkins Marsh in *Man and Nature* (1864).[40] Drawing on ancient Greek texts, Fraas showed how plant species moved from south to north, or from the plains to the mountains, as local climates gradually grow hotter and dryer. According to Fraas, this climate change results from excessive deforestation demanded by ancient civilizations. Such stories of the disintegration of ancient societies also have obvious relevance for our contemporary situation.

Fraas likewise warned against the excessive use of timber by modern industry, a process already well underway during his time that would have a huge impact on European civilization. Marx's readings of Fraas introduced him to the problem of Europe's disappearing forests, as documented in his notebook: "France has now no more than one-twelfth of her earlier forest area, England only 4 big forests among 69 forests; in Italy and the southwestern European peninsula the stand of trees that was also common on

the plain in the past can be no longer found even in the mountains."[41] Fraas lamented that further technological development would enable the cutting of trees at higher mountain elevations and only accelerate deforestation.

Reading Fraas's book, Marx came to see a great tension between ecological sustainability and the ever-increasing demand for wood to fuel capitalist production. Marx's insight into the disturbance of "metabolic interaction" between human and nature in capitalism goes beyond the problem of soil exhaustion in Liebig's sense and extends to the issue of deforestation. Of course, as the second edition of *Capital* indicates, this does not mean that Marx abandoned Liebig's theory. On the contrary, he continued to honor Liebig's contribution as essential to his critique of modern agriculture. Nonetheless, when Marx wrote of an "unconscious socialist tendency" in Fraas's work, it is clear that Marx now regarded the rehabilitation of the metabolism between human and nature as a central project of socialism, with a much larger scope than in the first edition of volume one of *Capital*.

Marx's interest in deforestation was not limited to reading Fraas. In the beginning of 1868, he also read John D. Tuckett's *History of the Past and Present State of the Labouring Population*, noting the numbers of important pages. On one of those few pages Marx recorded, Tuckett argues:

> the indolence of our forefathers appears a subject of regret, in neglecting the raising of trees as well as in many instances causing the destruction of the forests without sufficiently replacing them with young plants. This general waste appears to have been greatest just before the use of sea coal [for smelting iron] was discovered when the consumption for the use of forging Iron, was so great that it appeared as if it would sweep down all the timber and woods in the country.… However at the present day the plantations of trees, not only add to the usefulness, but also tend to the embellishment of the country, and produce screens to break the rapid currants of the winds.… The great advantage in planting a large body of wood in a naked country is not at first perceived. Because there is nothing to resist the cold winds, cattle fed thereon are stunted in growth and the vegetation has often the appearance of being scorched with fire, or beat with a stick. Moreover by giving warmth and comfort to cattle, half the fodder will satisfy them.[42]

Forests play an important *economic* role in agriculture and stock farming, and this is clearly what interested Marx in 1868.

Although Marx does not directly mention either Fraas's or Tuckett's work after 1868, the influence of their ideas is clearly visible in the second manuscript for volume two of *Capital*, written between 1868 and 1870. Marx had already noted in the manuscript for volume three that deforestation would not be sustainable under the system of private property, even if it could be more or less sustainable when conducted

under state property.[43] After 1868, Marx paid greater attention to the problem of the modern robbery system, which he now expanded from crop production to include deforestation. In this vein, Marx cites Friedrich Kirchhof's *Manual of Agricultural Business Operations* [*Handbuch der landwirthschaftlichen Betriebslehre*] (1852), in support of the incompatibility between the logic of capital and the material characteristics of forestation.[44] He points out that the long time required for forestation imposes a natural limit, compelling capital to try to shorten the cycle of deforestation and regrowth as much as possible. In the manuscript to volume two of *Capital*, Marx comments on a passage from Kirchhof's book: "The development of culture and of industry in general has evinced itself in such energetic destruction of forest that everything done by it conversely for their preservation and restoration appears infinitesimal."[45] Marx is certainly conscious of the danger that this deforestation will cause not only a wood shortage but also a changing climate, which is tied to a more existential crisis of human civilization.

A comparison with the writing of the young Marx illustrates this dramatic development of his ecological thought. In the *Communist Manifesto*, Marx and Engels write of the historic changes brought by the power of capital:

> The bourgeoisie, during its rule of scarce one hundred years, has created more massive and more colossal productive forces than have all preceding generations together. Subjection of Nature's forces to man, machinery, application of chemistry to industry and agriculture, steam-navigation, railways, electric telegraphs, clearing of whole continents for cultivation, canalization of rivers, whole populations conjured out of the ground.[46]

Michael Löwy has criticized this passage as a manifestation of Marx and Engels's naïve attitude toward modernization and ignorance of ecological destruction under capitalist development: "Paying homage to the bourgeoisie for its unprecedented ability to develop the productive forces," he writes, "Marx and Engels unreservedly celebrated the 'Subjection of Nature's forces to man' and the 'clearing of whole continents for cultivation' by modern bourgeois production."[47] Löwy's reading of Marx's alleged "Prometheanism" might seem hard to refute here, although Foster provides another view.[48] However, Löwy's criticism, even if his interpretation accurately reflects Marx's thinking at the time, can hardly be generalized across Marx's entire career, since his critique of capitalism became steadily more ecological with each passing year. As seen above, the evolution of his thought subsequent to volume one of *Capital* shows that in his later years, Marx became seriously interested in the problem of deforestation, and it is highly doubtful that the late Marx would praise

mass deforestation in the name of progress, without regard to the conscious and sustainable regulation of the metabolic interaction between humanity and nature.

The Further Scope of Marx's Ecological Critique

Marx's ecological interests in this period also extended to stock farming. In 1865–66, he had already read Léonce de Lavergne's *Rural Economy of England, Scotland, and Ireland*, in which the French agricultural economist argued for the superiority of English agriculture. Lavergne offered as an example the English breeding process developed by Robert Bakewell, with its "system of selection," enabling sheep to grow faster and provide more meat, with only the bone mass necessary for their survival.[49] Marx's reaction in his notebook to this "improvement" is suggestive: "Characterized by precocity, in entirety sickliness, want of bone, a lot of development of fat and flesh etc. All these are artificial products. Disgusting!"[50] Such remarks belie any image of Marx as an uncritical supporter of modern technological advances.

Since the beginning of the nineteenth century, Bakewell's "New Leicester" sheep had been brought into Ireland, where they were bred with indigenous sheep to yield a new breed, Roscommon, meant to increase Ireland's agricultural productivity.[51] Marx was fully aware of this artificial modification of regional ecosystems for the purposes of capital accumulation, and rejected it despite its apparent "improvement" of productivity: the health and well-being of animals were being subordinated to the utility of capital. Thus Marx made clear in 1865 that this kind of "progress" was really no progress at all, because it could only be achieved by annihilating the sustainable metabolic interaction between humans and nature.

When Marx returned to the topic of capitalist stock farming in the second manuscript for volume two of *Capital*, he found it unsustainable for the same reason that marked capitalist forestation: The time of production is often simply too long for capital. Here Marx refers to William Walter Good's *Political, Agricultural and Commercial Fallacies* (1866):

> For this reason, remembering that farming is governed by the principles of political economy, the calves which used to come south from the dairying counties for rearing, are now largely sacrificed at times at a week and ten days old, in the shambles of Birmingham, Manchester, Liverpool, and other large neighboring towns.… What these little men now say, in reply to recommendations to rear, is, "We know very well it would pay to rear on milk, but it would first require us to put our hands in our purse, which we cannot do, and then we should have to wait a long time for a return, instead of getting it at once by dairying."[52]

No matter how fast the growth of cattle becomes, thanks to Bakewell and other breeders, it only shortens the time of premature slaughter in favor of a shorter turnover for capital. According to Marx, this too does not count as "development" of productive forces, precisely because it can only take place by sacrificing sustainability for the sake of short-term profit.

All these are just examples found in the notebooks of 1868. Marx at the time was also intrigued by William Stanley Jevons's *Coal Question* (1865), whose warning about the coming exhaustion of England's coal supply provoked intense discussion in the Parliament.[53] Without doubt, Marx was studying the books mentioned above as he prepared the manuscripts of *Capital*, and continued to do so into the 1870s and 1880s. So it is quite reasonable to conclude that Marx planned to use these new empirical materials to elaborate on issues such as the turnover of capital, rent theory, and the profit rate. In one passage, Marx actually writes that premature slaughter will ultimately cause "big damages" to agricultural production.[54] Or, as Marx discusses in another section of the manuscript of 1867–68, the exhaustion of soils or mines could also reach such an extent that the "diminishing natural condition of productivity" in agriculture and extractive industry could no longer be counterbalanced by increasing labor productivity.[55]

Not surprisingly, Marx's calculations of profit rates in the manuscript include those cases where profit rates sink due to price increases in the "floating" parts of constant capital, suggesting that the law of the falling profit rate should not be treated as a mere mathematical formula. Its real dynamic is tightly linked to the material components of capital and cannot be treated independently of them.[56] In other words, the valorization and accumulation of capital is not an abstract movement of value; capital is necessarily incarnated in material components, inevitably taking on an "organic composition"—a term taken from Liebig's *Agricultural Chemistry*—constrained by concrete material elements of the labor process. Despite its elasticity, this organic structure of capital cannot be arbitrarily modified, or made to diverge too far from the material character of each natural element of production. Capital ultimately cannot ignore the natural world.

This does not mean that capitalism will inevitably collapse one day. Fully exploiting the material elasticity, capital always tries to overcome limitations through scientific and technological innovation. Capitalism's potential for adaptation is so great that it can likely survive as a dominant social system until most parts of the earth become unsuitable for human habitation.[57] As Marx's notebooks on natural science document, he was particularly interested in comprehending the rifts in the process of metabolic interaction between humans and nature that result from endless

transformations of the material world for the sake of the efficient valorization of capital. These metabolic rifts are all the more disastrous because they erode the material conditions for "sustainable human development."[58]

Marx understood these rifts as a manifestation of the fundamental contradictions of capitalism, and thought it necessary to study them carefully as part of the building of a radical socialist movement. As shown in this article, Marx was well aware that the ecological critique of capitalism was not completed by Liebig's theory, and tried to develop and extend it by drawing on new research from diverse areas of ecology, agriculture, and botany. Marx's economic and ecological theory is not outdated at all, but remains fully open to new possibilities for integrating natural scientific knowledge with the critique of contemporary capitalism.

Notes

1. See John Bellamy Foster, preface to the new edition of Paul Burkett, *Marx and Nature* (Chicago: Haymarket, 2014).

2. Funding and support for the MEGA project has now been extended for the next 15 years. This article is based on my research as a visiting scholar at the Berlin-Brandenburg Academy of Sciences in 2015. I am especially thankful to Gerald Hubmann, who supported my project from the beginning.

3. Paul Burkett and John Bellamy Foster, "The Podolinsky Myth," *Historical Materialism* 16, no. 1 (2008): 115–61.

4. Foster, *Marx's Ecology* (New York: Monthly Review Press, 2000), chapter 4; Kohei Saito, "The Emergence of Marx's Critique of Modern Agriculture," *Monthly Review* 66, no. 5 (October 2014): 25–46.

5. Karl Marx and Frederick Engels, *Marx-Engels-Gesamtausgabe* (MEGA) II, vol. 6 (Berlin: De Gruyter, 1975), 409.

6. John Bellamy Foster, Brett Clark, and Richard York, *The Ecological Rift* (New York: Monthly Review Press, 2010), 7.

7. MEGA II, vol. 5, 410.

8. Carl-Erich Vollgraf, Introduction to MEGA II, vol. 4.3, 461. It is important, however, to note that Marx had said the same thing in a letter to Engels on February 13, 1866. See Karl Marx and Frederick Engels, *Collected Works* (New York: International Publishers, 1975), vol. 42, 227. There he wrote, "I had to plough through the new agricultural chemistry in Germany, in particular Liebig and Schönbein, which is more important for this matter than all the economists put together."

9. Karl Marx, *Capital*, vol. 1 (London: Penguin, 1976), 638; emphasis added.

10. Liebig's introduction includes a section called "National Economy and Agriculture"; Marx begins his excerpts with this section, then returns to the beginning of introduction.

11. Wilhelm Roscher, *System der Volkswirthschaft*, 4th ed., vol. 2 (Stuttgart: Cotta'scher, 1865), 66.

12. Karl Marx and Friederick Engels, *Collected Works*, vol. 42, 507–8.

13. See especially Karl Marx, *Capital*, vol. 3 (London: Penguin, 1981), 878.

14. For an introductory discussion of Liebig's theory, see William H. Brock, *Justus von Liebig: The Chemical Gatekeeper* (Cambridge: Cambridge University Press, 1997), chapter 6.

15. Foster, *Marx's Ecology*, 153.

16. Michael Perelman, "The Comparative Sociology of Environmental Economics in the Works of Henry Carey and Karl Marx," *History of Economics Review* 36 (2002): 85–110.

17. Eugen Dühring, *Carey's Umwälzung der Volkswirthschaftslehre und Socialwissenschaft* (Munich: Fleischmann, 1865), xiii.

18. Eugen Dühring, *Kritische Grundlegung der Volkswirthschaftslehre* (Berlin: Eichhoff, 1866), 230.

19. Dühring, *Carey's Umwälzung*, 67. Though Dühring does not use this expression to characterize Liebig's theory, Karl Arnd claims that it is haunted by a "ghost of soil exhaustion." See Karl Arnd, *Justus von Liebig's Agrikulturchemie und sein Gespenst der Bodenerschöpfung* (Frankfurt am Main: Brönner, 1864).

20. Liebig, *Einleitung in die Naturgesetze des Feldbaues* (Braunschweig: Friedrich Vieweg, 1862), 125.

21. On the importance of Anderson to Marx's whole argument see Foster, *Marx's Ecology*, 142–47.

22. Liebig intentionally wrote in provocative terms in hopes of restoring his professional fame, and in that sense the seventh edition was quite successful. See Mark R. Finlay, "The Rehabilitation of an Agricultural Chemist: Justus von Liebig and the Seventh Edition," *Ambix* 38, no. 3 (1991): 155–66.

23. Dühring, *Carey's Umwälzung*, 67.

24. Marx and Engels, *Collected Works*, vol. 43, 384.

25. Roscher, *Nationalökonomie des Ackerbaues*, 65.

26. Marx-Engels Archive (MEA), International Institute of Social History, Sign. B 107, 31–32. Albert Friedrich Lange, *J. St. Mill's Ansichten über die sociale Frage und die angebliche Umwälzung der Socialwissenschaft durch Carey* (Duisburg: Falk and Lange, 1866), 197.

27. Ibid., 203.

28. MEGA IV, vol. 32, 42.

29. Julius Au, *Hilfsdüngermittel in ihrer volks- und privatwirtschaftlichen Bedeutung* (Heidelberg: Verlagsbuchhandlung von Fr. Bassermann, 1869), 179.

30. MEGA IV, vol. 32, 42.

31. Marx and Engels, *Collected Works*, vol. 43, 527.

32. MEA, Sign. B 107, 13.

33. Carl Fraas, *Die Ackerbaukrisen und ihre Heilmittel* (Leipzig: Brockhaus, 1866), 151.

34. Charles Lyell, *Principles of Geology*, vol. 3 (London: John Murray, 1832), 61.

35. MEA, Sign. B 107, 94; Carl Fraas, *Die Natur der Landwirthschaft*, vol. 1 (München: Cotta'sche, 1857) 17.

36. Marx and Engels, *Collected Works*, vol. 42, 559.

37. Fraas, *Natur der Landwirthschaft*, vol. 1, 357.

38. Marx and Engels, *Collected Works*, vol. 42, 559.

39. Fraas, *Die Ackerbaukrisen und ihre Heilmittel*, 141.

40. George Perkins Marsh, *Man and Nature* (Seattle: University of Washington Press, 2003), 14.

41. MEA, Sign. B 112, 45. Carl Fraas, *Klima und Pflanzenwelt in der Zeit: Ein Beitrag zur Geschichte beider* (Landshut: J. G. Wölfle, 1847), 7.

42. MEA, Sign. B 111, 1. John Devell Tuckett, *A History of the Past and Present State of the Labouring Population* (London: Longman, Brown, Green and Longmans, 1846), vol. 2, 402.

43. MEGA II, vol. 4.2, 670.

44. Friedrich Kirchhof, *Handbuch der landwirthschaftlichen Betriebslehre* (Dessau: Moriz Ratz, 1852). Marx owned a copy of this book (MEGA IV, vol. 32, 673).

45. MEGA II, vol. 11, 203; Karl Marx, *Capital*, vol. 2 (London: Penguin, 1978), 322.

46. Marx and Engels, *Collected Works*, vol. 6, 489.

47. Michael Löwy, "Globalization and Internationalism: How Up-to-date is the Communist Manifesto?" *Monthly Review* 50, no. 6 (November 1998): 20.

48. John Bellamy Foster, *The Ecological Revolution* (New York: Monthly Review Press, 2009), 213–32.

49. Léonce de Lavergne, *Rural Economy of England, Scotland, and Ireland* (Edinburgh: William Blackwood, 1855), 19–20, 37–39.

50. MEA, Sign. B 106, 209; William Walter Good, *Political, Agricultural and Commerical Fallacies* (London: Edward Stanford, 1866), 11–12.

51. Janet Vorwald Dohner, ed., *The Encyclopedia of Historic and Endangered Livestock and Poultry Breeds* (New Haven, CT: Yale University Press, 2001), 121.

52. MEGA II, vol. 11, 188.

53. MEA, Sign. B 128, 2.

54. MEGA II, vol. 11, 187.

55. MEGA II, vol. 4.3, 80.

56. For a more mathematical treatment of the law, see Michael Heinrich, *An Introduction to the Three Volumes of Karl Marx's Capital* (New York: Monthly Review Press, 2012), chapter 7.

57. Burkett, *Marx and Nature*, 192.

58. John Bellamy Foster, "The Great Capitalist Climacteric," *Monthly Review* 67, no. 6 (November 2015): 9.

MONTHLY REVIEW *Fifty Years Ago*

Beginning nearly a century ago, some 20 million Vietnamese were herded, together with their Laotian, Cambodian, and other neighbors, into "French Indo-China," a tiny corner of the planet-wide French empire. These Asian colonials resented and hated their European overlord. War turmoil from 1939 to 1945 created a situation that made Vietnamese independence a possibility. The Vietnamese seized the opportunity and, after a decade of furious fighting, won independence in 1954.

Strings were attached to the "independence" that was granted. Vietnam was "temporarily" divided into two parts. The part of Vietnam north of the 17th parallel was established as an independent, sovereign nation. The part of Vietnam south of the 17th parallel passed rapidly under the control of the United States.

Within two years, under the 1954 Geneva Agreements, an election was to be held throughout Vietnam, under international auspices. In this election the Vietnamese people, South and North, were to decide their own future. Because of United States pressures, this election was never held. Instead, in violation of the Geneva Agreements, United States arms and military personnel were moved into South Vietnam. By 1965 the United States controlled the capitol and parts of South Vietnam economically, politically, and militarily. The greater part of the country and the majority of its people were living under the National Liberation Front. In 1965 United States armed forces, assisted by South Vietnamese, were fighting a furious, bloody war to destroy the National Liberation Front and compel the Vietnamese to accept a government chosen by the United States.

—Scott Nearing, "World Events," *Monthly Review*, February 1966