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The Dialectical Agroecologist

An Introduction

Coupling the words dialectical and agroecologist may seem odd. Such is our intent. Intellectual creativity begins when pairs of things seem incongruous, which is kind of what dialectical structure is all about in the first place and is a running narrative throughout this book. Agroecology itself suggests two realms, agriculture and ecology, again a pair that will seem incongruous, even contradictory, to some readers, again kind of what dialectical structure is all about, and again a running narrative throughout this book. The dialectical method emerges from a deep understanding that human beings are constantly comparing and contrasting, pitting one idea against another, sometimes very informally and personally in imagination and thought, sometimes purposefully and collectively as laws, treaties, and interpersonal responsibilities are negotiated. The agroecologist understands that ecological systems exist in material reality and that understanding them in all their complexity is as noble a goal as the pursuit of truth anywhere. Yet this basic goal is combined with putting that understanding to use in transforming the agriculture dominant today into a more rational form. Our central argument is that the dialectical method applied to agroecosystems is not only the right thing to do but is the best way we can move most quickly toward a solution to one of the most important problems we face today, the environmental and social consequences of the modern industrial capitalist agricultural system.

We the authors are by training biologists. As such we have been inspired by Levins and Lewontin's (1985) *The Dialectical Biologist*. And today we sense the need for such inspiration to travel far and wide. The climate is changing, biodiversity is crashing, some people starve and others gorge – all issues associated with the global food system. Facing such pressing problems, agroecology provides knowledge and inspiration to pursue solutions. Combining the analysis and insights of *The Dialectical Biologist* with the experiences and theory of agroecology is the goal of this book. We share our analyses as self-described dialectical agroecologists.

Humanity is beset with significant problems, although a cynical historian might dismissively note that such has always seemed true. Yet today's problems threaten us in unusually diverse ways, from the morality of the astounding inequalities worldwide, to the still unknown extent of biodiversity destruction, and even to the continuation of human civilization as challenged by the new climates we are currently creating. In the end they mostly emerge from a failure to fully appreciate the environmental consequences of

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socio/political/technical decisions. In our youth climate change was fringe, biodiversity was packed away nicely in national parks, and world hunger was an occasional problem somewhere else, usually in Africa. Today such issues are regular discussion topics, from isolated rural communities in Chiapas, Mexico, to trendy coffee shops in Cambridge, UK. They are issues complicated by a myriad of forces, all of which interpenetrate one another, a central theme in dialectics, as we shall see. Yet there is an obvious node that modulates those multiple interpenetrating networks – food, both its production and its consumption. Who produces it, how it is produced, how and to where it is distributed, and who consumes it are questions that intersect many contemporary existential issues. It is inherently one of the subjects of environmental sciences writ large. Indeed, it is at the center of the most critical issues facing humanity today: climate change, biodiversity loss, and a truly astounding level of social inequality, including who remains hungry every day.

1.1 The Modern Industrial Food System: Its Problems and Its Antithesis

An irrational enthusiasm about food production emerged at the sunset of World War II. The techno-sophisticated new world order had gotten the upper hand on the ghastly operation of Fascism and, as had happened so frequently before, the horizon was filled with the enthusiastic prospects of a world "finally" come to its senses. And agriculture was part of that. A cornucopia was to be brought to the world with agricultural machinery and chemicals, with all the problems posed by nature to be solved by the science of chemistry and mechanical engineering. As with the Fascists, nature would be conquered. The fly in the ointment was quick to emerge in the remarkable detective work of an amazing woman, Rachel Carson. With the relatable image of birds no longer filling the springtime air, she expanded that image to all of biodiversity and the ongoing harm it was experiencing from precisely those products that were supposed to be providing the new cornucopia. Pesticides, she noted, were killing things, and way more things than they were supposed to. With her popular book *Silent Spring* (1962) and her testimony in US federal court, the worldwide environmental movement began.

Carson's warning is an increasing reality, with some claims that the world faces a loss of biodiversity comparable to the great extinction events of the past. Agriculture, that new form that was to provide the proverbial cornucopia, is now recognized as the most important driver of biodiversity loss.[1] And it is not just the birds and their songs that are disappearing. Insects, the most biodiverse of the organisms we can see, have gone the way of spring birdsongs, with reports of losses in insect biomass of up to 75% in the past 30 years. Insects are now understood to perform valuable services such as pollination, pest control, decomposition, and soil turnover. And with the loss of insects, reinforcing Carson's powerful metaphor of silence in the springtime, birds, many of which eat insects, have declined by up to two-thirds in some regions of Europe.[2] The establishment of massive industrial monocultures, whether of grain to feed livestock or tropical fruits to tickle the taste buds of high-end consumers, mostly in the Global North, results in vast areas of pesticide-drenched landscapes that insects and other stars of the biodiversity constellation need to traverse in order to survive in the long run.[3]

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In addition to playing out in exactly the way Carson predicted with regard to biodiversity, our new understanding of the global climate has connected her warnings to another ecological disaster, global climate change. The industrial food system contributes as much as a third of total greenhouse gas emissions to the atmosphere,[4] the most of any sector, including energy and transportation. More specifically, agriculture and industrial livestock production are the major sources of nitrous oxide emissions, one of the most potent greenhouse gases in terms of warming per carbon. Likewise, paddy rice and beef production represent the main sources of methane, the second most potent greenhouse gas.[5]

Finally, the industrial capitalist agricultural system is also implicated in the growing gap between rich and poor, from its origins in the slavery of sugar and cotton plantations, to today's peasants expropriated from their traditional lands to make way for cattle ranches in Brazil and palm oil plantations in Indonesia, among the many examples that could be cited, constituting a significant fraction of Fanon's wretched.[6]

These issues and more are tied ultimately to the modern agricultural system and its complex ballet of ecological, socioeconomic, and political performances. The antithesis is agroecology, a subject expanding rapidly across the globe. Seemingly nothing more than a portmanteau of agriculture and ecology – doing agriculture in an ecological way – agroecology is actually a rich and complex movement still in its evolutionary stage, as we detail later in this chapter. It is, we argue, the socio/political/ecological answer to our existential crises of climate change and biodiversity loss, and part of the answer to our contemporary issues of social injustice. Is it a catchall, a totalizing discourse, a "win–win" or "shelf-ready" solution? Hardly. Indeed, such catchphrases are antithetical to the approach we seek to promote in this book. Rather, agroecology is the salon in which many of the world's problems can be analyzed and set on a progressive path, given the central place of food in all human societies. It is a place for invention, intellectual and practical, not a list of prescriptions.

While the "agro" part of agroecology is obvious, the "ecology" part is not as obvious as it may initially seem. Ecology, the science that studies interactions among living organisms and between them and their environments, is a complicated subject, seemingly becoming more complicated the more it is studied. Observations of birds and insects, hiking trips with friends, reading or watching documentaries about nature are all excellent activities that provide us with a sense of wonder and appreciation of nature and of ecology, to be sure. Yet the scientific field of ecology is rather more complicated in our contemporary world. It has had quite a short history within the framework of Western science. At about the same time Marx was dissecting the capitalist system and Darwin was giving us a powerful way to understand the biological world, ecology was just emerging as a scientific field. It was first defined by Darwin's friend and colleague Ernst Haeckel in his acceptance speech for his professorship at Jena University:

> By ecology we mean the body of knowledge concerning the economy of nature, the total relations of the animal to both its inorganic and organic environment; including its friendly and inimical relations with those animals and plants with which it comes into contact. In a word, all the complex relationships referred to as the struggle for existence.[7]

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Most practicing ecologists would recognize this definition as remarkably modern in its basic intent. Yet, like Darwin, Haeckel was an evolutionary biologist for whom ecology was more of a backdrop in front of which evolution was taking place. In the subsequent century ecology was hardly recognized as a scientific field. For example, when one of us (JV) began his academic career there were few, if any, ecology departments in universities. Yet today it is one of the most active of the natural and social sciences, providing a potential platform on which to readjust programs, plans, and actions. Politically, socially, and technically it proffers a necessary knowledge base for all environmental sciences.

In recent decades ecology as a field of study has become more closely linked with another intellectual current, complex systems, and consequently intersects naturally with agroecology and, according to our analysis, the dialectical method. At the risk of oversimplification, we argue that the dialectical method has much in common with the modern discipline of complexity science, a discipline penetrating dramatically into the field of ecology.[8] An excellent early statement of the nature of complex systems, due to Miller and Page, is:

> If parts are really independent from one another, then even when we aggregate them we should be able to predict and understand such "complicated" systems. As the parts begin to connect with one another and interact more, however, the scientific underpinnings of this approach begin to fail, and we move from the realm of complication to complexity, and reduction no longer gives us insight into construction.[9]

In their quick summary of the spirit of the dialectical method, Levins and Lewontin had already noted:

> It is not that the whole is more than the sum of its parts. But that the parts acquire new properties. But as the parts acquire properties by being together, they impart to the whole new properties, which are reflected in changes in the parts, and so on. Parts and wholes evolve in consequence of their relationship, and the relationship itself evolves. These are the properties of things we call dialectical: that one thing cannot exist without the other, that one acquires its properties from its relation to the other, that the properties of both evolve as a consequence of their interpenetration.[10]

From these two statements alone it would seem that complex systems and the dialectical method have a lot in common. It is worth some reflection, as Levins and Lewontin clearly state in the passage quoted, on what might be the distinction between a complex systems approach and a dialectical approach, specifically in the context of the agroecosystem. The difference is certainly historical – complex systems emerged mainly from the disciplines of physics and mathematics while dialectics emerged from philosophy and sociopolitical analysis. Yet in our contemporary time it seems the two have converged in significant ways, although probably both dialecticians and complexity scientists would demur, at least some of them.

1.2 The Dialectical Method in Principle

It is unfortunate that the residual prejudices of Cold War propaganda still affect our ability to embrace dialectics, tied, as it is by political conservatism, to Soviet-style Communism.

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Yet it is not really controversial, if viewed outside that unfortunate political framing. Lenin once noted, "What Marx and Engels called the dialectic method … is nothing more nor less than the scientific method."[11] Experiments are done to test theories. If the results of an experiment are distinct from what was expected from the theory, that is a contradiction, and the search for a resolution of that contradiction (the synthesis) is part and parcel of what all scientists do (or should do). When two theories predict different things, that is a contradiction, and resolving that contradiction is the goal of further theory development. In a sense it is all too obvious. However, as Levins and Lewontin argue, although the scientific method in its elementary school guise might be a good example of the dialectical method, the latter is actually much more than just that.

At its foundation it is convenient (perhaps excessively elementary for some) to go back to Hegel's three elementary principles of dialectics: (1) the interpenetration of opposites, (2) the negation of contradiction, and (3) the transformation of the quantitative to the qualitative. Frequently these three principles are applied in a superficial fashion, as if following a simple recipe. We seek ultimately to avoid such an error but begin with some simple examples to illustrate how natural it is to apply the method when things are simple. Our goal, ultimately, is to employ the dialectical method in much more complicated issues, illustrating how taking that frame of reference aids in understanding the world. So we give the basic foundational ideas serious center stage from the beginning, but we proceed to explore extensions and elaborations, not only in the spirit of Marx and Engels, but also with the explicit recognition that much of the work in the current field of complex systems not only already is dialectical but serves to expand the intellectual reach of dialectics. We begin with a brief outline of Hegel's elementary principles.

Careful thought usually involves examining contradictions. Thoughts about interpreting a world that contains contradictory elements are in constant flux in our minds. We may acknowledge the beauty of a painting yet somehow feel uncomfortable when looking at it. We may find Betty to be a brilliant person but see her as prejudicial against certain accepted facts. We may find the idea of democracy a fundamental good but bristle against its shortcomings and recoil at those who claim it as a philosophy yet act as if it were the enemy.[12] The list could go on. A fruitful (and we would argue normal and common) way of making progress in understanding ourselves and the world is to search out the contradictions, things that oppose one another. Seek those places where we seem to believe "A is true" and "A is not true" simultaneously. The Hegelian notion of the interpenetration of opposites suggests that each of these elements gains at least part of its meaning from its opposite ("A is true" gains part of its meaning from its blatant contradictory nature to "A is false"). Take as an example "pesticides kill pests" versus "pesticides generate pests," an obvious contradiction. We gain understanding when we examine their interpenetration. Pesticides do indeed kill pests; they were designed to do so. But they also kill the natural enemies of other potential pests, transforming the potential pest into an actual pest. We gain understanding of a concept from a search for its opposite. As an unfolding of the idea as a complex system, the simple "A/not A" contradiction is multiplied by many "interpenetrating opposites." Consequently, searching for truth demands we ask the key question "what else is involved?" as a central feature of our analysis.

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Confronting contradictions eventually results in their negation.[13] That is, as we search for a reason that both A and not A can coexist in our mind, we eventually (hopefully) find a synthesis. In formal terminology we think of one side (e.g., A) as a thesis and the other side (e.g., not A) as its antithesis. Resolving the contradiction thus creates a "synthesis" of the thesis/antithesis contradiction. In our previous example of pesticides, the synthesis is that by killing the natural enemies of both the pest and other potential pests, pesticides result in outbreaks of new pests. In the classic scientific method, the thesis, a theory, may confront the antithesis, an experimental result (e.g., data not consistent with the theory's predictions), resulting in a synthesis that requires either a change in the theory (in which case it generates a new thesis) or an examination of problems in experimental techniques that produced anomalous results (in which case a modified experiment is warranted) – the Hegelian principle of negation of negation is thus reflected in the progress of normal science.[14]

In the physical world we have many standard examples of the transformation of the quantitative to the qualitative – water becomes cooler and cooler and eventually turns into ice quite rapidly. In physical science this is called a phase transition. The Hegelian principle is meant to apply to a great deal more than the classical physical cases of phase transitions. In ecology we sometimes refer to such a structure as a "regime change" resulting from a "critical transition."[15] For example, continual cropping of a monoculture of wheat in an irrigated system relying on fossil water (i.e., with no recharging of the aquifer with rainfall) may result in a slow but persistent reduction in yield. But then suddenly (because of the inevitable salinization of the soil) the system collapses and there is a complete crop failure. The incremental quantitative increase in salinity results in a sudden qualitative change, the failure of the crop. The idea is commonly applied in sociopolitical settings, such as the growing dissatisfaction with the central role of the monarchy in eighteenth-century France leading to the French Revolution. The connection to agriculture and food systems is frequently evident in such sociopolitical contradictions, given the central and dramatic role that peasants play in the unfolding of revolutionary change.[16]

Applying these three principles can generate correct, yet frequently obvious, conclusions, and examples are sometimes offered only for clarifying the methodology, leaving the reader mystified: Why go through all that trouble just to conclude the obvious?[17] But applying the dialectical method in more complicated and contested situations is not always as straightforward as some of the more elementary and didactic ones, chosen precisely because they are indeed obvious. To take such an example, a crop plant grows faster when its growing root system encounters more nitrogen in the soil, yet when we add more nitrogen the plant's growth rate declines. This contradiction, well known to organic gardeners, is resolved by carefully examining the system and looking beyond the crop and nitrogen, asking what else there is that could be affecting the system. Part of the overall system of the plant and its nitrogen requirements is the microbiome (the bacteria and other microscopic organisms in the soil), which likewise uses nitrogen. Adding nitrogen to the soil not only provided more nitrogen to the crop plant, but also to the organisms in the microbiome. Those organisms, taking advantage of the extra nitrogen, began expanding their populations, eventually using up all the added nitrogen, and, because they now have become

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more abundant than before the nitrogen was added, utilize much of the original nitrogen in the soil. The original observed contradiction (plant growth is enhanced by nitrogen yet adding nitrogen slows plant growth) was negated by asking what else is involved and acknowledging that the "system," properly viewed, was not the plant/nitrogen system, but rather the plant/microbiome/nitrogen system. Our view of the relevant objects changed from a plant and the nitrogen to a biological system and the nitrogen, in a sense from the quasi-quantitative understanding of "the amount of nitrogen determines how fast the plant grows" to the quasi-qualitative "the system of concern is the biological/chemical nexus."

Marx and Engels transformed these principles from their idealistic formulation in Hegel to inform the material world,[18] suggesting that the operation of nature and society was an unfolding of dialectical laws, the material world itself operating dialectically – dialectical materialism. With such a lofty purpose, it is certainly more than just an example of the scientific method, as the previously quoted dismissal by Lenin had charged. Taking an agroecological example, this approach would suggest that there is a fundamental contradiction in the relationship between a wasp parasitoid that attacks a moth larva (perhaps a larva that consumes a crop). The parasitoid evolves to be ever more efficient at finding its host, the moth larvae, and ever more productive of its own offspring. But the more efficient the parasitoid, the more likely it is that it will drive the moth population to extinction (at any specific site). With its host extinct, the parasitoid will starve to death. In other words, the more efficient a parasitoid becomes, the more likely it is to drive itself to extinction. In this case, the thesis is "attack as many larvae as possible" and the antithesis is "drive yourself to extinction." A synthesis (resolution of the contradiction) comes from (among many possible others) a spatial distribution that includes patches where the moth larvae are protected (essentially a refuge for the larvae), allowing them to escape the parasites and thus keep the populations of parasitoids and moths going at lower levels.[19] Marx and Engels argued that viewing nature (and society) from this perspective presents a powerful methodological framework as we seek to understand the operation of nature and society.

Hegel famously stated that "the truth is the whole," the whole being the collection of interpenetrating parts having reconciled their contradictory natures. Yet that reconciliation leads to other contradictory and interpenetrating parts, rendering the "whole" a temporary unbalanced truth. Understanding a dialectical whole thus itself is a process of unfolding ever-increasing complexity. One goal in a dialectical analysis thus is recognizing and studying this unfolding, the historicity of the development of knowledge or understanding.

All agroecosystems have two histories, the history of the agroecosystem *per se* (the object of study) and the history of how scientists have been thinking about that agroecosystem.[20] The *swidden* agricultural system (also call slash-and-burn agriculture), for example, has a history related to the principles of domestication and even before, when the first hominoids started experimenting with using fire as an environmental management tool.[21] But it also has a history of how analysts, scientific and otherwise, have understood and described it, beginning with descriptions of the system and the mechanisms that make it work,[22] to later vilification of the system as responsible for deforestation,[23] to more recent redemption of its more traditional applications and how it maintains biodiversity at the landscape level.[24]

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Agroecosystems, like other complex systems, are defined by interconnected components. The interconnected nature renders "emergent" properties, which is to say properties that are not evident from a consideration of each element separately. Furthermore, these interconnections are, almost always, nonlinear. So, for example, in studying the *milpa* system Benitez and colleagues describe it as a complex system that "consists of cultivated plants, associated uncultivated plants and animals, soil micro and meso-organisms and human agency."[25] It is the interaction among these components that results in the emergent properties of the system referred to as the *milpa*.

These interacting components of agroecosystems inevitably result in system heterogeneity. As Levins and Lewontin (1985) indicate, the whole is a relationship among heterogeneous parts that have no necessary prior independent existence as parts but that acquire these properties as part of a particular whole. So, for example, in the coffee agroecosystem in Puerto Rico the ant known locally as *abayarde* (*Wasmannia auropunctata*) acquires properties of a pest when considering it as part of a system of coffee production, since it can inflict severe stings on farmworkers while they are harvesting the coffee berries.[26] Indeed, farmworkers frequently refuse to harvest coffee in heavily infected parts of the farms. However, *abayarde* acquires properties of a biological control agent since it preys on the coffee berry borer and the coffee leaf miner, two of the main pests of coffee.[27] Thus, the coffee agroecosystem as a whole acquires different properties when the *abayarde* is present than when it is absent. And beyond the coffee agroecosystem the *abayarde* exists as part of the general ant community, competing with other ants, displacing some and being displaced by others,[28] forming part of the rich and continually changing biodiversity of Puerto Rico. Such change is inherent in dialectical rendering.

Indeed, in the dialectical approach, change is seen as the result of opposing forces acting on system components and equilibrium is considered a temporary balance of opposing forces. Persistence and equilibrium are not the natural state of things but require explanation, which must be sought in the action of opposing forces, or interpenetration of opposites. In other words, the stable equilibrium so sought after in ecology, or in the popular idea of "the balance of nature," may exist in quite special cases, yet most of the time systems are not in equilibrium but rather in a chaotic unstable state. So, for example, the predator–prey system in biological control is a system in which the parts confront each other as opposites, aphids and their predatory lady beetles, for instance. It is not that the lady beetles eat the aphids and that is the end of the story. Rather, the lady beetles eat the aphids and decrease the aphid population, but by decreasing the aphid population they affect their own population (since now there is less food), and as the lady beetle population declines due to lack of food, the aphid population is released from predation pressure and increases in number. Faced with a higher aphid population, the lady beetle population increases again and so forth, thereby generating oscillations between predator, the lady beetles, and prey, the aphids.

However, in the spirit of dialectical analysis we ask "what else is involved?" and the analysis inevitably becomes more complicated, complex, and presumably useful. The two populations in a predator–prey pair are opposite poles of the process, since predation, the process, simultaneously determines the death rate of aphids and the birth rate of lady

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beetles. In that way, the interaction between lady beetles and aphids drives the population dynamics of both, leading to oscillations. But the simplistic assumption that such a system must eventually "stabilize" is counter to the spirit of a dialectical analysis. Indeed, strong nonlinearities added to the system tend to destabilize the predatory effect, resulting in the biological control paradox – the more efficient the predator is in killing the pest, the more likely it is that the predator population itself will collapse due to the lack of food, and that the pest population will subsequently increase to levels that can cause significant damage to the crop (similar to the example of the parasitoids and moth larvae that we presented earlier).[29] Instabilities can thus be seen as emerging from the interpenetration of opposites.[30]

Such processes are common in agroecosystems and the more diverse the agroecosystem, the more opposites and the more interpenetration. Thus we see, for example, more oscillatory systems and more coupling of these oscillatory systems, generating a panoply of complex, and frequently chaotic, behaviors. In agroecosystems (or any natural system) it is common for a pest to have multiple natural enemies, generating a basic structure of coupled oscillators.[31] For example, an aphid species can be eaten by lady beetles and also be attacked by a fungal pathogen, such as *Bauveria basiana.*[32] Constructing this qualitative arrangement as a theoretical exercise,[33] the two oscillators (beetle/aphid and fungus/aphid), operating independently, are unstable, with natural enemies crashing and the pest going uncontrolled. However, when the two unstable oscillators are connected, in this case through intraguild predation (the predator eating some of the prey that was infected with the fungus), the system becomes persistent and the pest remains under control, albeit with complex chaotic fluctuations.

Finally, the dialectical approach sees the various levels of organization as partially autonomous and reciprocally interacting,[34] therefore rendering the whole not reducible to collections of fundamental parts. Furthermore, analyzing those fundamental parts will not provide the knowledge necessary to understand the whole, since the whole and the parts do not completely determine each other. In ecology there are various hierarchical levels of organization going from the molecular, to the individual, to populations, to communities, to ecosystems, and finally to the biogeographic level. But the individual is not just a collection of molecules, and a population is not just a collection of individuals, nor is the community just a collection of populations. The ecological population is an intermediate level of organization that affects and is affected by the other levels, the community of which it is a part and the individuals that comprise it. So, for example, the richness and species composition of the assemblage of soil microorganisms in an agroecosystem are determined by the dynamics of local extinction and colonization (biogeographic level); by interactions with other species (community level); by population parameters such as birth rate, fecundity, death rates, and so on (population level); and by the genetic composition of the species that determine physiological tolerance levels, mobility, and so on (individual and genetic levels). Local extinction depends on the state of the local populations and colonization depends on the number of propagules the populations can produce, their ability to move among suitable patches, and their ability to become established locally. The ability to move from one suitable patch to another depends not only on the characteristics of the propagule itself (e.g., how resistant it may be to a range of environmental conditions) but

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also to external environmental or biological conditions (wind, water, or other organisms that are agents of transportation of the propagule), the quality of the matrix through which the propagule needs to travel (which is determined by management decisions made by the farmers that inhabit that matrix), and the size and number of patches and distance among patches of suitable habitat. The genetic makeup of the species in the community is a consequence of mutation, the process of selection, gene exchange with other individuals of the same population (and sometimes other populations or even other species), and drift. But, of course, the other members of the community affect natural selection and therefore influence all other parameters. Based on this understanding of how communities are related to other levels of organization, Levins and Lewontin conclude that the ecological community is a contingent whole in reciprocal interaction with the lower- and higher-level wholes and is not completely determined by them, but strikes temporary equilibria with them. And we agree.

Human agency, in the context of the agroecosystem, affects each of these levels from the genetic to the biogeographic, as much as it itself is so affected. The indirect "social decision" to transform agriculture as part of the Industrial Revolution brought into play a cacophony of economic, social, political, cultural, and, ultimately, ecological factors. Land enclosures, whether the eighteenth-century English forms or the twenty-first-century neoliberal land-grabbing forms, simultaneously create environments subjected to the poisons of pesticides and landless workers subjected to the logic of wage slavery. And land rent, extortion by the "owner" of the land, paved the way for the eventual financialization of the agricultural enterprise where many of today's "farmers" grow crops for the main purpose of paying interest on a bank loan. Whereas peasant farmers operated on a series of decisions that needed to be balanced with one another, as brilliantly elaborated by Chyanov over a century ago,[35] the industrial capitalist family farmer's decisions are similarly in need of balance – pay the interest or let the combine be repossessed; take out a second mortgage on the farmhouse to buy the latest tractor or buy the parts to fix the old. Clearly these balances are ever transforming in time and space.

1.3 Dialectics in Practice: Rules of Thumb

As wrong as Lenin may have been to characterize the dialectical method as nothing more than the scientific method, it is nevertheless useful to make such simplifications when political or physical circumstances require generalized (or simplified?) analysis. We thus offer a simple two-part rule to keep in mind when utilizing the dialectical method in an agroecological context, whether simply in the study of the system or in actions aimed at improving it, or even, in a more politically motivated practice, dismantling it.

With the urge to satisfy legitimate goals of acknowledging complexity in ecological systems, dialectical ecologists ask of their study systems "what else is there?" – what are the variables or connections that I have thus far been unable to notice and are perhaps key to driving the whole system? Our description of the dialectical method is meant to suggest that such is our *modus operandi* in both natural history and theory. As is the case with most ecologists dedicated to understanding the complexity of nature, fears of intellectual myopia

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compel us to examine every corner and crack in the natural system for a complication that we have overlooked that could be key to understanding. Thus "what else is there?" is not just window dressing but is central to our goals, driven by the pursuit of a dialectical methodology. Yet the outcome of this passion can be an excessive complexity-itus, a feeling that the complexity of ecological systems, if we are honest and include everything we know about them, mitigates understanding. At times this situation can result from easily avoidable naïve reductionism (as the exemplar of modeling bulldozers with quarks brings clearly to light),[36] but it is more difficult when the components themselves and their interconnections multiply obsessively from our insistence on the "what else is there?" epistemology. The old adage from pop ecology that everything is connected to everything else can lead to intellectual paralysis.

The obvious antidote to this dilemma is the negation "what can we ignore?" Acknowledging complexity, it is not difficult in ecological research and analysis to accumulate ever more interpenetrating components. As our metaphors and models become so enriched, they also become weighted down with complexity, some of which is essential, some of which affects the overall understanding only trivially. The art of science at this stage is to somehow recognize what can be left out without leaving out essentials. As Richard Levins once said, commenting on the sometimes frustrating search for the most precise model, "the best model of a beaver is another beaver, preferably the same one," a rephrasing of the quark-constructed bulldozer but, more profoundly, acknowledging the need for simplified abstract expression, regardless of the level in the hierarchy. Indeed, seeking simplicity in models (whether mathematical or qualitative and conceptual, contemporary or historical) is widely acknowledged as part and parcel of the scientific method, if not intellectual activity more generally. We argue that it is an essential element in the spirit of a dialectical analysis.

This leads us to the obvious dialectical pair: "what else is there?" and "what can we ignore?" The synthesis of this antithetical pair is quite obviously the acknowledgment that science (and we would argue all intellectual activity) is a process, not a noun. As we ask "what else is there?" we do so with the clear understanding that after we add that something else, the next question we need to ask is "what can we ignore?" And then repeat. Yet in actual application there is complexity in the construction process, as much is there is complexity in the subjects we seek to understand. There is also art involved in our rule of thumb, "what else is there?" combined with "what can we ignore?" Not just **anything** else to include, not just **anything** to ignore.

When studying the natural world we seek models (metaphors) to help understand that world, and we seek, or should seek, the contradictions embedded in, or contained between, competing metaphors. Understanding the human component is no different in contemporary practice, yet it takes on a particular form as we incorporate the essential historicity into the analysis. Historical materialist dialectics seeks to interpret the unfolding of history as a series of dialectical relationships, thesis/antithesis/synthesis, repeat. Rather than historically driving along a smooth apex bordered on either side by conflicting interests creating a balancing act, we drive through a mosaic of contradictions and resolutions, the seemingly smooth balances turning into qualitatively distinct structures containing new

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contradictions, sometimes quite unpredictably. Just as the development of a scientific (broadly speaking) model of the world jumps dialectically in fits and starts, the unfolding of history is also visible through the dialectical lens. As we struggle to understand the complexities of agroecosystems, especially in an agroecological context, our thoughts and debates and collective decision processes would do well to keep this rule of thumb in mind, but also to remain mindful of the temporary nature of the "knowledge" it imparts to us.

1.4 Agriculture versus Agroecology

Few would think of visiting a garbage dump, or a superfund site, or a nuclear waste facility, or an old abandoned industrial park for a vacation. Notwithstanding the few individuals attracted to such places (recall the growing attraction of tourists to Chernobyl), most of us would prefer a crystal-clear Caribbean beach, a breathtaking mountain retreat, or a hyper-diverse rainforest retreat as a place for relaxation and inspiration.

It may be impossible to find one environmental experience that represents a point of yearning for everyone, irrespective of personal history, geographic location, or sociopolitical class. Yet there are those environments that few would yearn to visit for relaxation or inspiration. When you ask a friend or coworker "Where are you going for vacation?" might you expect the answer to be "to the banana plantations of Honduras," or "to the soybean fields of Brazil," or perhaps "to the vegetable monocultures of the Salinas Valley of California," or maybe "to the feedlots of Colorado," or "the grain monocultures of Ukraine," or "the oil palm plantations of Borneo?" Indeed, purposefully visiting such landscapes today would seem as odd as purposefully visiting garbage dumps or superfund sites. But they are the undeniable face of what is marketed as the wonders of the modern scientific approach to agriculture – the industrialized, efficient, capitalist agricultural system. There is something off kilter in this generalization – a revulsion toward what is touted as a triumphal symbol of capitalist technological achievement.

Looking deeper, these industrial agricultural systems provide yet more negativity than is implied in their unique "anticharm aesthetics." Hidden below the soil surface is a potpourri of microbes that relish the chemical nitrogen applied to the fields, churning out carbon dioxide, methane, and nitrous oxide, contributing significantly to the global warming crisis. And above, the surrounding air contains the remains of the chemical poisons that kill not only pests but a lot of the biodiversity, including the insects that live in tiny patches of natural vegetation dotted here and there among the kilometers of monocultures. The surrounding social fabric, while largely invisible to the casual observer, contains other kinds of seeds – poverty, inequality, despair, racism, dispossession. The politics, also hidden from the casual observer, can be vicious, with boss-man control (and they are usually men), worker mistreatment, and, especially in the Global South, mercenary gunmen assuring that boss-man remains boss.

If these observations even partially resonate, there must be some underlying justification for maintaining this seemingly egregious system – the modern industrial capitalist agricultural system. We propose that there are two such justifications. One is true, the other is pure propaganda. The true one is that these systems are tremendously profitable to their owners,

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or, in today's world, the investors holding shares in the farms, or, as they say, the farming enterprise writ large. Usually not actually farmers in the sense of someone who nourishes and cares for the land, these farming enterprisers gain a lot from the current arrangement and stand to lose a lot if their golden-egg-laying geese were to disappear.

The justification we claim to be pure propaganda is that these environmentally devastating landscapes are necessary to feed the world's population, that this industrial system is the most efficient system of food production the world has ever seen, and that if we were to eliminate it there would be massive starvation the world over. This is not true. The propaganda may seem rational – the old system of actual farmers producing food on their land and provisioning the rest of us is way too inefficient to be able to provide food to the exceptionally large population we have in a nation, or the world; a single person (farmer) used to provide food for ten people, now they provide for hundreds; less land is required for food production, leaving more to conserve nature; so much is produced so efficiently that food is cheap for everyone. Although such proclamations may seem true, not even one of them is factual! In fact, it is all a rationale for tremendous profits for the few, not a rational analysis of how to produce food for the many. A political rationale, not a rational analysis.[37]

An alternative that has emerged from peasant farmers in the Global South is agroecology. Although agroecology may still be considered marginal to the industrial capitalist agricultural system, it is a real, actually practiced practice, and it is growing. Furthermore, many progressive thinkers and farmers in parts of the Global North have embraced agroecology as an important alternative that can take us out of the industrial agriculture rut we seem to be in, although the dominant ideology today remains something like "modern agriculture, despite its problems, will remain with us always, an inevitable structure responding to the needs of a growing population." This attitude is not new in history. Automobiles eventually canceled the famous cry "get a horse," the steam engine eventually replaced John Henry's hammer, and many a monarch lost their head as the Enlightenment canceled the very idea of monarchy. In other words, inefficient and/or noxious arrangements have been replaced before, even those that seemed in their day to be ordained inevitabilities of nature (horse-drawn carriages, the "steel-driving man," and monarchs). Today we see the hopeful sign that the evident problems caused by (and continuing to be caused by) the industrial agricultural system need not persist except for the political power currently adjudicated by an informal monarchy (the oligarchs of the large corporate interests) that has seemingly taken over. Yet it would be understandable if our hopeful sign might seem Pollyannaish as we face the political force of the industrial agricultural system, with its economic power and seemingly impenetrable ideological hegemony.

This apparent contradiction between our hopefulness and the constitution of our despair may be partially resolved by a glance at deep history.[38] Depending on the interpretation of the evidence, our species has been on Earth, pretty much unchanged as a biological species, for at least 100,000 years (perhaps 200,000 or even more), and our more general "human line of evolution" a million or more. We have been eating all that time. Acquiring the food we need to survive has long been an ecological process, whether scavenging on the carcasses left by predators on the African savannah, or diverting streams and rivers to capture fish in Australia, or burning grassland to encourage new shoots that attract large herbivores

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that we can then capture in South Asia. We have been modifying, or engineering, our ecosystems so as to enhance our abilities to gather, or harvest, food. With anthropological and archeological evidence coming in at an impressive rate, it appears that the so-called hunting and gathering, or foraging, stage of existence was our style for almost all of our history, and clearly recognized "agriculture" was frequently an accompanying activity (sometimes quite transient). If we seek a general answer to the question "What is agriculture?" perhaps we should answer "nothing special," just a rather extreme and recent way of ecosystem management. Indeed, foraging for food in an environment recently subjected to fire is almost certainly different than in an environment that has never burned.

So our evolutionary line has been engaged in a host of activities related to food procurement for as long as we have been able to modify environments, even if it was as simple an act as setting fire to a field. And recall, the control of fire was an "invention" of *Homo erectus*, not us. The rise and fall of cities, cultures, and ways of life, documented so extensively by Graeber and Wengrow in The *Dawn of Everything*,[39] must have, at least sometimes, involved a major shift in our ecosystem management systems. We revisit all of these comments as we summarize the principles of food acquisition in Chapter 2.

1.5 The Four Pillars of Agroecology

Today, on most of what we regard as agricultural land, a system of agriculture unique in history dominates – the industrial capitalist system. Whether the maize fields of North America or the soybean plantations of South America, the oil palm plantations of South Asia or the wheat fields of Ukraine, the pattern is evident. Industrial-scale production dominates. Yet across the world most people we regard as farmers do not grow crops this way – the average small-scale producer uses a variety of more traditional methods, usually not in a monoculture and usually not heavily dependent on external and expensive inputs like pesticides and chemical fertilizers. While a majority of farmland is currently devoted to the industrial system, the majority of farmers are not. While a majority of that industrial farmland produces animal feed, industrial feedstocks, ethanol, and additives for the food processing industry, the majority of farmers produce food for people.[40] The agroecology movement to some extent defines itself as politically aligned with the food producers and scientifically aligned with the science of ecology. This alignment jibes well with the general attitude of those food producers, which is to say, the world's small-scale peasant farmers.[41]

In this basic picture there are three issues of concern. First, farmland should be used primarily for food production.[42] Currently it is not. Second, whatever agricultural production exists, its contribution to global warming should be minimized. Currently it is not. Third, agricultural landscapes should not restrict the dynamic processes that maintain biodiversity. Currently they do. If, in a utopian world, we should decide to devote agriculture to the production of food with minimal input to global warming and biodiversity loss, and maximum output of healthy food for people to eat, that would be good. Yet the utmost irony is that we seem to be called on to refer to "healthy food production without destroying the planet," a utopian position.

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Agroecology stands as the alternative that could respond to this call, even as it is derided by some as utopian.[43] A long time ago (1990), along with Peter Rosset and Ron Carroll, one of us (JV) helped organize a series of essays about the global agricultural system and published them in a book, the title of which was *Agroecology*. As I (JV) recall we had little discussion about why we called it that, it just seemed right at the time. The chapters ranged over multiple disciplines, traditional knowledge systems, rural sociology, ecology, economics, geography, and chemistry, among others. It just seemed natural that all of that interdisciplinary material belonged in what we imagined would be an "ecological" approach to agriculture, and the word agroecology just jumped out. Others had used the word earlier and similar ideas were expressed by other terms – organic, ecological, sustainable, renewable, and others.[44] It seemed, at the time, that the word agroecology sort of encompassed all of those other handles.

In subsequent years more specific meaning has been embedded in the term. It contains elements of its etymological parent, the science of ecology, but it is much more. Gathering, as it does, information from those who have been farming in a traditional manner for generations, the wisdom of the ancestors, or traditional knowledge, has become an essential feature. And the ideology of complete domination over nature is rejected almost completely in favor of using nature's architecture as a blueprint for design. Furthermore, the political actions of peasant farmers, broadly conceived, have come front and center, from the rebellions against historical land enclosures to the current rallying cry for "food sovereignty."

Agroecology has come to signify a radical departure from the post-World War II industrial agricultural consensus, in both the Global North and the Global South. It is a powerful movement, with expansive expectations for "regime change." As with other movements with transformative potential (e.g., socialism, democracy), its precise meaning is inevitably vague, typically taking on the specific meaning that any practitioner deems correct, or at least convenient. Yet it self-consciously reflects a kind of "New Deal" idealism that has ushered its entrance into diverse forums ranging from the Food and Agriculture Organization of the United Nations to the Zapatista revolutionaries of southern Mexico.[45]

So what indeed is agroecology? Its development over the past few decades has rendered it a complicated topic. In our interpretation, agroecology as currently envisioned by (we think) all interested parties is a platform for research, practice, and political action, associated with small-scale (or peasant) agriculture, with a strong rejection of the well-known harmful practices of industrial capitalist agriculture. It is a platform that we visualize as resting on four pillars: science, traditional knowledge, nature, and political action. A quick rendering of each of these four pillars is warranted.

1.5.1 The First Pillar of Agroecology: Science

The idea of Western science has been simultaneously demonized and worshiped, frequently depending on the milieu in which it is situated. In particular, applying science to agriculture has two recent histories. There is a science that emerged from the post-World War II conventional consensus, with its extreme form of reductionist thinking – effectively confusing the question "what is it?" with the question "what is it made of?" – and adherence to the

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institutionalized structure of publishing, grant-getting, and influencing. The other science admits that science itself is an evolving tradition. As Richard Levins noted long ago,[46] the actual practice and philosophy of science in the Western tradition are flexible and changing concepts, depending on where you are in time and space. If Pythagoras was its beginning, we must acknowledge that its first goal was not at all to understand the material world but to relate in some mysterious way to the deities of the day, an attitude that sat quite well with Isaac Newton and his stated purpose to understand the mind of God (and for him that was not just metaphor). Indeed calculus, a subject that some would suggest is among the most profound pieces of deep understanding *Homo sapiens* has ever achieved, was invented quite explicitly to aid in understanding the Christian God, not the material world.[47] And even the expansion of the so-called scientific revolution to the European continent created a bit of a rift in the interpretation of science, with British exuberance in practical application to the new gears and levers of the machines of the Industrial Revolution, contrasting with the French who saw the revolutionary potential in a deepening of our philosophical understanding of nature. What was to England and the applied Newtonians the beginning of engineering was to France and the attendees of, for example, Emile du Chatelet's salon, a deep understanding of how the world works.[48] And even in the present "enlightened" times, science seems sometimes to serve the ideological needs of large corporations, yet at other times its insistence that propositions be taken seriously only when there is evidence to support them serves the critics of those corporations, including us. Science in service of capitalism versus science in service of the people, in contemporary parlance.

Applied to the question of food production, a most inspirational modern practitioner was George Washington Carver. From an active concern with the real problems faced by the small farming sector, Carver not only did science, but based his science on the generalized needs of the community he sought to serve. As an educator he taught biology at Tuskegee University. As a scientist he researched various aspects of what would today be called plant ecology. As an activist he brought modern scientific knowledge to the attention of the Black farming community. His program might be likened to the general idea of "science for the people" in that his focus was on improving the practice of agriculture through crop diversification and careful soil management, bringing that knowledge directly to the poor Black farmers of the southern United States.

Carver is representative of science as applied to agriculture in general. Yet his implicit goal, due to his commitment to small-scale Black farmers, aimed at practicing science to benefit the poor farmers of the late nineteenth and early twentieth centuries. The science on which agroecology is based is the science of ecology. And as we remarked at the opening of this chapter, the fact must be confronted that this science, ecology, is a science that remains young and not very well developed. Also we noted that Chapter 4 of Darwin's famous treatise contains conceptual formations and exemplary observations from nature that could be taken as an initial textbook in ecology, although its first formal use in Western literature was by Haeckel, as we described previously.

Yet it was not until the mid to late twentieth century that ecology emerged as a relatively concrete division of the Western science tradition, with professional societies, university departments, and research institutes the world over. In its modern form it draws

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extensively from other disciplines, especially mathematics and chemistry, and spawns its own interdisciplinarity with subjects such as "ecological economics" and "political ecology." Traditional themes of agricultural practice, such as the control of pests or maintenance of soil fertility, are easily captured within the normal framework of this young science. And it is important to emphasize its youth. If physics began with Democritus some 2,500 years ago and took its modern form with Newton in the seventeenth century, the science of ecology is yet an infant. Couple that youth with the evident fact that we seek to understand a very complex subject, and we must conclude that any intelligent adherent to the subject will be, should be, enormously humble about what we can confidently say, scientifically, about the world.

It is also worth noting that Western science is not monolithic. Comparing the science of ecology, or for that matter all of biology, to that of physics we see a dramatic difference. Physics can legitimately claim "universal" understanding. Knowing the mass of a planet and the position and mass of another object in space along with its speed and velocity, we can say how long before that object will crash into the planet. This applies to *all* planets and *all* objects. For any interesting question in ecology, such universal statements are not possible. Although one may note, as we have just done, that ecology is young compared to physics, it is also the case that ecology intends to understand far more complicated things than physics, and rather than scientific laws like the law of gravity, the most we can hope for is a set of "organizing metaphors."[49] Yet the principle of "evidence" remains as a theoretical principle and any organizing metaphor should legitimately be subjected to that basic principle, acknowledging that the very notion of "evidence" itself is necessarily negotiable.

The non-Western version of ecology, popular among promoters of agroecology, is, as its name implies, pretty much everything any culture has ever said about "the total relations of the animal to both its inorganic and organic environment," to refer back to the original traditional first use of the word in the West.[50]

1.5.2 The Second Pillar of Agroecology: Traditional Knowledge

The lack of formal education in the Western tradition does not mean a lack of education. When analyzing ecological topics such as the agroecosystem, it is evident that the natural world has surrounded "traditional" people with a profound classroom, sometimes only personally experienced, but sometimes with a long list of remembrances from generations past. Indeed, it might be argued that most knowledge is indigenous knowledge. Embedded in every culture is knowledge not only about the culture itself but about how that culture intersects with the natural world. This evident fact becomes especially important in agriculture, which effectively is just an extreme form of management of the local ecosystem, as we explore in detail in Chapter 2.

An historical event drives this idea home. Albert Howard and his wife Gabrielle Matthaei were English agronomists/botanists in early twentieth-century Britain. This was a time when the enthusiasm for the Industrial Revolution was at its peak and machines were making the world an easier place to live in. Agricultural innovations were particularly popular in England. Pride in the evident advancement of the Industrial Revolution in

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transforming the agricultural sector drove the authorities to dispatch Howard to India, then still an English colony, to bring the wonders of English modern agriculture to the poor and "ignorant" Indian farmers. Howard and Matthaei discovered, however, that traditional Indian farmers not only knew what they were doing, but had developed techniques that were more sophisticated than what the English agricultural establishment was practicing. Reflecting on his time in India, Howard's book *An Agricultural Testament* still reads today as a practical guide to ecological farming, based on the traditional knowledge he gained from his interactions with Indian farmers.

One of the techniques that attracted the Howard/Matthaei team came to their attention while they were working at an English experimental station in Indore, in the state of Madhya Pradesh. There, based on observations of the traditional composting systems that local farmers had been using for generations, Howard and Matthaei engaged in experiments to generalize the system, which is today called the Indore composting method. It was, according to Howard, through detailed observations of and conversations with Indian traditional farmers that he gained the knowledge to develop the general procedure.

As with the traditions of Western science, traditional knowledge is always partial and evolving. The interaction of different forms of knowledge, especially in the context of the traditional, takes a variety of forms, with the popular notion of the "dialog of knowledges" frequently at play, forming a cauldron of variability as thesis and antithesis emerge from dialog and synthesis, resulting in further understanding of the world. Contrary examples certainly exist. For instance, some anthropologists generally acknowledge the process of schizogenesis, in which cultural norms of side-by-side cultures may undergo further differentiation due to repeated contact,[51] eschewing the adoption of the "other." Yet even here, within a given culture the spirit of sustaining a productive activity, whether agriculture or herding or fishing or gathering, accumulates wisdom from experience and social interactions, both among contemporaries and intergenerationally. Perhaps schizogenesis operative between cultures even enhances the progress in traditional knowledge within a culture.

As with the seeming romanticism suggesting the only knowledge worth knowing is to be found in the Western scientific project, romanticizing traditional knowledge can be just as misguided. As we note in Chapter 3, traditional knowledge is a complicated subject and is demonstrably wrong or misguided at times. A visit to the Almolonga valley in Guatemala several years ago serves as a dialectical example. Indigenous vegetable farmers there practice a complicated system of soil management. Taking cues from so-called soil shamans, farmers walk to the nearby hills to collect the leaf litter from particular forests. Three basic forest types, pine-dominated, oak-dominated, and mixed mesophytic, provide an obviously diverse physical and chemical leaf litter. The soil shaman recommends a particular mixture of the three litter types to use as a mulch in the, generally small, plots of individual farmers. Interestingly, for such farmers the "agroecosystem" is not limited to the plot of land on which their vegetables grow but includes the forested hills surrounding the valley. It would seem to be an impressive set of knowledge that provides an ecologically based soil management system. Yet a most evident contradiction can be seen in the excessive use of noxious pesticides to control pests. Although the weight of the pushers of chemical fertilizers seems not to have swayed this culture from continuing its traditional

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knowledge base for soil management, the pressure from sales representatives of noxious pesticides seems to have successfully replaced whatever traditional pest management systems had been in place before. Tradition survived in one case but lost out in the other.

There is much to analyze regarding traditional knowledge, especially when it is taken as a subject distinct from Western scientific knowledge, as we analyze in Chapter 3. Suffice it to say here that even in the classic case of the Indore composting method, a great deal of focus has been on the techniques contained in traditional knowledge, especially those techniques that might be adopted to improve agriculture in the Global North, as we have used this example here. Yet there has been little concern for the agency of the traditional people providing the knowledge. Some suggest that this is a general problem in the study of traditional systems.[52] We might contemplate, for example, what the Howard/Matthaei team learned, or whether they even sought to learn, about Indian traditional farmers' attitudes to British imperialism and whether those attitudes were as important to the team as the details of the Indore composting system.

1.5.3 The Third Pillar of Agroecology: Nature

The third pillar of agroecology is nature itself. Much like traditional knowledge frequently claims, the structure of the natural world provides us with insight about how our agriculture actually works. An inspirational figure on this front is Rachel Carson, and not just for her pioneering investigative reporting that gave us the modern environmental movement with the publication of *Silent Spring*. Rather, two of her previous books, *The Sea Around Us* and *At the Edge of the Sea*, published in the early 1950s, present the natural world as on the one hand wondrous but on the other hand complex. While she never said anything about the use of nature as a template for agriculture, she certainly saw the intricate structure of the natural world that was being harmed by the agrochemicals that were then being increasingly used in agriculture. But her writing is inspirational and imparts something of the awe one can experience when immersed in the natural world, whether it be a coral reef in Indonesia, a rainforest in Borneo, a savannah in Kenya, or a shaded coffee farm in Mexico – judging from our own personal experiences.

It is that sensitivity to "Mother Earth," perhaps sometimes overly romantic but seemingly universal in "premodern" cultures, that inspires a view of agriculture as part of that natural world, worthy of the same respect that we should be giving that natural world and that most traditional societies do. Our attitude toward agriculture, as Rachel Carson would have said, should be as deep and thoughtful as our attitude toward the natural world.

What emerges from this "sense of wonder" is a general philosophy that agroecosystems are part of the natural world and that the architectural models we use to engineer our agroecosystems should be borrowed from that natural world, not from industrial monstrosities belching poisons so as to make the wealthy even wealthier and the poor even poorer. Our model for the architecture of agriculture should be the natural world, not the modern factory.

The issue evidently becomes quite complicated when pushed to its limits. Original Australians actively used fire to create particular habitat formations that would encourage particular animal species they sought to hunt. They certainly understood the nature of fire

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in their ecosystem to enable them to do that. The dehesa farmers of Spain and Portugal rear pigs in the oak savannah, which looks very much like the oak savannahs that dominated the area before humans arrived and the native wild boars ate the acorns currently eaten by domestic pigs. So agriculture, broadly conceived, is sometimes undertaken within existing natural conditions such that nature's architecture is not only preserved but purposefully modified to nudge it in one direction or another, to promote or enhance food procurement. It is a "thought-intensive, gentle technology" and provides an epistemological template for us.[53]

Other examples exist in which the natural world is explicitly used as an architectural template on which the agricultural system is built. For example, the *kuojtakiloyan* ("useful forest" or "forest that produces") of Mexico presents an environment that effectively mimics the natural forests of the area. It is a polyculture of avocado, citrus, macadamia, mango, jonote, and sapote trees, interplanted with sweet potatoes, cinnamon, chalahuites, gourds, and bananas along with a variety of edible mushrooms and herbs.[54] In an attempt at a more general approach, Malézieux suggests "mimicry" specifically with a three-category system, wherein agricultural systems seem to mimic natural systems – tropical rainforest, tropical dry forest, and the American prairie.[55] Using ecological concepts of nature's organizational complexity has a long tradition among those who ponder the characteristics of both nature and agriculture,[56] reflecting Wes Jackson's notion of "natural systems agriculture," a moniker that is self-explanatory and reflects what much traditional knowledge either implicitly or explicitly acknowledges.

There is a danger again of romanticization. Incomplete understanding of the science of ecology may encourage unrealistic interpretations of what a particular piece of nature is actually all about. The British invasion of Australia is an excellent example, wherein fire was regarded as "obviously" an enemy of the natural world and fire suppression became part of the colonial disaster. Traditional knowledge that drove the sustainable use of fire in food procurement was thus trumped by a false perspective of the ecology of local "nature" (that it was "destroyed" by fire). Failure to understand how the natural world works in this particular circumstance destroyed the local food procurement system (and additionally caused the global extinction of at least one species of mammal).[57] A false or outmoded understanding of ecological principles can lead to a misunderstanding of how nature works, making the use of that nature suspicious at best.

1.5.4 The Fourth Pillar of Agroecology: Political Action

The fourth pillar of agroecology stems from a social structure that has existed probably since the emergence of agriculture, perhaps even before. Struggles for land and the dignity of peasant societies have a long history. The group we highlight, although others could be equally taken as models, are the True Levelers or, as they became known, the Diggers – they were mainly farmers. In their statement of 1649, "Declaration of the poor oppressed people of England," they state, in part:

> we are resolved to be cheated no longer, nor be held under the slavish fear of you no longer, seeing the Earth was made for us, as well as for you. … [as] the Common Land belongs to us who are the

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poor oppressed, … we are resolved to try the uttermost in the light of reason, to know whether we shall be free men, or slaves. If we lie still, and let you steale away our Birthrights, we perish; … and therefore by the law of contract with you, freedom in the land is our portion as well as yours, equal with you: And if we strive for freedom, and your murdering, governing Laws destroy us, we can but perish.

Therefore we require, and we resolve to take both Common Land, and Common woods to be a livelihood for us, and look upon you as equal with us, not above us, knowing very well, that *England* the land of our Nativity, is to be a common Treasury of livelihood to all.

… we shall endeavour by our righteous acting not to leave the earth any longer intangled unto our children, by self-seeking proprietors; But to leave it a free store-house, and common treasury to all ….

That is, collective political action taken on behalf of those who provide food to the people, symbolized here by the Diggers, is part and parcel of agroecology. To repeat, the Diggers are just one example, a rather famous one to be sure. But revolts of the peasantry certainly go back as far as recorded history and undoubtedly formed part of the fabric of how societies sometimes change – people gain power over others, then too much power, then the "others" revolt, and society at large is reinvented. And that power dynamic frequently is contained in the contradiction between the rural and the urban, after the urban became a "niche," a powerful foundation on which some forms of class structure emerge, a topic we return to in Chapter 8. If social classes are inevitably destined to struggle with one another, the location of the oppressed classes has frequently been among those who provide the society in general with its most basic substance, food. As detailed in Chapter 8, contemporary culture contains a worldwide movement of people engaged in that sociopolitical struggle, La Via Campesina, representing the peasant farmers of the world.

So, in the end, we propose thinking about agroecology in terms of these four pillars on which the agroecological platform sits: *science*, as reflected in the life of the former slave George Washington Carver; *traditional knowledge*, as symbolized by Indian farmers' composting techniques and their recognition by the English team of Howard and Matthaei; *nature*, as so brilliantly written about by Rachel Carson and frequently employed in traditional systems; and *political action*, from the Diggers of the seventeenth century to La Via Campesina of the twenty-first. Yet it is not the case that there are four distinct subjects here. Agroecology, as properly conceived, is the intersection of all of these. While some thinkers and actors emphasize one or the other, the proper philosophical position is that the intersection of these pillars is the most important nourishment that brings forth a true agroecology. Science is strongly influenced by traditional knowledge, much of which comes from a deep and abiding appreciation of the natural world, which is frequently conditioned by the political actions of peasants seeking to redress grievances. And as in most human endeavors, deep contradictions arise. Traditional knowledge may say that trees grow toward the wind while science says they grow toward the light, a contradiction resolved with the synthesis that the observations leading to the traditional knowledge were made in a valley where wind and sun enter from the same point.[58] Nature's structure may imply a perennial polyculture for a natural systems agriculture but science notes that such a natural system may be only one of two alternative states,[59] suggesting a forest garden is just as much natural

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systems agriculture as a perennial polyculture. Individual actors, individual organizations, and individual informal groups may emphasize one or the other of our four proposed pillars, but true agroecology comes from their common intersection and interpenetration.

There is an additional component of agroecology that remains implicit in much of the literature yet is sometimes left unsaid due to its uncomfortable implications. While moving forward toward an agroecological future, the four pillars we discuss here certainly can inform a program of "investment" in the future of agriculture, from the technical side of pest control and soil nutrient management to the political demands of agrarian reform championed by groups like La Via Campesina.[60] But such investment inevitably faces the reality of the current dominance of the industrial agricultural system, with its massive monocultures, concentrated land holdings, corporate capitalist structure, and poisonous technical packages. Investing in agroecology faces the proverbial prospect of doing the same thing and expecting different outcomes. If we seek a true transformation of world agriculture, making small changes, whether of a technical or political nature, is bound to fail if the dominant form of agriculture is not challenged.[61] In a parallel fashion the prospect of combating climate change requires *investment* in new technologies of renewable energy generation. Yet all rational actors acknowledge the need for a simultaneous *divestment* from those technologies that continue to cause the problems we seek to solve. And the realities of continuing climate change, and other evident problems, require *investment* in new technologies of agroecological production. Yet all rational actors acknowledge (or should) the need for a simultaneous *divestment* from those technologies that continue to cause the problems we seek to solve. We need not only to invest in developing and promoting the new agroecological platform, we need also to divest the technologies that continue causing the problems, the industrial capitalist agricultural system. New technologies, or new cultural commitments, or new political actions are obviously necessary. But if these are done with the, perhaps tacit, assumption that the underlying cause of the problems can be ignored, we actually serve the masters by fixing some of the problems they have created. Whether it is global food insecurity or massive insertion of nitrous oxide into the environment, the agroecological movement must simultaneously seek positive growth and challenge the ongoing destruction – growth in agroecological development and expansion while challenging the industrial capitalist agricultural model.

1.6 Agroecology: Theory and Praxis

Applying the science of ecology to the evident contemporary crises, we face two contradictory challenges. First, there is the acknowledged urgency of the three cataclysms, climate change, biodiversity loss, and world hunger. The sense of urgency is palpable in public culture and anchored by substantial scientific support. What was predicted in theory two decades ago is now reality in practice, from California fires to floods in Bangladesh, and we urgently need to step in and make substantial changes quickly. Second, we now have "a sense that our time calls for deep and long-term civilizational changes,"[62] not exactly an attitude that blends well with the evident urgency and need to make changes quickly. An urgency for action to make long-term civilizational changes is quite the contradiction.

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There is in our view a synthesis – the move toward dismantling the industrial capitalist system along with the promotion of agroecology.

To repeat much of what we already have said in this chapter, one of the main sources of the contemporary urgency is the modern industrial agricultural system – affecting climate change, biodiversity loss, and hunger. Somewhere between 30% and 50% of the greenhouse gases we pour into the atmosphere come, either directly or indirectly, from that system.[63] The crisis of declining biodiversity likewise is either directly or indirectly attributed to the industrial agricultural system, although, as the former president of Brazil demonstrated, simple traditional corruption is frequently involved.[64] And finally, the cornucopia of food and "end-of-hunger" narratives so often argued as evidence of the need for the current system have not worked out so well, with 50% of the world's population going to bed hungry every night and another 20% suffering from health-threatening obesity, both being results, direct and indirect, of the industrial agricultural system writ large. Given all of this, a rational person might be tempted to suggest that the "civilizational change" required is parallel to such changes in the past, and that negative or pessimistic attitudes facing the prospect of that change only provide barriers to its realization – it is hard to take much action if you are paralyzed by pessimism.

There is, unfortunately, a false optimism that can, we believe, be even worse. A popular stance among those seeking to address the urgency of climate change, biodiversity loss, and world hunger seems on the surface bold and forward-looking – refine the technology of "clean energy," enclose more of the world in biological preserves (protected areas), and produce more food to feed the hungry. One can hardly find fault with such goals. Nevertheless, as Anand Giridharadas (2019) popularized in his *Winners Take All* best-seller, ignoring the root cause of a problem can make efforts to solve it pointless – bailing out a leaking boat while ignoring the holes in its bottom. Of course, the pursuit of civilizational change seems grandiose. But as an organizing metaphor, we argue, it is the pursuit itself that is required at the present time. And fortunately for the present argument, there is a vision, growing worldwide, of that civilizational change – agroecology.

Promotion of the agroecology agenda, which we advocate, must face a key simple fact – the science of ecology is complex, sometimes enigmatic, and currently poorly developed. The civilizational change required is to cast off the industrial agricultural system and replace it with agroecology. Yet as we move in the direction of expanding production of an agroecological kind to replace the collapsing industrial system, we face our ignorance. It sometimes seems, as we begin understanding the complexities of the new agroecosystems, that we must engage in production technology without fully understanding that technology, that the complexities of ecology need to be fully understood before any near-term action can realistically take place, the complexity-itus we referred to earlier. Wallowing in the uncertainty inherent in such a complex system, our only advice to the expanding agroecological sector can be that we really have no idea how to somehow "optimize" agroecology.

This honest humility refers to the immediate problem of local praxis in time and space. While it is true that we make the path by walking,[65] it is also true that we must have some sort of "castle on the hill" and adjust our path accordingly. Such philosophizing, while inherently necessary for truly revolutionary praxis, denies the practical necessities of those

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who are actively seeking to construct the agroecological vision. To the millions of small-scale and peasant farmers trying to produce agroecologically we offer the fact that the combination of available traditional knowledge, obvious structural features of the natural world, inspiration and knowledge gained from political struggle, and whatever temporary knowledge is provided by the science of ecology suggests a rich collection of rules of thumb. Some of them may turn out to be oversimplifications or even wrong, but on balance we do know how to make agroecological farms, not with fixed rules of ecology or deep epistemology that stems from either nature or traditional knowledge, but temporary constructions that make sense for production, for maintaining biodiversity, for not poisoning the Earth – the rules of thumb that work sometimes, perhaps frequently, but remain based on a temporary state of contemporary knowledge, part of which acknowledges that it is temporary and always in need of refinement.

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