

The economic legacy of the Holocene

The significance of the agricultural revolution is underappreciated in the discourse on the problematic relationship between economy and Earth. The emergence of agriculture was a major transition in the social evolution of humans; it established a structure and dynamic to economic life that has been with us ever since. The economic order that devolved from agriculture was characterized by profound, productive, interdependent, mutually reinforcing interactions that drove human expansionism. The relationships among humans and between humans and the other-than-human world were fundamentally altered with agriculture, while the material reproduction of humans became a self-referential enterprise with the integrity and force of a 'superorganism'. Cross species comparison of agricultural species, and the use of an expanded evolutionary framework to interpret it, reveal that economic order is a foundational aspect of collective species existence with currency in the matrix of species evolution. In the case of humans, agriculture was not simply the result of the Holocene warming and human ingenuity, but also of the complex play of evolution on external and internal factors that set the course and stage for the rise of global capitalism and the sixth mass extinction.

There now exists an untenable trajectory of human economic order on Earth where mass extinction and ecological decay follow in its path. The best intentions we muster to change course seem mostly to bolster the denial of our situation. The other-than-human world now has become almost entirely eclipsed by an unassailable 'superorganism' that continues to expand. Mass extinction is no longer a matter of geological history; instead it is the present anthropogenic reality.

I begin with the circumstances that led me to alter my own approach to this complicated matter of economy and Earth. In the mid-1990s I had the privilege of working closely with my stepfather, the human ecologist Paul Shepard. His interdisciplinary scholarship expanded the discourse on the relationship between humans and the other-than-human world. I was placed in an intimate connection with him by virtue of family and by the accident of his illness. I helped him bring closure to his life's work in the two years it took him to die of lung cancer. My role was modest in

that I organized papers, pursued references and did the mundane tasks associated with helping him to publish his last books in the limited time he had (Shepard, 1996; Shepard, 1998). In the end, this rather functionary role connected me with the literature, debates and ideas of his world, eventually altering my own.

I have many poignant recollections of this time but one, in particular, is relevant here. In the week before he died, when the lines of time and space began to break down as they reliably do, Paul turned to my mother one night and said that she should not be alarmed if, when she awoke, he was not there – she would find him in the back yard scything. At the time, it seemed to me a strange place for him to go when imminent death allowed him the freedom to wander anywhere. After all, he had dedicated his life work to a critical and scathing appraisal of the impact of agriculture on humans and Earth, and all that had been lost when humans began to domesticate plants and animals. I thought he would return to the Pleistocene but instead he engaged an act of the Holocene: scything. Clearly enough, on

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his deathbed Paul was not finished thinking about the importance of agriculture. I have since internalized his deathbed inclination: this impulse to account for what happened to humans and Earth when humans began the cultivation of annual grains and embarked on animal agriculture.

The significance of the agricultural revolution

My predisposition toward the importance of the agricultural revolution sensitized me to approach the structure and dynamic of human expansion that now plagues the Earth from a deep historical perspective. Human population went from around 6 million people at the start of the Holocene (some 10,000 years ago) to at least 100 million a mere 8000 years later (Biraben, 2003). Put another way, we were anatomically modern humans, by some estimates, for 150,000 years as hunters and gatherers and had only reached a total human population of around 6 million when agriculture emerged. Agriculture – and specifically agriculture based on annual grains and domesticated animals – gave rise to an accelerated rate of human population growth and to the formation of concentrated and sedentary living in the form of state societies in a relatively short period of time. Agriculture was not a continuation along a linear path of human alteration of the other-than-human world; rather it was an abrupt turn – an altogether new trajectory – and, I would argue, a major evolutionary transition for humans.

The agricultural revolution is the direct antecedent of the present-day collision course between the global economy and Earth, and capitalism is a particular institutional rendering of a system change that had been in motion for 10,000 years before the market economy was fully engaged. Yet in most conversations about the present, some combination of the triumvirate of the industrial revolution, technology and capitalism is viewed as the key force that led to the alteration of our circumstances. The importance of the agricultural revolution all but recedes

into the realm of obscurity, never fully discounted but never wholly acknowledged either.

The work of Jason W Moore is illustrative of this trend (Moore, 2016). Moore proposes renaming our present epoch the ‘Capitalocene’ in the spirit of focusing attention on what he sees as the source of the problem – namely, capitalism. I am sympathetic to Moore’s attempt to argue that the Anthropocene did not begin in the last 200 years but with capitalism’s *longue durée*, perhaps beginning in the 14th century when capitalism’s ‘world ecology’ took hold. Yet I am disturbed at the high discount rate he applies to human prehistory and to the importance of the agricultural revolution in his account. Moore argues that analysis should begin with “the relations between (and among) humans and the rest of nature and thence move toward geological and biophysical change” instead of the more common approach of beginning with “biospheric consequences” and moving “toward social history” (Moore, 2016: 97). Yet, evaluated on this basis, the agricultural revolution ought to register as monumentally important because it profoundly altered the relationships both among humans, and between humans and the other-than-human world. In fact, one might argue, ‘the rest is history’.

Let me be clear: I appreciate the need to deal with the particulars of capitalism in its unique rendering of domination, exploitation, expansion, extinction and ecological decay. Yet if we place capitalism in a broader historical context, there is much to be gained in our understanding of the emergence and complexity of its economic order, the challenge of changing it and the deep ecological perspective that must inform this revolutionary work.

While it may be true in some very general sense that ‘humans change the environment and the environment changes humans’ this process was not – as Moore (2016) suggests – a simple continuum over time until the epochal changes brought about by the emergence of capitalism. On the contrary, the agricultural revolution of the Neolithic period brought about a huge,

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qualitative shift in the relative influence of one on the other. The domestication of annual grains and livestock was a distinct, momentous change in the weighted dialectic of humans changing the environment and the environment changing humans; it was the fundamental change that set the stage for the emergence of capitalism's world ecology. Hence, in many ways it is the configuration of advanced globalized capitalism and state societies that arose out of agriculture that is the continuum, while the shift from hunters and gatherers to state societies is the key rupture.

Agricultural insects

My understanding of the importance of the altered economic order put in motion with agriculture made me curious about whether we were the only species to have engaged in an agricultural mode of production. After all, we compare ourselves to other species all the time so that we might better understand how we came to be what we are. This exercise did not take me to primates – they do not practise agriculture – but it did take me to the social insects that do: ants and termites. Few people seem to register this fact, and even among those who do there is little appreciation for any relevance it might have to our human story – perhaps because, after all, we are on an individual basis so completely different. Clearly it was not the comparison of individual ants with individual humans that intrigued me; it was their collective similarities around an agricultural way of life. It turns out that the structure and dynamic of the economy of agricultural insects is very similar to that of humans after humans made the agricultural transition: it is expansionary, interdependent, autocatalytic and involves an extensive and hierarchical division of labour.¹ While I do not want to make the mistake of assuming that a similar outcome means that ultimate causes are the same, neither do I want to discount what appears to demand a closer look (for further discussion, see Gowdy and Krall [2013], Gowdy and Krall [2014], Gowdy and Krall [2016a] and Gowdy and Krall [2016b]).



Figure 1. A leafcutter ant (*Atta cephalotes*) in Costa Rica (Peter Nijenhuis; CC BY-NC-ND 2.0; <https://creativecommons.org/licenses/by-nc-nd/2.0/>).

The most highly evolved agricultural ants are in the genus *Atta*, and are commonly known as leafcutter ants. As the common name suggests, they cut leaves and process them in an assembly-line fashion that involves a complex division of labour. The largest ants cut big pieces (Figure 1) that are transferred to smaller ants, who further cut them and so on until the pieces end up with the smallest assembly line ants that “mold the fragments into pellets, add fecal droplets” and insert them in a place where an even smaller ant can plant “loose strands of fungus” on them (Hölldobler and Wilson, 2010: 55). There are also ants that are in charge of defence, ants that remove waste, ants that take care of broods and so forth. With this extensive division of labour the leafcutter ants build underground colonies that are architecturally sophisticated and can unify as many as a million ants around a focused enterprise of fungus farming. As a species, the leafcutters ants have clearly tapped into collective benefits in their ability to articulate and reproduce themselves efficiently around such fungal production.

The colony's ants are so profoundly interdependent, with this elaborate division of labour, that individual autonomy is essentially non-existent and ‘cooperation’ is so extreme that some members of the colony are sterile. No single ant has knowledge of

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fungal production; rather, that knowledge is embedded in the collective, in the way it works around the common purpose. Following the lead of Hölldobler and Wilson (2010), it does not seem a stretch to call what the ants have ‘civilization’, and to refer to the colony itself as a ‘superorganism’ in virtue of the intelligence and order it possesses unto itself. Indeed, it is the colony, as a unit of selection, that has standing in the matrix of evolution. These species are extremely successful by biological and evolutionary standards. The autocatalytic interplay of fungal production and population growth allows for tremendous expansion in colony size. There is also expansion – via the migration of a colony to a new nest site, and the establishment of new colonies.

Other observers have noted the parallels between these superorganisms and human societies in relation to the practice of agriculture. For example, in his review of Wilson and Hölldobler’s book *The Superorganism*, Tim Flannery (2009) states: “it is the changes wrought in attine societies by agriculture that the principle interest for the student of human societies lies.” Again, what is evident in this comparison between agricultural species is the social–structural and population dynamics similarities that are nothing short of astonishing.

When I became aware of these similarities in economic organization and population dynamics in connection with agriculture, I found it impossible to settle my mind on anything else. I was compelled to identify the processes and mechanisms that gave rise to strikingly similar economic configurations in otherwise very dissimilar species. The agricultural revolution of humans did not appear to be only a matter of ingenuity, intentionality, reason, institutions and culture, since agricultural insects had achieved the same milestone, the same configuration and the same ‘success’ millions of years before humans.

As an aside, I also wonder whether Adam Smith and his tome on capitalism might have turned out very differently had he been aware of the amazing *Atta* ants. He certainly would never have been able to claim that the human capacity for a division of labour

“is common to all men, and to be found in no other race of animals” (Smith, 1976: 17). Perhaps Smith might have concentrated more on the co-evolutionary fabric of cultivation and the species proclivities engaged and extended therein in his discourse on the invisible hand.

Economic order and its drivers in the matrix of evolution

In my exploration of agricultural species I did something that progressive social scientists generally avoid: I looked to evolutionary biology for guidance because I could think of no other way to explain the parallels between agricultural humans and agricultural insects (Gowdy and Krall, 2013; Gowdy and Krall, 2014; Gowdy and Krall, 2016a; Gowdy and Krall, 2016b). I began to realize that our understanding of the rupture that occurred in the structure and dynamic of economic life after agriculture might benefit from evolutionary theory – and particularly from being treated in an extended evolutionary framework that embraces the complexity of evolution as it relates to the formation of groups, the evolution of cooperation, and niche construction (e.g. Margulis, 1970; Okasha, 2006; Wilson and Wilson, 2007; Pigliucci and Muller, 2010; Jablonka and Lamb, 2014; Laland *et al.*, 2015). This extended evolutionary theory allows analyses to move beyond the narrow confines of genes and kin selection, and is now explored in the well-established tradition in evolutionary biology known as sociobiology. In our papers, John Gowdy and I have argued that sociobiology can accommodate the formation of the economic collective as a force, and unit of selection, in the matrix of evolution.

I realize there is something off-putting about this approach because using evolution to explore economic order can make the latter seem deterministic (and, for that matter, make the former seem theoretically loose). I think of it differently. An expanded evolutionary framework simply gives us one more piece in the puzzle in our quest to understand the emergence and success of an economic order, most especially the problematic economic order that started with agriculture that we now have on our

hands. It encourages greater appreciation for how fundamental economic order is to species life, and it helps us to understand that economic order might be approached best from the vantage point of *collective* behaviour rather than from attempting to aggregate *individual* behaviour. We have been led in much of economic theory to an emphasis on the role of the individual in economic order – from simplistic readings of Adam Smith to the banal assumptions of the behaviour of ‘rational economic man’. Yet the more appropriate emphasis may be on the formation and dynamic of economic order from the perspective of the collective, where the whole becomes something greater than the sum of its parts, with an integrity and force in the play of evolution. Again we can note that, once formed, agricultural groups outcompeted non-agricultural groups as indicated by the gauge used in evolution: fitness.

In the process of focusing on the formation and integrity of the ‘superorganism’ around the agricultural mode of production and reproduction, I began to concentrate on cross-species mechanisms of economic formation. It was in this way that I circled back to the division of labour as an elemental potential of a species life – something that opened up possibilities for the species, and that could be actualized in certain conditions (when it was beneficial for the species to do so). In the case of agricultural insects and humans, the division of labour seemed a particularly important species capability that helped to give rise to agriculture, to structure group cohesion and to extend its influence – especially via the expansionist and warring proclivities of agricultural societies.

In my inquiry into human agriculture, I tried to separate the question of the division of labour from the question of culture because insect species that practise agriculture do not have culture as we generally think of it (Krall, 2018). I am aware that culture permeates human social order, which would seem to make this exercise somewhat contrived. The rationale is that this disaggregation is an attempt to get at something elemental, especially in the context of thinking about the mechanistic relationships that frame

economic order *across* species. It is worth noting that sociologist Emile Durkheim was also inclined to see something beyond the realm of culture in the division of labour, writing in 1893 (Durkheim, 1964: 40):

It is no longer considered only a social institution that has its source in the intelligence and will of men, but a phenomenon of general biology whose conditions must be sought in the essential properties of organized matter.

The ant (and termite) species that practise agriculture clearly have the species potential to engage a division of labour. Again Tim Flannery (2009) makes this connection in his review of *The Superorganism*: “Clearly, not only did the attines beat us to agriculture, but they exemplified the concept of the division of labour long before Adam Smith stated it.” Humans came into the Holocene with this propensity already established, but it was engaged rather modestly and loosely, mostly along the axes of age and gender. Agriculture extended and elaborated the division of labour to create an interdependent collective focused around grain and livestock production. The division of labour appears to have been a particularly important driver of a new economic order (Gowdy and Krall, 2013; Gowdy and Krall, 2014; Gowdy and Krall, 2016a; Gowdy and Krall, 2016b).

From a purely economic perspective, the division of labour offers efficiency benefits to the species that practise it. That is, greater output is produced per unit of species input – which, in the case of the agricultural revolution, amounted to a food surplus. Hence, there were (are) clear adaptive, positive feedback loops for societies (be they human, ant or termite) that engage this strategy. It is clear that agriculture extended the division of labour among the species that practised it, and the interdependence created therein imbued agricultural societies with cohesion and unity that gave them integrity and currency in the matrix of evolution. Over 10,000 years in human societies this order was accentuated with institutions and technologies that reinforced the fundamental structure and dynamics of

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interdependence, surplus and geographical expansionism that began with agriculture. Think about where this has led – to the detailed division of labour embodied in assembly-line production, on the one hand, and to the human takeover of the biosphere, on the other.

Human agriculture: The engagement of an economic superorganism

Agriculture based on grain cultivation and livestock production is a multi-layered evolutionary process. A categorically different human ecology and human economy emerged out of the complex potentiality of the human species and Earth around the cultivation of grains and domestication of animals. As with colonies of agricultural insects, the human economy became something of a ‘superorganism’ with formidable evolutionary advantage, but simultaneously created an accompanying human ecology characterized by duality. The Holocene warming and its climate stability were necessary for successful agriculture. A good stock of fertile soil also helped to jump-start the process. Embedded soil carbon too was a driver in this transition to agriculture. These were the external conditions that tipped the scale favourably in the direction of agriculture, but they were not the whole story in the emergence of agriculture. For this we have to look more closely at the interplay or co-evolution of internal factors and their force as a collective whole.

Agriculture required good co-evolutionary potential between people, plants and animals. This co-evolution set in motion the formation of a wholly integrated and structurally interdependent collective order that had never been the hallmark of the human economy before. Of course, there was cultural cohesion in society long before agriculture, and the human capacity for cooperation was well developed (Richerson and Boyd, 2006; Bowles and Gintis, 2011; Moffett, 2013). Yet it was only with agriculture that the cooperation of society in material life took on the characteristics of a ‘superorganism’: an insular, autocatalytic, interdependently ordered whole (Gowdy and Krall, 2013; Gowdy and Krall, 2014; Gowdy and Krall, 2016a;

Gowdy and Krall, 2016b). Individual autonomy in material life all but disappeared and the profound material interdependence gave new power to the collective enterprise focused and structured around agriculture’s demands. Importantly, the ecology of human material life took on a dynamic of expansionism and conquest and a related duality between humans and the other-than-human world emerged.

In the case of grain agriculture, each species had qualities enhanced and extended by the interactions that brought agriculture to fruition and formed this economic whole. Annual grains were quick to give co-evolutionary results because they were planted and thereby selected every year, so any attribute in them that worked well for humans (e.g. non-shattering seeds and large seed size) could be accentuated in a relatively short period of time (Cox, 2009). As well, grains provided good raw material for surplus: they could be easily stored. At the same time, the problematic ecology of grains and grazing – involving loss of soil fertility, soil erosion and landscape degradation – continuously pushed human expansion.

Our grasp of the co-evolutionary dynamic of agriculture is not complete unless we also understand the ways that *human* propensities were moulded by the engagement with agriculture. Humans were reconfigured, perhaps more profoundly than the annual grains and domesticated animals with which they interacted. This change was not apparent in the human genome (with a few exceptions), but in the structure and power of the collective formation and cohesion of agricultural groups. The human capacity for cooperation and a division of labour had never integrated humans with such machine-like precision, and such extensive interdependence in material procurement, until agriculture honed this human propensity in concert with cultivated grains. As previously noted, humans had an autochthonous propensity to engage a division of labour, and this species potential, like the genetic potentialities toward larger and non-shattering seeds in annual grains, became more fully expressed and entrenched with agriculture.

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It is possible that without the propensity for a division of labour the initial challenges of agriculture would never have been successfully overcome. Certainly the productive benefits would not have been fully realized and agriculture might never have gained the currency it did as a dominant mode of production. Experiments with initial cultivation benefited from this propensity simply because hunting and gathering continued, and the multitude of tasks associated with cultivation were additive. Quite simply, there were more jobs to be done. The efficiencies inherent in a division of labour constantly pushed the boundaries of production toward surplus, further extending the division of labour in a positive feedback cycle and thereby reinforcing grain cultivation as a viable material strategy for humans. This occurred despite declines in human health, stature and intelligence, and the increasing numbers of humans relegated to slavery, coerced labour, military conscription and other forms of hierarchical subjugation (Larson, 2006; Scott, 2017). Economic structure around grain and livestock agriculture fed back on itself in an autocatalytic dynamic with formidable positive feedback loops pushing the expansion of population and the division of labour. This was not a steady-state system of equilibrium – it was a tremendously expansionary system with vast state societies developing in a relatively short period of time after the first seeds of domesticated annuals popped through the cultivated soils of the Holocene. A new economic order had taken hold of humans that would direct the path of society, culture and technology for millennia.

The ecology of dualism embodied in the organization of work

The restructuring of society around agriculture was also expressed in the organization of work around the rhythm and dynamic required for the cultivation of annual grains. Annual grains demanded work that could be routinized, rationalized and standardized. The structure of work associated with agriculture was dictated by the needs of its domesticates in the

same way that the diversity of plants and animals that were utilized by hunters and gatherers to procure their material life dictated the structure of the work of hunters and gatherers. However, the knowledge and skill associated with hunting and gathering resided in the *individual*, and in the quality of observation and understanding of a varied and complex nonhuman world. Engagement with this world was simply not amenable to standardization and rationalization in the way it came to be with agriculture. Richard Lee observed that pre-agricultural societies (bands) had “a degree of freedom unheard of in more hierarchical societies. In the organization of production foragers could work their own schedules” (Lee, 1998: 12).

Philosopher Bill Vitek aptly describes what agriculture did to the human understanding of the other-than-human-world (Vitek, 2018):

Ancient and indigenous understandings of a wild, creative and sacred Earth were interrupted, driven underground, and nearly eliminated by the invention of annual, monoculture agriculture 10,000 years ago. With its powerful dualisms pitting crop against weed and livestock against predator, agriculture established attitudes that nature was to be subdued or ignored.

Thus the duality of human–nature separation emerged out of agriculture, turning everything that interrupted and derailed the effort to grow grains and livestock into ‘weed’, ‘pest’, and (despised) ‘predator’. But this duality was also expressed in the very structure of productive life which became a more insular, focused, routinized, rationalized and integrated collective enterprise dictated by the demands of annual grains and livestock. Humans as a collective whole easily adapted to this regiment, while as individuals they had no choice but to submit to it.

Agriculture reduced the complexity in the provisioning of food to mundane and routinized tasks, leading anthropologist James C Scott to conclude: “I am tempted to see the late Neolithic revolution, for all its contributions to large-scale societies, as something of a deskilling” (Scott, 2017: 91–2).

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With cereal production, knowledge and skill came to reside in the routines of ‘fixed-field farming’ of cereal grains. The routines were daily and seasonal where sowing, weeding, watering, cutting, bundling, threshing, gleaning, winnowing, sieving, drying (*etc.*) dictated the rhythm and structure of the day. Scott tells us: “These meticulous, demanding, interlocked, and mandatory annual and daily routines [...] strap agriculturalists to a minutely choreographed dance steps” and insist “on a certain pattern of cooperation and coordination” (Scott, 2017: 92). Scott argues that we thus became “disciplined and subordinated to the metronome of our own crops [...] Once *Homo sapiens* took that fateful step into agriculture, our species entered an austere monastery whose taskmaster was mostly the genetic clockwork of a few plants” (Scott, 2017: 92). Yet in the routinized work around annual grains and domestic livestock, with a species well adapted to working together through a division of labour, there were efficiencies in this material strategy, and surplus to be had, tipping the trajectory of human social evolution in the direction of the expansionary ‘superorganism’.

Thus agriculture ushered in the ecology of duality and domination that emerged out of, and found expression in, the very fabric of productive activity. The human domination that resulted must certainly not be interpreted as some pinnacle of evolutionary perfection. The gain was in the economic efficiencies that provided a reliable flow of grain and grain surplus, which became the central focus of the human diet and human productive activity, and which provided the raw material for expansion and for the formation of state civilization and hierarchy. Yet the quality of the day-to-day interaction of humans with the other-than-human world had been irrevocably altered – turning what was once symbiotic and ritual coexistence into drudgery and an agonistic relationship to resource, pest and predator. Material provisioning of life no longer expanded the human imagination nor reinforced a sense of belonging in the ecosphere; instead, it dulled the senses and distanced humans from the other-than-human world.

The other side of despair

Confronting the untenable economic trajectory we find ourselves with demands that we assess our circumstances forthrightly. My best judgement tells me that there is much to lose in this historical moment by relying on naive optimism – especially when it comes to economic matters. I apologize that in the face of this cataclysm I have only some cautionary notes to offer on how to approach this problem of economy and Earth in a manner that avoids the platitudes and simplifications that cause us to underestimate the challenge before us.

The emergence of our economic order is perhaps more complicated and disturbing than we imagined. As discussed above, an examination of the convergent evolution of humans and social insects that practise agriculture is instructive in getting us to think about our economic order more expansively. Economic order for humans is something more than the interplay of intelligence, culture, intentionality and technology. It goes deep into foundational aspects of how we collectively became what we are, and the processes that influence how we are altered over time. This is no simple matter. It is not simply the ‘dark side’ of our nature that has landed us here, but a more subtle, unintentional but very real evolutionary play around the inherent tendencies of our species and annual grains in the rich Pleistocene soils and the Holocene warming. Evolution has its way of playing on small changes that end in more profound outcomes; evolution is not a teleological process that aims at perfection, but a process that unfurls on the basis of short- to medium-range advantages in fitness.

Cereal and animal agriculture ushered in an altered economic order of a formidable ‘superorganism.’ The dynamic of expansion and surplus production, the profound material interdependence, and the alienated relationship with the other-than-human world remain with us in the morphed form of global capitalism and its attendant technologies, ideologies and institutions. So much the worse for us and

for Earth. Ten thousand years with this system have only served to enhance and cement its tendencies. If we want to stop the wholesale extermination of the other-than-human world and leave reasonable possibilities for future generations of humans, we will have to dismantle this economic 'superorganism'. This is no easy matter, and the question of the effectiveness of human agency on this front obviously looms large.

On the hopeful side, while our social order is the legacy of the Holocene, *Homo sapiens* is a species evolved to resonate in the rhythm and dynamic of a rich biosphere (Shepard, 1982). In this sense, we are very much a Pleistocene species. It is only because of the converging contingencies of the peculiar Holocene trajectory that we have forgotten this and succumbed to a cultural amnesia engendered by a human supremacy that we have labelled as "progress" (Crist, 2017). We have to override the force of this Holocene legacy with Pleistocene sensibilities. Those sensibilities inform us that we need to be careful about our numbers and recognize that population growth is a pernicious part of an autocatalytic, agricultural dynamic that we ignore at our own peril.

Our Pleistocene sensibilities also tell us that we need to be careful about our propensity for cooperation and, in particular, how we order ourselves collectively around material life. It is one thing to work together in small groups and help each other out; it is another to become mechanistically structured around technologies and institutions that reduce us to mere cogs, to casualties or appendages of the collective's expansionism, and alienate us from, and diminish and destroy, the other-than-human world. Annual grains, a bloated livestock industry, industrial technology, state societies and market capitalism are examples of problematic outcomes, technologies and institutional arrangements that come straight out of the Holocene manual. Unfortunately, they have been all too good at offering up economic efficiency, surplus and increased population, and historically these have had

currency with our species in the matrix of our social evolution. We would be well advised, however, to understand that evolution cannot see ahead; that a strategy has been evolutionarily successful in the short-haul is no guarantee that it will be successful in the long haul.

Some experimentation with doing things differently is underway. For example, Wes Jackson and the plant scientists working at The Land Institute in Salina, KS, USA, are carrying out a revolutionary agenda with a 'Pleistocene mind' right now. They are developing perennial grains grown in a system of perennial polyculture modelled after the prairie ecosystem. This is a remarkable experiment towards a different model of food production but, as Jackson is well aware, it is not enough for a wholesale shift in our problematic "10,000 year old problem" (Jackson *et al.*, this issue). To that end he has initiated an Ecosphere Studies initiative to attempt to push a 'cultural' shift. I suspect this will be the more difficult arm of the ongoing revolution since the trajectory set in motion with agriculture has deep evolutionary roots and 10,000 years of institutional and technological amplification.

Paul Shepard's scything was the meditation of someone standing on a border between two worlds. Looking back, he could still meet the eye of a wolf at the edge of a field. He could still glimpse the "finely tuned" human ecology of our Pleistocene evolution with its demography of "a slow-breeding, large intelligent primate" (Shepard, 1998: 169). Looking forward, he understood that a madness had overtaken us. An unimaginable future was unfolding, unforeseen by those who scythed those first domesticated grains and ploughed the first fields. Shepard might have wondered whether it was possible to linger very long between these two worlds. We are not lingering, not anymore. The death knell of the other-than-human world is ringing loud and clear. We have 2 billion more people on Earth now than we did two decades ago when Paul did his scything, global gross domestic product has doubled in that time, and mass extinction is the order of the day.

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Our debt to the other-than-human world is past due. We need a different trajectory where our goal is a finely tuned human ecology in which we are not a dominant species, but just one of many. It seems fitting to have an inclination to begin a change with agriculture but the reach of a different agriculture must be expansive. It must extend beyond the fields of food production and give rise to a fundamentally different landscape of economic order. ■

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Note

¹ The term 'autocatalytic' is used here (rather than 'dialectical') to highlight that this involves a positive feedback cycle that produces a non-linear growth curve.

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