The ultrasocial origin of the Anthropocene

John Gowdy & Lisi Krall

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[Abstract]

The current geological epoch has been dubbed the Anthropocene—the age of humans. We argue that the roots of the Anthropocene lie in the agricultural revolution that began some 8000 years ago. Unique human psychological and cultural characteristics were present in our distant hunter-gatherer past, but in terms of the biophysical impact of our species, agricultural represented an unequivocal and decisive evolutionary break. With the transition to agriculture human society began to function as a superorganism functioning as a single unit designed by social natural selection to produce economic surplus. Where environmental conditions were permitted, early human agricultural societies followed the same pattern as a few social insects and exhibited explosive population growth, complex and detailed division of labor, intensive resource exploitation, territorial expansion, and a social organization favoring the survival and growth of the supergroup over the well-being of individuals within the group. Similar economic forces lie behind ultrasociality in social insects and humans—increased productivity from the division of labor, increasing returns to scale, and the exploitation of stocks of productive resources. Exploring the evolutionary mechanisms behind ultrasociality offers insights into the growth imperative that threatens the stability of the earth's life support systems.

[Epigraph]

> "Humanity today is like a walking dreamer, caught between the fantasies of sleep and the chaos of the real world. The mind seeks but cannot find the precise place and hour. We have created a Star Wars civilization, with Stone Age emotions, medieval institutions, and god-like technology. We thrash about. We are terribly confused by the mere fact of our existence, and a danger to ourselves and to the rest of life."
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> E.O. Wilson, 2012, The Social Conquest of Earth

Introduction: Ultrasociality and the Human Predicament

In terms of the relationship between the human species and the rest of the planet two questions stand out. The first question is how humans came to so dominate the earth's biophysical processes that we are now in danger of a major state shift in the earth's biosphere threatening to disrupt human civilization (Barnosky et al., 2012)? The second question is why, in the face of impending disaster, does our species seem so incapable of making the basic societal changes needed to insure our long-run survival (Mukerjee, 2013)? We argue that the answers to these questions lie deep in our evolutionary history. We are one of a handful of species that became ultrasocial, a broad term including humans as well as other species that have achieved higher level social organization. We use Campbell's (1982, 160) definition of ultrasociality:

Ultrasociality refers to the most social of animal organizations, with full time division of labor, specialists who gather no food but are fed by others, effective sharing of information about sources of food and danger, self-sacrificial effort in collective defense. This level has been achieved by ants, termites and humans in several scattered archaic city-states.

Like several social insect societies that made the leap to agriculture, human society began to function like a single organism dedicated to the purpose of producing an economic surplus. With this transformation we joined the 13-14 or so species that originally became eusocial. Among these, ants and termites went on to become ultrasocial, particularly with the adoption of agriculture (E.O. Wilson, 2012, 136).[1] Ultrasociality eventually gave us civilization and the material abundance much of humankind enjoys, but the reorganization of human society for surplus production also gave us two predicaments that we seem unable to solve—the unsustainable use of the planet's biophysical resources and the extreme material and social inequality that character-

[1] There is no consensus among biologists or social scientists as to the definitions of eusocial or ultrasocial. We use the term eusocial to refer to social insects and a handful of other species having an advanced level of colonial existence, a high degree of division of labor and a sharp division between sterile and reproductive castes (Wilson and Holldobler, [2005], 13368). Termites were the first eusocial species to evolve some 175 million years ago, apparently from a single ancestor. Eusocial ants also arose from a single ancestor about 150 million years ago. Eusociality arose three times independently in wasps and four times independently in bees. Eusocially appeared once among mammals (the naked mole rat), once among beetles, and perhaps three times in shrimp. See the discussion in E.O. Wilson (2012, 136-37).

izes most contemporary human societies. We share the characteristic of ecosystem domination with social insects; the second characteristic is unique to humans. Great strides have been made by evolutionary biologists in understanding the causes and consequences of ultrasociality in a variety of species. These understandings can offer key insights into the current human predicament.

The current geological epoch, which according to most geologists began with the industrial revolution about 300 years ago, and according to archeologists it began with the Holocene and human agriculture (Balter, 2013), has been dubbed the Anthropocene or age of humans. Our species now dominates the basic biophysical processes of planet earth and is influencing the course of evolution of the rest of the world's species (Barnosky et al., 2012; Steffen et al., 2011). The human impact on planet earth in the Anthropocene is staggering. Humans comprise about 50% of the earth's mammalian biomass (and the percentage is even greater if our livestock is included). Sanderson et al. (2002) calculated that over 80% of the global terrestrial biosphere is under direct human influence. Hannah et al. (1994) estimate that 36% of the earth's bioproductive surface is dominated by humans. The global human appropriation of net primary production (HANPP) was estimated by Vitousek et al. (1997) to be about 20% of potential net primary product (intermediate estimate). If anything, the human expropriation of the world's bioproductive capacity is accelerating. The human population has almost tripled since 1960, adding 1 billion people in the last 13 years (see the summary of HANPP studies in Haberl et al., 2010). Ecosystem dominance is a characteristic we share with social insects.

To appreciate the uniqueness of the Anthropocene it is important to understand our evolutionary history. In particular itis essential to recognize that with the adoption of agriculture the evolution of human society was fundamentally altered, in terms of the relationship between the human and non-human world, and the relationship of humans to each other. We have argued elsewhere (Gowdy and Krall, 2013) that the population explosion that came with agriculture-termed the Neolithic Demographic Transition (NDT)-can be understood as a major evolutionary event wherein groups of individuals become economically organized to function as a superorganism. We argue in this paper that the ultrasocial revolution of human society that began with agriculture inexorably led us to the Anthropocene.

We fully recognize that humans are unique in their degree of intelligence and in the intentionality of individual behavior. Intelligence and culture allowed humans to adapt to the extreme climate change of the Pleistocene by using new technologies and flexible cultures (Richerson and Boyd, 2005). Likewise, after agriculture human intelligence made it possible to create new technologies to exploit resources like fossil fuels unavailable to other species. But we also believe that faith in human uniqueness and agency has blinded us to the evolutionary forces driving human social organization. We emphasize this point because the constraints on human intentionality imposed by ultrasociality have been neglected. Ultrasociality has given human society features that make it extremely difficult to change course even in the face of impending disaster. We are not suggesting that there is no human agency but we are suggesting that the role of human agency is much less powerful than we think. *Individual intentionally* is not the same as *societal intentionality* and itis the latter that we call into question.

Beyond Selfish Economic Man and Selfish Genes: Multi-level Selection (MLS) and the New Sociobiology

Today, the field of evolutionary biology is at the frontier of enhancing our knowledge of human nature and human society. It is ironic that many social scientists still wish to isolate themselves from evolutionary biology in spite of the fact that mounting scientific evidence from the fields of animal behavior, behavioral science, and neuroscience confirms what the critics of reductionist approaches have argued for decades. Cooperation and altruism are pervasive in nature and humans are uniquely social mammals (de Waal, 2009; Frith and Frith, 2010; Waring, 2010). There is now solid scientific evidence that humans thrive in a complex system of cooperation, competition, and evolved social norms. As Waring (2010) points out, evolutionary concepts play a prominent role in ecological economics. But the prejudice against biological explanations of human behavior still stands as a barrier to developing realistic theories of human decision-making and effective social policies (see Hodgson and Knudson, 2010).

Evolutionary biology has hada rocky and complicated intellectual relationship with the social sciences. On one hand there exists a rich tradition of exchange of ideas as in Thomas Malthus's inspiration for Darwin and Wallace's theory of evolution by natural selection. A long line of progressive social scientists, from Veblen (1898) to Chomsky (2005), has drawn inspiration from evolutionary biology. Yet there is resistance to evolutionary explanations of social phenomena. Wilson's (1975) original formulation of sociobiology in the 1970s relied to a large extent on an interpretation of social evolution inspired by Hamilton's (1964) idea of inclusive fitness, also known as kin selection (see the discussion in E.O. Wilson, 2012, Chapter 6). Kin selection implies that altruism and cooperation can exist only because it is a way an organism can pass on genes shared by relatives.[1] In the 1970s the selfish gene idea was popularized by Dawkins (1976) and by parodies of sociobiology promoted by economists (Becker, 1976; Hirshleifer, [1977]).[2]

[1] As the biologist J.B.S. Haldane put it "I would jump into a river to save two brothers, but not one, or to save eight cousins but not seven." (Lehrer, 2012, 36).

[2] In an article in *Business Week* titled "A Genetic Defense of the Free Market," (April 10, 1978) Gary Becker commented: "Bioeconomics says that government programs that force individuals to be less competitive and selfish than they are genetically programmed to be are preordained to fail." (See Gowdy et al., 2013).

By the 1980s accounts of behavior based on selfish individualism had converged among economists and biologists. Most biologists rejected any notion of natural selection above the level of the individual (Dawkins, 1982; Trivers, 1985; Williams, 1985). Likewise, conservative economists rejected the notion that individual behavior could be anything other than self-regarding (Becker, 1976; see Hodgson, [2013]). In standard economics, the starting point for understanding human behavior has been the self-regarding, selfish individual— leaving culture and collective behavior outside the realm of economics. Many economists have long adopted crude survival of the fittest ideas to justify an unequal distribution of income and wealth. Friedman's (1954) classic article on economic methodology advanced a "natural law" of optimization through markets in that the fittest (most efficient) firms prosper and the unfit ones fall behind (see D.S. Wilson, 2012). Conservative economists still promote the idea that helping the "unfit" is a category of "moral hazard"—a violation of the laws of nature and harmful to the social good. Given the intellectual history of the use and abuse of biological theories to promote reactionary social policies, it is not surprising that many social scientists still have an aversion to biology and in particular to sociobiology.

But evolutionary biology has moved far beyond individualistic, bottom-up explanations of individual behavior and of living systems. In fact, at the same time that mainstream biology was consolidating around the "selfish gene", the idea was being reconsidered by some of the same biologists who first popularized the concept (Wilson, 2010; Wilson and Wilson, 2007). Hamilton (1975), inspired by the work of Price (1970), embraced the idea of multi-level selection (MLS).[3] E.O. Wilson's work on the evolution of eusocial insects convinced him that inclusive fitness was an inadequate explanation of cooperative behavior (E.O. Wilson, 2012; Nowak et al., 2010). Field biologists discovered that cooperation is widespread among a variety of species and that much of this cooperation could not be explained by kin selection alone (Goodnight, 2005; Goodnight and Stevens, 1997; Wilson, 2010). Remarkable examples of non-kin cooperation have raised doubts about the robustness of kinship explanations of ultrasociality. For example, it was recently discovered that two distinct species of spiders cooperate to provide extended maternal care of obviously unrelated individuals (Grinsted et al., [2012]). Johns et al. (2009) document a case where unrelated termite colonies merge and operate as a single unit. Furthermore, biologists have realized that the genotype-phenotype distinction was not as rigid as assumed by many selfish gene advocates. Different environments can call forth strikingly a different phenotype expression. Phenotype plasticity is thought to be a key feature of the evolution of social insects (Keller and Ross, 1993).

Although still controversial, a consensus is emerging that evolution has been driven by a process of MLS (Campbell, 1983; E.O. Wilson, 2012; Goodnight, 2005; Okasha,

[3] Wilson (2010) points out that Hamilton's change of position is not widely appreciated by biologists. His citation analysis of Hamilton's papers showed that his first (1964) formulation rejecting group selection and his second (1975) formulation embracing group selection are cited in a 15:1 ratio with no trend for the 1975 paper to become more frequently cited.

2006; van den Bergh and Gowdy, 2009; Wilson, 2010). Wilson (2010) makes a convincing case that kin selection and group selection can both be accounted for by the MLS theory. Multi-level selection and by extension group selection are complicated. As described by Okasha, MLS1 is the case where certain traits (like altruism to use D.S. Wilson's example) detrimental to the relative fitness of individuals within a group nonetheless get reproduced in a population. The essential logic of MLS1 is quite simple. Selfish individuals outcompete altruists within a group, but altruistic groups outcompete selfish groups (Wilson and Wilson, 2007). But MLS and group selection are less straightforward than MLS1 would imply because the group may be defined by a cluster of "emergent characters." Thus the play of selection may be not on a single trait but on a cluster of traits that come to define the group. And the group is not simply the aggregation of individuals with certain traits that have a greater probability of being reproduced because of the existence of the group, but rather the group has an advantageous character or trait all of its own. From the level of the organism, the MLS theory can be extended downward to explain cooperative and selfish genes, or upward to explain the evolution of group coalitions (Wilson et al., 2013). Wade et al. (2010) show that models of kin selection and group selection are not contradictory but in fact mathematically equivalent.

The MLS theory is beginning to integrate current social science research from behavioral economics, evolutionary psychology, neuroscience, and interdisciplinary studies of higher-level social organization. We propose that it also helps to explain the evolution of complex economic systems. We have argued elsewhere that group selection takes on a new force with the transition to agriculture (Gowdy and Krall, 2013). What happens with this transition is not simply a matter of selection at the group level resolving a collective action problem among individuals. With the transition to agriculture the group as an adaptive unit comes to constitute a wholly different gestalt driven by the imperative to produce surplus. Thus the group is by definition the embodiment of a bioeconomic evolutionary force that is central to understanding the evolution of ultrasociality in humans and by extension complex society in general and its ecological consequences. MLS adds to the literature on ecological and cultural coevolution of human society (Gual and Norgaard, 2010; Smaldino, in press; Waring, 2010; Waring and Richerson, 2011).

It is natural that attempts to understand our evolutionary behavioral attributes have looked first at our closest relatives, the great apes and other primates (de Waal, 2009). But the evolution and organization of social insects can also give us insights into human social evolution. Individuals within many species can form groups. And the selection of groups need not be based on genes but rather on group level traits also subject to the forces of natural selection (El-Hani and Emmeche, 2000; Ghiselin, 1974; Martmez and Moya, 2011; Reeve and Holldobler, 2007). The same evolutionary principles apply to groups of very different kinds of organisms unrelated by kinship. By focusing on group selection we do not mean to downplay the importance of individual selection or individual behavior. But in terms of understanding the internal logic of the human economy, and our relationship to the natural world, we believe that we have as much to learn from social insects as we do from our closest primate relatives.

The Social Conquest of the Earth

Evolutionary history can be understood as a series of punctuations representing jumps to higher levels of organization (Margulis, 1998; Smith and Szathmary, 1995; Wilson, 2010; Wilson and Wilson, 2007). Keller (1999: 60) writes: "The major transitions in evolutionary units are from individual genes to networks of genes, from gene networks to bacterialike cells, from bacterialike cells to eukaryotic cells with organelles, from cells to multicellular organisms, and from solitary organisms to societies." Higher-level selection processes have been central to the evolution of complexity (Martmez and Moya, [2011]). While MLS helps us to understand the evolution of groups, it is important to understand that the force of group selection is amplified in the transition to ultrasociality. It exaggerates between- group differences and homogenizes within-group outcomes, even when individual specialization increases. In those species that have attained ultrasociality the group comes to resemble a superorganism. E.O. Wilson (2012) argues that the "social domination of earth" by ultrasocial (he uses the term eusocial) species is a striking example of the evolutionary success of higher-level organization.

The consequences of ultrasociality that came with agriculture for both humans and a few social insects include (1) explosive population growth, (2) domination of the ecosystems in which they occur, (3) intensive and extensive mobilization of natural resources toward the imperative of surplus production, and (4) hierarchical organization and the subjugation of individuals to promote the success of the group entity. The widespread adoption of agriculture by humans followed the same pattern set by eusocial insects beginning tens of millions of years ago (Diamond, 1998; Gowdy and Krall, 2013; Mueller et al., 1998). As in human history, the adoption of agriculture by eusocial insects was a watershed in their evolutionary history.

Eusociality in insects is rare but overwhelmingly successful when it appears. Once present it dramatically enhances the competitive ability of the colony and leads to a dominance of the ecosystems in which it occurs. Ants and termites comprise about 30% of the entire animal biomass in the Brazilian rainforest (Holldobler and Wilson, 2011, 6) and 75% of the insect biomass. Worldwide the social insects-ants, termites, bees, and wasps-comprise about 2% of the earth's insect species, but they account for 50% of the earth's insect biomass (Holldobler and Wilson, [2009], 4). One of the most complex social insects, leafcutter ants, live in large cities of millions of individuals devoted to a single purpose— the cultivation ofa specific kind of fungus that feeds the entire colony.

The entire leafcutter ant society is organized toward the goal of producing fungus.[1] Ant agriculture arose about 50 million years ago in the neotropics (Schultz and Brady, 2008). The first agricultural ants cultivated a diverse variety of crops. One group of these ants-*Attine* or leafcutter ants-evolved relatively recently, about 8-12 million years ago, and became the dominant herbivore in the neotropics. Attine ants cultivate a single species of fungus which they feed a variety of leaves, flowers and grass. According to Schultz and Brady (2008, 5435): "This key evolutionary innovation renders a mature Atta colony the ecological equivalent of a large mammalian herbivore in terms of collective biomass, lifespan, and quantity of plant material consumed." Social insects, like their human counterparts, dominate the ecosystems where they occur, pushing competitors to the margins and harnessing other species to assist in their collective enterprises.

We have argued that common evolutionary mechanisms are at work in human and non-human ultrasocial transitions (Gowdy and Krall, [2013]). The specifics of the human transition may differ from ants but like that of the social insects, it was driven by the impersonal forces of natural selection. For both humans and social insects, with the adoption of agriculture the nature of the "group" changed from a collection of individuals cooperating to achieve mutually beneficial outcomes, to something akin to a superorganism centered on a narrow economic purpose, namely, the production of agricultural surplus. In ultrasocial species, the flourishing of the group is often at odds with the well-being of particular individuals in the group (Anderson and McShea, 2001; Gowdy and Krall, [2013]).

The evolutionary leap to ultrasociality in humans had its origin in the unique ability of humans to cooperate with one another. Prosocial traits were part of the human experience long before agriculture. The path to human sociality was paved in the Upper Paleolithic with the evolution of the social brain (Frith and Frith, 2010; Sherwood et al., [2008]). Our propensity to cooperate is a trait that in many ways defines what it is to be human (Wexler, 2006). We are strikingly different from our primate relatives in the extent to which we cooperate with non-kin (Hill et al., 2011). The ability of humans to cooperate with each other made possible the evolution of traits that define our species—language, culture, technology, and complex social structure. Sometime in the Upper Pleistocene these traits gave us art (more than 70 K years ago, Tollefson, 2012) music (at least 30 K years ago, Conrad et al., 2009), and a flourishing of sophisticated technology (100 K or more years ago, Henshilwood et al., 2011).

Recently a number of authors (de Waal, 2009; Nowak and Hightower, 2011; Pagel, 2011) have rightly argued that the human propensity to cooperate with others is the greatest human asset and perhaps the only hope for a sustainable and equitable future. But this optimism can be pushed too far. Pagel (2011, 299) writes:

[1] The remarkable power of natural selection to give rise to complex social and technological structures can be seen in the video of an ant city in Brazil:http://www.youtube. com/watch?v=D_TTb15mZx4.

Modern societies differ vastly from the small tribes that once competed to occupy Earth. But the old psychology plays out well in our globalized multicultural world. Our species' history is the progressive triumph of cooperation over conflict as people recognized that cooperation could return greater rewards than endless cycles of betrayal and revenge.

Stressing the virtues of cooperation is in many ways a more nu- anced approach to human nature than the selfish gene/economic man worldview. But the dark side to human cooperation must be understood if we are to realistically assess our present circumstances. As in the evolutionary history of social insects, cooperation was a pre-adaptation to ultrasociality. Beginning with the agricultural revolution, the human propensity to cooperate was co-opted by a bioeconomic evolutionary force as several large-scale hierarchical societies emerged and took on the characteristics of a superorganism. This ultrasocial transition reshaped human relationships and the relationship of humans to the natural world. With the transition to agriculture, the average individual was worse off even though the group flourished—individual well-being was diminished for the numerical and material success of the superorganism. We believe that the focus on individual selection and the neglect of MLS has blinded us to the complex and ambiguous evolutionary history of our propensity for cooperation.

We claim that the human superorganism is a self-organized higher- level system forged by Darwinian selection processes. As with societies of Attine ants, the system holds together and forms a structured whole responsible for the organization and execution of the material reproduction of society. It is a self-referential, interlocking system focused around an economic dynamic that defines the group: for agriculture, the imperative of producing agricultural surplus; for contemporary capitalism, the creation of surplus value. This system continues to evolve today as it engulfs a larger and larger portion of the earth's natural resources and consolidates its power to bring the world's population under a single production system operating under a unified "cosmology" (Gowdy et al., 2013; Sahlins, 1996). To the extent that the system is the result of mechanical evolutionary processes it is neither optimal nor progressive. The system may be "natural" but this does not mean that it is benign.

The Neolithic Demographic Transition (NDT) as an Ultrasocial Transformation

Homo sapiens lived sustainably on the planet for something like 200,000 years. Quite suddenly, in only a few thousand years after the widespread adoption of agriculture beginning about 8000 years ago, the human population exploded with the NDT (Biraben, 2003; Bocquet-Appel, 2011; Cox et al., 2009). Biraben (2003) estimates that the world population between 50,000 BCE and 40,000 BCE was about 1.5 million. Around 6000 BCE the human population stood at 4-6 million. By the beginning of the Common Era some 2000 years ago, the number of humans on the planet had skyrocketed to over 250 million. The population increase after agriculture was unprecedented in the prior 200,000 history of *Homo sapiens* (Biraben, 2003).[1]

Before the widespread adoption of agriculture, humans lived as hunter-gatherers in fluid societies without permanent settlements. Although there was great variation in hunter-gatherer economies (Kelly, 1995), it can generally be said that, compared to early agricultural civilizations, hunter-gatherer societies were environmentally sustainable, stable, egalitarian, and except for age and gender, largely undifferentiated in terms of division of labor (Bird-David, 1992; Boehm, 1993; Gowdy, 1998).[2] By "sustainable" we do not mean to apply intentionality. The economic anthropology literature distinguishes between "conservation" and "sustainability" with the former representing intentional, costly behavior, and the latter referring to outcomes that are not necessar-

[1] There exists a surprising lack of appreciation of the uniqueness and importance of the agricultural transition. Part of the neglect may be due to scale used in graphs to depict human population growth. With a scale that has to show the current population of 7 billion, the magnitude of the change from 4 million to 200 million with the agricultural revolution is hardly noticeable (see for example, Figure 1 in Nekola et al., 2013).

[2] The early (1960s and 1970s) anthropological consensus regarding hunter-gatherer societies as being equitable and sustainable has been challenged by a number of alternative perspectives (see the discussions by Solway and Lee, 1990; Lee, 1992; Alvard, [1998]). The fact that hunter-gatherers lived in societies that were generally sustainable and equitable may be hard for some people to accept because it doesn't fit the "progress" narrative of Western cosmology (Gowdy, 1998, 1999; Gowdy et al., 2013). Much of the discussion surrounding the "noble savage" controversy lumps together pre-agricultural hunter-gatherers, non-Western agriculturalists, and contemporary marginalized peoples who hunt using modern weapons and/or for trade with a dominant culture (see, for example, Krech, 1999). We fully recognize, however, that hunter-gatherers undoubtedly shared many of the foibles of modern humans.

ily intentional (Alvard, 1998; Hames, 2007; Smith and Wishnie, 2000). Throughout this paper we focus on outcomes not individual motivations, although it must be said that small-scale societies have a variety of norms and institutions to overcome free-riding and the overuse of collective resources (Ostrom, 1990).

Judging from the few remaining hunting and gathering societies and from historical accounts, it can be said that, in general, huntergatherers were aggressively egalitarian with vigorously enforced leveling mechanisms (Boehm, 1993; Lee, 1993). Boehm (1993, 239) writes: "Granting the serious limitations of reliable data, simple foragers, complex hunter-gatherers, people living in tribal segmentary systems, and people living in what I have called incipient chief- doms would appear to exhibit a strong set of egalitarian values that express an active distaste for too much hierarchy and actively take steps to avoid being seriously dominated." Egalitarianism does not come automatically in hunter-gatherer societies and it does not mean that resources are always distributed equally but it does imply some measure of individual autonomy (Kelly, 1995, 296). And material egalitarianism is certainly structurally encouraged in hunter-gatherers by the lack of emphasis on the production of material things. Perhaps the important lesson to be learned is that a variety of hunter-gatherer cultures recognized the dangers of hierarchy and privilege and actively intervened to minimize these disruptive threats.

Some division of labor existed, based on age and gender, but it was not organized around intensive modes of production. Hunter-gatherers lived off the flows of energy from a wide variety of plants and animals and thus the daily rhythm and orientation of the hunter-gatherer was fundamentally different than it became when humans began to exploit the stock of fertile soil and manage photosynthetic off-take through cultivation of plants and domestication of animals. Hunter-gatherers were embedded within an ecological dynamic that was not primarily directed by them. The control they exercised over the external world was modest compared to what it subsequently became and the economic imperative was fundamentally different; surplus production was not part of their economic dynamic. In a simplistic sense, there was no particular economic preoccupation for the hunter-gatherer. Sahlins (1968) has called hunter-gatherers "uneconomic man." The focus of economic activity was on production for livelihood rather than production for surplus.

This basic change in economic organization had profound consequences. First, with agriculture, many human societies entered a pattern of intensive resource exploitation, overshoot and collapse (Diamond, 2005; Tainter, 1988). Second, quality of life for the average person, in terms of human health and individual autonomy, declined sharply (Cohen and Crane-Kramer, 2007; Diamond, 1997; Lambert, 2009; Manning, 2004; Mummert et al., 2011; Shepard, 1973). In an extensive worldwide study comparing the skeletal remains of agricultural societies with their hunter-gatherer forbearers Larsen (2006, 12) found that: "Although agriculture provided the economic basis for the rise of states and development of civilizations, the change in diet and acquisition of food resulted in a decline in quality of life for most human populations in the last 10,000 years." In a review of recent studies of societies shifting from foraging to agriculture Mummert et al. (2011, 284) conclude: "The impact of agriculture, accompanied by increasing population density and a rise in infectious diseases, was observed to decrease stature in populations from across the entire globe and regardless of the temporal period during which agriculture was adopted, including Europe, Africa, the Middle East, Asia, South America, and North America." We should remember that as late as 1900 human life expectancy was only about 30 years. This decline in individual well-being is consistent with our argument that the NDT represented a transition to ultrasociality and that the "good of the group" no longer corresponded to the good of the average individual.

In contrast to hunter-gatherers, agriculturalists collectively mobilized efforts toward intensively exploiting land to grow only a few crops (Diamond, 1997; Fisher-Kowalski et al., 2011; Price and Bar-Yosef, 2011). Agriculturalists tapped into the stock of fertile soil and began a more concentrated and group-directed expropriation of photosynthetic production. Before agriculture people were surely bound together but they weren't rigidly bound around a narrow economic purpose. Hunter-gatherer use of the photosynthetic productivity ofa given place was modest, leaving much of this energy capture to other species. With the advent of settled agriculture the dynamic of the group as an adaptive unit took on a different purpose: it became focused and tightly bound together and insular around the imperative of surplus production. Thus the biophysical impact of human society, as well as its composition and structure, changed with agriculture. In the agrarian order of things the majority of the waking lives of most people were centered on purely economic activity of agricultural production and as Jackson (2013, 27) points out: "The landscape simplified by agriculture locked our ancestors into a life of 'thistles, thorns, and sweat of brow'".

The bioeconomic dynamic was one ofa finely articulated adaptive unit, binding together producers and expropriators in an economic dance geared toward expansion. This marked a fundamental shift in human ecology and economy, a reorientation of humans away from a diffused interchange with each other and a diverse nonhuman world and toward a concentrated orientation around an economic world: The human social system was transformed into a selforganizing, self-referential entity whose imperative was to produce agricultural surplus. The most successful agricultural societies were able to dominate local ecosystems and push other species and the remaining hunter-gatherer cultures to the margins. With agriculture, the human propensity for cooperation found a different institutional, cultural and evolutionary expression. Cooperation became structured in a different group dynamic; a dynamic that created a system with an impulse that is something more than the aggregation of the individuals that comprise the group and in fact diminishes the agency of any individual. Out of the many human groups that adopted agriculture, some grew into agricultural civilizations that were hierarchical, differentiated into strikingly unequal social classes, and were aggressively expansionary. With the agricultural transition, individuals began to function as parts ofa superorganism, not unlike the ants that so fascinate us.

In brief, the story of this transition is as follows. Mobile hunters- gatherers moved through places that were prime locations for production of cereal grains and they had the time to experiment with planting since their days were not filled with never-ending toil. Studies of contemporary hunters and gatherers indicate that our hunter-gatherer ancestors had ample leisure time (Lee and Devore, 1968; Sahlins, 1968). As the climate warmed and became more stable during the Holocene their experiments were increasingly productive in terms of yield per unit of land though not necessarily in terms of caloric output per unit of labor. On a purely biophysical level, agriculture meant a fundamental change in net energy available to humans. Intensive cultivation resulted in more dense living arrangements and a more sedentary life. Sedentary life also altered the population dynamic. The greater population density further diminished the viability of hunting and gathering and limited the ability of the individual to live independently of the group.

Sedentary life created both the *opportunity* for accumulation (simply because people did not have to carry their possessions) but also the *imperative* for accumulation of food. Defense was essential to the success of agricultural groups and expansion became increasingly necessary to accommodate population growth, the growth of increasing numbers of nonproductive individuals (those engaged in defense) and to counteract the loss of soil fertility associated with the growth of annuals. With settled agriculture the fact that individuals had no other option to secure the material necessities of their lives other than to participate in agricultural production placed cooperation at the disposal of both direct and indirect coercion. An autocatalytic process was set in motion, molded around a division of labor itself derivative of the necessity of defense and the imperative of expansion.[3]

The division of labor in early civilizations became more extensive, rigid, and detailed and the imperative to increase agricultural output became more pronounced also. Cooperation, a human preadaptation to ultrasociality, became structured in a rigid and hierarchical way where individuals were left with little choice about their role in the cooperative enterprises of society and those cooperative enterprises were dominated by and pivoted around a narrow collective economic purpose. Work was fundamentally reorganized extending both the productive and social division of labor.

Eventually state societies evolved out of the Neolithic revolution and, in fact, did so rather quickly and there was a remarkably similar structure to state societies that developed independently (Bowles, 2011; Rindos, 1984). Sanderson (1999, 69) tells us that "...the worldwide parallelism in the rise of the civilization and the state is the single most important thing that must be explained by any theory of the origin of the state." But in the theories of the independent development of the Neolithic revolution

[3] A similar pattern has been described for termites: "A suite of ecological and life-history traits of termites and their ancestors may have predisposed them toward eusocial evolution. These characteristics include familial associations in cloistered, food-rich habitats; slow development; overlap of generations; monogamy; iteroparity; high-risk dispersal for individuals; opportunities for nest inheritance by offspring remaining in their natal nest; and advantages of group defense." (Thorne, 1997).

and the independent and rapid emergence of state societies, evolutionary biology has seldom played a major role. Anthropologists concentrate on population, irrigation, environmental circumscription, resource concentration as the most proximate reasons for the formation of state societies. We argue that our understanding of the Neolithic revolution and the development of agrarian state societies can and should be informed by evolutionary biology and specifically by viewing the transition to agriculture as a bioeconomic process, an ultrasocial transition. The evolution of primary states from simple agricultural societies to imperialistic empires was driven by the forces of group selection (Turchin, 2003; Wilson, 1997, 2002). Groups that were the most efficient surplus producers, the most cohesive, the most successful militarists, and the most expansionary out-competed the others. Cultural mechanisms—hierarchical religions, deference to authority, bureaucratic structures of redistribution and reciprocity reinforced these societies. The social characteristics and belief systems of those early ultrasocial societies that won the struggle for survival in the Neolithic paved the way for the rise of global capitalism and the full force of the Anthropocene.

From State Societies to Market Societies: Setting the Stage for the Anthropocene

Agriculture and the evolution of state societies altered the biophysical dynamic of human society. The expansionary nature of these societies and their capacity for surplus production encouraged extensive trading networks creating a more interconnected material world. While highly successful, many of these societies eventually collapsed of their own weight (Diamond, 2005; Tainter, 1988; Tainter et al., [2006]). Their far-reaching ecological impacts were unsustainable and the requirement of supporting the human infrastructure to manage their complexity became increasingly challenging (Wickham, 1984). In Europe the collapse of the Roman Empire diffused into feudal society which was a less centralized version of state society: hierarchical, militaristic with an interdependence of producers and appropriators around intensive agricultural production with the imperative of surplus production embedded in the social order. Eventually, the regrouping of the bioeconomic evolutionary dynamic that began with agriculture gave rise to capitalism—a continuum along the human ultrasocial path.

Many critics of capitalism will be uncomfortable with the proposition that this mode of production is the result of a larger evolutionary dynamic because this proposition suggests a certain naturalism to capitalism. Wood (1999, 7-8) says "The naturalization of capitalism, which denies its specificity and the long and painful historical processes that brought it into being, limits our understanding of the past. At the same time, it restricts our hopes and expectations for the future, for if capitalism is the natural culmination of history, then surmounting it is unimaginable." We have a different interpretation of the naturalization of capitalism. Moreover, we argue against Wood's notion that understanding the naturalization of capitalism is problematic because it "restricts our hopes and expectations for the future". In fact, we claim that if we are to think clearly about the monumental task of disengaging our present world order it is necessary to understand and appreciate its evolutionary impulse.

Adam Smith held that capitalism was a natural order because it built on natural human proclivities to self-interest and to truck, barter and exchange. Although we posit a naturalism to capitalism, we similarly argue against Smith's interpretation of that naturalism. We believe that it is natural in the sense that there is an evolutionary processworking through natural selection at the group level-that leads us toward highly integrated, expansionist, hierarchical, self-referential and economically oriented systems. This dynamic is more correctly associated with the human propensity for co-operation, the development of a trait group, and the force of group selection than with individualism and the propensity to truck, barter and exchange (Wilson and Gowdy, under review). Others who have criticized Smith for his notion that capitalism is the natural order of society have failed to entertain the possibility that there may be an evolutionary proclivity to end up with this system. For example, Polanyi (1944, 43) claimed with regard to Smith: "No less a thinker than Adam Smith suggested that the division of labor in society was dependent upon the existence of markets, or as he put it, upon man's propensity to barter, truck and exchange one thing for another.In retrospect it can be said that no misreading of the past ever proved more prophetic of the future." Polanyi is correct in the sense that the division of labor in the past had not depended on markets. But in an evolutionary context there are important ways in which the organization of labor in agricultural societies of the past is connected to its organization under capitalism. From the beginning of agriculture the production of surplus had simultaneously engaged a more extensive division of labor but this division of labor did not depend on markets, rather is was part of the formation of the trait group. The expansion of markets was a later outgrowth of the ultrasocial transition with agriculture. Eventually markets take the dynamic of surplus production down a more accelerated path in terms of ecosystem dominance.

The particularity of capitalism concealed from Polanyi the evolutionary dynamic that connected capitalism to the economic systems that emerged after the transition to agriculture. Polanyi (1944, 46) lumps all pre-capitalist societies together and tells us: "The outstanding discovery of recent historical and anthropological research is that man's economy, as a rule, is submerged in his social relationships." It is true that with capitalism the organization of economic production and the connection between production and distribution is no longer mediated with the same cultural and institutional overlay. But the existence of a self-referential, economically oriented society structured around a more pronounced and economically interdependent division of labor and an internalized imperative of expansion predates capitalism. Polanyi and many other scholars of capitalism fail to appreciate the profound economic revolution that had taken place before capitalism. The dominant cultures that arose from group competition among early agricultural societies shared characteristics that made them successful. They were cohesive, expansionary, and successful at generating economic surplus—the very characteristics that were to drive the Anthropocene.

The challenge we face is to understand the particular way the evolutionary dynamic already at play was extended with capitalism. One thing should be made clear about the particularity of capitalism. Capitalism is a market society and this is different than a society where markets are ancillary to economic activity. State societies had markets and so did feudal societies but they were not market societies. This point has been made by Polanyi (1944, 88): "A market economy is an economic system controlled, regulated, and directed by markets alone; order in production and distribution of goods is entrusted to this self-regulating mechanism.” In a market society, markets “control, regulate and direct” the economic system and replace bureaucratic control, divine right and other ways of organizing production and distribution. The evolutionary impulse and structure of market society as an ultrasocial system was of the same ilk as the post agricultural societies that preceded it but market society was a distinctive rendering of the dynamic of surplus production. In fact one could easily argue that with capitalism the institutional (cultural) overlay of society more fully accommodated and invigorated the somewhat mechanistic system in motion since the advent of agriculture. Markets and the productive capabilities of society expanded.

Markets predated capitalism and emerged out of the utrasocial transformation that came with agriculture. As previously stated, they are the consequence, not the cause, of surplus production. A system where the imperative of surplus and expansion had been internalized would be naturally predisposed to trade. The world systems literature has explored the expansion of trade in detail and identified it in the context of a world system that emerged before the 16th and 17th centuries (Abu-Lughod, 1988; Frank, 1990; Gills and Frank, 1991). While the world systems literature does connect trade and commercialization to the emergence of capitalism it does not connect them to the more fundamental evolutionary dynamic at play. Making this connection allows us to view trade and commercialization, and by extension capitalism, as the result of a more fundamental world system that began with settled agriculture. Nonetheless the expansion of commercialization and trade connected the world in a way that it had not been connected before and put in place a positive feedback loop engendering the institutional changes that made capitalism a unique variation on an old theme.

In order for markets to direct the particular way in which economic evolution proceeded, a reconfiguration of the division of labor and the structure of surplus production had to take place. This required loosening feudal bonds and reorganization of the imperative of surplus production. This history is complicated but in brief it can be viewed as follows. The expansion of trade began this reconfiguration as the merchant class expanded. The expansion of trade was facilitated by increased agricultural productivity that occurred with the transition from the two field system of agriculture to the more productive three field system of agriculture. This change allowed for the support of a larger non-agricultural population and expanded the use of horses which enhanced transportation and by extension trade (Hunt, 2003). Robert Heilbroner refers to the emerging merchant class as a “disturbing leaven in the mix of medieval life...” (Heilbroner, 1986, 33) And trade itself had already created a commercial impulse that was thriving especially in regions where trade was encouraged by sea, as in the case of Venice for example.

With the rise of a merchant class came the gradual expansion of towns—an economic entity separate from the manor, and the rise of towns helped to break down feudal bonds as the relationship between town and feudal estate and feudal relationships themselves increasingly became monetized.

England is instructive here because it was the hotbed of capitalist development. England was an island nation, thus it was well integrated into a trading nexus. It was never as far from a port in England to its interior as it was on the continent. Towns associated with the expansion of trade and their contact with the interior feudal estates developed more easily in England and these towns encroached on the manor and on the structure of rural life. The expansion of trade increasingly monetized manorial relationships and eventually created circumstances whereby tenant farmers rented land and hired an agrarian working class, this internalized an imperative to increase agricultural productivity because tenant farmers could benefit from greater productivity. As well a working class was encouraged because land was enclosed to raise sheep for the burgeoning market in wool—severing ties of people to self-sufficiency on land and creating a cheap unattached labor force that could supply labor to nonagricultural enterprises. Hobsbaum (1962, 31) tells us:

Agriculture was already prepared to carry out its three fundamental functions in an era of industrialization: to increase production and productivity, so as to feed a rapidly rising non-agricultural population; to provide a large and rising surplus of potential recruits for the towns and industries; and to provide a mechanism for the accumulation of capital to be used in the more modern sectors of the economy.

Of course laws, particularly in property ownership and the obligation of society to the poor were altered to allow land and labor to be fully commodified.

Fossil Fuels, Industrial Capitalism, and the Current Demographic Transition

After centuries of relatively slow growth, the human population began its second major explosion, the current demographic transition— from under 700 million in the year 1700 to over 7 billion today (Biraben, 2003). Economic life moved beyond its agrarian focus as agriculture became but one component of the economic orientation of society and the capital accumulated in agriculture spilled over into other sectors. With the expansion of trade, production began its reorganization before the industrial revolution. Guilds and merchants predate the industrial revolution and the "putting out" system was well established in rural areas before the industrial revolution took hold. But there were increasing inefficiencies, bottlenecks, etc. in these systems as seen in the example of textile production. A more integrated system was demanded. In order for the large scale use of mechanization to take hold and more intimately and seamlessly connect the system of production, sufficient energy was necessary. Steffen et al. (2011, 848) point out:

One feature stood out in the world that humanity left as it entered the Industrial Revolution; it was a world dominated by a growing energy bottleneck. The primary energy sources were tightly constrained in magnitude and location. They consisted of wind and water moving across the Earth's surface, and, on the biosphere, plants and animals. All of these energy sources are ultimately derived from the flow of energy from the Sun, which drives atmospheric circulation and the hydrological cycle and provides the fundamental energy source for photosynthesis. These processes have inescapable intrinsic inefficiencies; plants use less than 1% of the incoming solar radiation for photosynthesis and animals eating plants obtain only about 10% of the energy stored in the plants. These energy constraints provided a strong bottleneck for the growth of human numbers and activity.

Were it not for the accommodating coal fields of England, the path of economic evolution and the development of capitalism would have been profoundly altered. Petty commodity production would surely have remained the order of the day. Fossil fuels-a vast, accessible, and flexible energy source-moved humans to a seemingly unlimited stock of energy.[1] Landes (1969, 97) lays out the transition in economic terms and brings the industrial revolution into focus:

By 1800 the United Kingdom was using perhaps 11 million tons of coal a year; by 1830, the amount had doubled; fifteen years later it had doubled again; and by 1870 it was crossing the 100-million- ton mark. This last was equivalent to 850 million calories of energy, enough to feed a population of 850 million adult males for a year (actual population was then about 31 million).

Landes (1969, 122) identifies the fundamental change in economic society that ensued with the industrial revolution and the rise of manufacturing when he tells us that within the economy "the vital organs were transformed" and "determined the metabolism of the entire system."

With the industrial revolution the breadth of output expanded and production was reorganized. Tremendous expansion took place first in textiles, mining, chemicals and transportation. The organization of work was altered as the rhythm of economic life came to be dictated by the pace of the machine. Again Landes (1969, 43) comments: "Now work had to be done in a factory, at a pace set by tireless, inanimate equipment...The factory was a new kind of prison; the clock a new kind of jailer."

In this way the ultrasocial impulse of human evolution took on a more pronounced dynamic, ushering in the Anthropocene. Productive activity and the division of labor were extended especially since the imperative of surplus had been reconfigured around both an altered energy dynamic and an altered group dynamic. The advantage of market society as an adaptive unit was clear as exemplified in the competition between India cottage cotton production and the mechanistic organization of production in British textiles.

Our ultrasocial evolution had taken yet another step along its evolutionary path. The imperative of surplus became embedded in the production of exchange value and the economic hierarchy that internalized it—those who came to control capital (the expropriators) were compelled to participate because their survival depended on it and those who engaged in the work of production had no other alternative to a livelihood than selling their labor power. The system became intricately articulated around this structure and highly productive and expansionary. The division of labor expanded and the interdependence of economic actors increased. This change entailed the cooptation of cooperation in a more insidious and subtle way. The institutional and cultural accommodations to the superorganism had lost their personal veil. The invisible hand of the market and its institutional fabric replaced the social mediation of lords and clergy. The profound effect of the system on individual well-being has been elaborated by many scholars (Braverman, 1974; Marcuse, 1968). The impersonal forces of the market system and its imperative of accumulation dictated participation

[1] There is an interesting connection between social insects and fossil fuels. Most fossil fuels were formed during the Carboniferous period 360-286 million years ago, long before the first eusocial insects (termites) were present. The decomposition of plant material by termites, beginning some 146 mya, has prevented most fossil fuel formation since then (Engel et al., 2009, 16, 18).

in economic society. Heilbroner (1986, 37-38) gives one of the best descriptions of this system and the interdependence it entailed in his discussion of capital:

Capital is therefore nota material thing but a process that uses material things as moments in it continuously dynamic existence. It is, moreover, a social process, not a physical one. Capital can, and indeed must, assume physical form, but its meaning can only be grasped if we perceive these material objects as embodying and symbolizing an expanding totality.At the center of this process is a social relationship between the *owners* of money and goods, the momentary embodiments of capital, and the users of these embodiments, who need them to carry on the activity of production on which their own livelihoods depend.

It is described here as a self-referential, expansionary system where classes are held together in articulate whole. The central focus of society is still economic but the economic purpose has been extended and heightened. The human ultrasocial transition becomes more dramatic and the institutional accommodation more complete. Economic life becomes more interdependent and mechanistic and in many ways more analogous to other ultrasocial species who articulate as a whole through phenotypic differentiation. But ours is a more complex story because our ability to construct culture creates a more elaborate and complex ultrasocial dance. Ecological balance and the quality of human existence are further altered with this variant of our ultrasocial evolution. And the biophysical consequences of this change were ever more astounding (Fischer-Kowalski and Haberl, 1998).

Is There a Way Forward? Downward Causation and Evolutionary Lock-in

Human culture is informed by bioeconomic forces in a process of downward causation which is an important feature of MLS (Campbell, 1974; El-Hani and Emmeche, 2000; Martinez and Moya, 2011). Higher order organization calls forth adaptations at lower levels to reinforce the higher order structure. What happens at lower levels must conform to the laws of the higher levels. Campbell (1974: 180) writes:

Where natural selection operates through life and death at a higher level of organization, the laws of the higher-level selective system determine in part the distribution of lower-level events and sub- stances.All processes at the lower levels of a hierarchy are restrained by and act in conformity to the laws of higher levels.

The transition to agriculture set into motion forces that led to a higher level of social organization around a new and distinctive bioeconomic dynamic that should be viewed as an articulate whole, a unified system. Through downward causation, the entire human economic enterprise including production systems, technologies, ideologies, laws and customs, in short the entire institutional and material fabric of economic society, has evolved as an interlocking, downward self-reinforcing entity around the bioeconomic dynamic at play. This process was extended dramatically with the development of capitalism. Technology provides a good example of the play of downward causation. Noble (1977, xxii) tells us:

This social process called technology.does not exist simply for itself, in a world of its own making. It is, rather, but one important aspect of the development of society as a whole.the development of technology, and thus the social development it implies, is as much determined by the breadth of vision that informs it, and the particular notions of social order to which it is bound, as by the mechanical relations between things and the physical laws of nature.

Indeed 'the breadth of the vision that informs it' is bioeconomic. Noble (1977: xx) is rightly led to question the "emancipatory potential of modern technology" and notes that the progress of technology under capitalism may be as likely to "generate a quiet, more subtle transformation, weaving a paralyzing web of instrumentality," as to generate revolutionary change. Of course, thereby reinforcing the integrity of the superorganism.

The salient question of the present iteration of our ultrasocial transition (global capitalism) is whether the contradictions in this mode of production will reach sufficient tension so that an entirely new system will emerge or whether the force of the system will hold together until ecological collapse becomes irrevocable. There is no question that the present contradictions in the system are formidable. Global capitalism cannot provide sufficient employment. In the US the unemployment rate continues to hover around 8%. In some countries in Europe it is as high as 25%. In the emerging economies the rate of growth to take up surplus labor is unsustainable—unless we believe that the Chinese and Indian economies can continue to double every ten years. And the structural manifestations of inequality and poverty are dramatic and irrevocably integrated into the system. These are not simple distribution problems and should not be perceived as such. They are systemic and structural problems of the system. The system now generates unemployment, inequality and poverty faster than the growth it generates can counteract them. And the dynamic of expansion is now running up against biophysical limits making it even less likely that sufficient growth will be forthcoming to resolve the problems of employment, inequality and poverty and more likely that we will push biophysical limits further to try to accomplish the impossible (Klitgaard and Krall, 2012). Aside from the multifarious problems of employment, inequality, poverty and biophysical limits there is the reality that the mass of humanity is vested in the system. It is somewhat misleading to think in terms of the 1% versus the 99%. The 99% are not monolithic and many among the 99% are heavily invested in and benefit from the status quo. The fear of destabilizing one's place in the system, no matter how precarious, is a check against altering it.

We like to think our current socio-economic system is something different in world history and that the trajectory of civilization is progressive. We view ourselves as being unique in terms of our storehouse of scientific knowledge, our unprecedented technological development, and our democratic institutions. We believe in the power of human agency. The input of evolutionary biology tells us that our present global economic order is derivative of an evolutionary leap that took hold with the advent of settled agriculture and continues with globalized capitalism. In terms of causes and consequences, the principles that govern this leap are similar to those that govern the development of eusocial insect species. In this we do not stand apart from other species despite our intelligence, inventiveness and our culture.

Two million years of human evolution made us cooperative, caring, intelligent, introspective, and creative. The evolution of this positive development for individual human well-being was co-opted by an odd and rare confluence of economics and higher-level evolutionary forces creating a system where the dynamic of expansion is structurally formulated around an interdependent division of labor tending toward hierarchy. This is a system that must be understood in its entirety and as the evolutionary outcome of MLS. The human economy is a finely articulated whole; an evolved ultrasocial entity, honed by the forces of natural selection. As such, production for livelihood was replaced a long time ago by the imperative of expansion and surplus production. The evolutionary imperative to survive and reproduce passed from the individual to the supergroup. Clearly this ultrasocial transition has not been an unqualified success when evaluated in the context of individual wellbeing or the biophysical impact of humans on earth. Globalization has taken hold and the extinction of languages and cultures in its wake are testament to the force of group selection. Global capitalism has had the evolutionary advantage. If we value human individuality, the integrity of cultures and their right to self-determination, the future of our species and the future of the other species that share this planet with us, we should recognize the negative dynamics of ultrasociality and get control of its worst aspects. Humans are not ants—there has always been resistance to the power of the system but resistance must be informed with a recognition of the power of the system as a system. The question for sustainability is whether we can gain control over a superorganism that has made us, in E.O. Wilson's words, "a danger to ourselves and the rest of life"? The haunting question that arises in light of an enhanced understanding of our evolutionary history is whether the power of human agency will be sufficient to confront the magnitude of our problem. We like to think so but then "*Homo sapiens*" is not a species known for its humility. Perhaps it is best to reside with our unfathomable economic challenges like 'how we bring closure to this economic system before we collapse'?

It is hard to be optimistic about our prospects. Unless we can figure out how to dismantle the superorganism, human society seems destined to crash or end up in a Brave New World dystopia. The present contradictions of the system and its ecological challenges cannot be effectively resolved without fundamental change to the system. If we are inclined to throw up our hands in resignation, we should keep in mind that evolution cannot see ahead and that it is not without its dead ends. As an evolutionary system, the human economy has no foresight. It can't look ahead to prevent collapse and will likely continue along its path as long as it can continue to function as an articulate whole.

We might begin by understanding that there is a difference between what will make the present system temporarily operate better and what will bring about the revolutionary change we need. Some examples will illustrate the importance of this understanding. Redistribution of income lessens the inequality in the system and makes the lives of some individuals better. It will not resolve the problem of an economic system that creates inequality and then depends on growth to solve it. Carbon taxes will make the price of fossil fuel higher and may bring about a reduction in its projected demand but carbon taxes will not resolve the long term problem of providing sufficient energy to fuel an ever expanding economy. Unfortunately, to accomplish this we will need all the energy we can amass; fossil fuel, nuclear and renewables. Given the structure of the economy and the now chronic problems of unemployment and falling real wages it seems unlikely that carbon taxes will be enacted if it is perceived that they will limit growth. Nor will carbon taxes and subsidies to renewables lead to a seamless transition to a new energy economy given the present structure of energy markets. As long as climate change and our present energy dynamic don't impinge on the structural integrity of the system, the system will continue in its present form unless we actively disengage it.

We do not offer a blueprint for how this might be accomplished, though we have no doubt one is needed. We can begin by nurturing both a more critical and detailed assessment of the evolutionary impulse of economic society and a far reaching and concerted effort to draft a blueprint to disengage the superorganism. We need to appreciate the magnitude of this task. It should occupy the best minds we have. Biophysical limits (informed by science) and the goal of creating a healthy human ecology that includes and prioritizes the presence of nonhuman life and nonhuman impulse should constantly inform the boundaries of what we propose.

Large-scale interventionist public policies are absolutely necessary to bring the superorganism, that is, the global market economy, under human control. Private ownership and enterprise and its prerogatives must be limited not simply through taxation and regulation but by taking large sectors of the economy out of the private enterprise altogether. We should be mindful of the threat of totalitarianism in the process of the large scale planning. Policies to reduce inequality and poverty must be constructed around a wholly different economic imperative. Redistribution and the expansion of social welfare policies are essential, but these are wholly insufficient if we engage in them in the context of a system that reproduces growth, inequality and economic insecurity as fast as we can institute policies to manage them. Dismantling the superorganism can't be managed with green growth, green consumerism, localized agriculture, riding bicycles or even worker co-ops especially if the latter are forced to function in our present system. Personal virtue is no match for the systemic problems we face.

What may seem a radical agenda should be juxtaposed with the cost of continuing on the present path. Indications are mounting that the world's natural and human systems are reaching a breaking point. Business as usual scenarios, whether for climate change (Anderson and Bows, 2008), biodiversity loss (Barnosky et al., [2012]), or employment (Bivens, 2011), all point to a potentially catastrophic future. The implications of human ultrasociality are clear. We are in the grip of an impersonal self-organizing system within which humans and essential elements of the natural world are expendable. It is a mechanical system that cannot see ahead to avoid catastrophe. Unless we actively get control of the system and redirect it toward human-centered ends and biophysical sustainability it is likely to collapse. Our prospects do not look good.

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Corresponding author. Tel.: +1 518 276 8094.

E-mail addresses: gowdyj@rpi.edu (J. Gowdy), lisi.krall@cortland.edu (L. Krall).

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