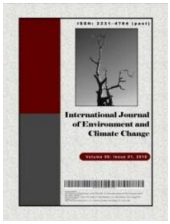

International Journal of Environment and Climate Change

8(3): 234-268, 2018; Article no.IJECC.2018.015
Previously known as British Journal of Environment & Climate Change
ISSN: 2231–4784

Human Interaction with the Natural Environment: The *POETICAS* Model as a Framework for Understanding and Praxis in Late Modernity

Thomas J. Burns[1*], Peyman Hekmatpour[1] and Kristen C. Speer[1]

[1]University of Oklahoma, 331 Kaufman Hall, Norman, OK 73019, USA.

Authors' contributions

This work was carried out in collaboration among all authors. Author TJB was primarily responsible for the overall design and outline of the study, writing general parts the manuscript and integrating the overall work. Author PH was primarily responsible for earlier drafts of the sections and case studies on Organizations & institutions, Technology, Culture and Illness & Health. Author KCS was primarily responsible for earlier drafts of the sections on Population and demography, Ecology, Affluence & inequality and Scale & time. All authors were involved throughout the project and each has read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2018/v8i327171

Review Article

Received 31 May 2018
Accepted 04 October 2018
Published 03 December 2018

ABSTRACT

Using the acronym *POETICAS*, we explore eight major facets of humankind's relationship with the natural environment. We make the case that, while they are not mutually exclusive, they are nonetheless analytically distinct. We explore the roles of: 1) Population & demography; 2) Organizations & institutions; 3) Ecology; 4) Technology; 5) Illness & health; 6) Culture; 7) Affluence & inequality; and 8) Scale & time. We examine each of these facets in turn, looking not only at their main effects, but also considering many of the interactions among these factors in a broader ecological context. Building on earlier models, we make a case that this broader and more robust model can offer a framework for civic discourse about the human-environment interface that is useable to a wide array of audiences, including students and researchers as well as policy makers, members of social movement organizations, and engaged citizens seeking an overarching framework that can help make sense of a variety of otherwise disparate findings.

Keywords: Human ecology; environmental sociology; POET; IPAT; STIRPAT technology; environmental health; environmental illness; cultural lag; civic discourse.

**Corresponding author: E-mail: proftommie@gmail.com;*

PREFACE:

The goals of this study are to: 1) define the most important collections of variables to consider when trying to make sense of the human interface with the natural environment; and 2) to explore complexities around each of those variables. These are crucial for a number of reasons.

In discussing the pressing, sometimes overwhelming, ecological problems in contemporary society, it is often the case that people 'talk past' one another. This is true for natural and social scientists studying the problem, as it is for citizens and policy makers. Major reasons for this include the lack of a common vocabulary, and a haziness about what variables are even important to consider.

In this paper, we seek to specify the major forces at play in the human-environmental interface. After a comprehensive review of several literatures surrounding these problems, we condense the discussion down to eight 'master variables' whose roles show up time and again, and thus are crucial to consider in any analysis. Which particular aspects of variables are under study tend to influence the outcomes and conclusions of the studies themselves. In using this term Master Variables, we acknowledge that each of these variables can be measured and even thought of in a variety of ways. This requires being mindful of how they are measured in a given study, and how that might affect the conclusions of that study.

It is important to understand that optimizing on one variable while ignoring the ecological nature of problems, may not necessarily be a step forward. A given variable can be isolated in theory, but it is vital to keep from reifying that theory, making the logical leap that it can actually work in the ecologically complex and interconnected world in an isolated way.

For example, what does it mean to model "technology" (which can and should be thought of in a variety of ways), when access to many technologies is heavily influenced by distribution factors in a society? In this example, it would also be necessary to consider the variable that in some models is characterized as "affluence" (or some variant, such as an ecological footprint or uneven ecological exchange). We summarize this set of qualifiers below under "Affluence and Inequality." There are additional variables to consider. These include Cultural and Demographic factors, as well as the Scale and Time frame of what we are seeking to understand or explain.

In defining and unpacking the key variables, it is also prudent to keep in mind that while these variables may work in isolation in theory, they virtually never do in practice. The interactions have influences that standard main-effects models fall short of accounting for. Coming to an understanding of ecological systems and humankind's embeddedness in them demands a continual mindfulness of these crucial, though often overlooked, considerations.

1. INTRODUCTION

One of the defining characteristics of the culture of late modernity is humanity's insatiable propensity to exploit the environment. Older ecological models have proven useful in explaining and understanding humankind's relationship with the natural world. However, these models are not entirely adequate, nor are they the best tools available, for the exploration of humankind's relationship with the earth—and the formulation of much needed solutions to the existential environmental dilemma that we find ourselves in today.

Sociologists are no less adept than other academics at finding and pointing out problems. At this point in time, the problems are well known—even if some choose to ignore or deny them. Workable alternatives to business as usual are needed now. Ideally, these alternatives will guide nations and individuals toward long-term and sustainable balance, and harmony between people and the earth.

To realize this goal, the previous models developed by early human ecologists need to be updated in order to better understand and solve human-environmental problems. In this paper, we build on older models, such as the POET (Population, Organization, Environment, Technology) and IPAT (where environmental Impact is a function of Population, Affluence and Technology) models. As this literature is reviewed extensively elsewhere, we do not

repeat it here. Rather, we refer the reader to over a dozen previous studies that go into older models [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16].

In this paper, we not only build on older models, but seek to fill much of the rather large holes in the coverage. Rather than go into the many nuances of older models and how they lack, we seek to develop a new model that is adequate to the task of making sense of the runaway environmental problems we now face. To this end, let us consider a more comprehensive, pragmatically useful model, characterized by the acronym POETICAS:

o (P)opulation

Total population is a vital factor, yet it is not the only important variable when it comes to predicting types of environmental outcomes. Other elements of population include urban/rural, age, and gender distributions, for example.

o (O)rganizations and Institutions

The societal institutions through which humans often function, have a profound effect on how we impact the environment. Such institutions include, for example, the economy, the political and education systems, and religion.

o (E)cology

This refers to all components of the environment—plants and forests, soil, water sources, and air. It also refers to the degradation and waste of those systems. Different factors impact the environment in different ways. For instance, rural population growth is associated with deforestation, while urban population growth is a strong predictor of greenhouse gas emissions. While the preponderance of research in environmental sociology does model the impact of social variables (such as population, affluence, and technology, in the case of the I=PAT model), on some aspect of the natural environment (e.g., deforestation, air pollution), there is a small but growing body of work that looks at social outcomes such as violence, illness, and economic decline that *result from* environmental deterioration. It is vital, as we study the connections between humans and the environment, also to consider models that move beyond isolating the environment in one part of the equation (viz., as the left side of the I=PAT equation), and to consider more broadly how it interacts with humankind.

o (T)echnology

Technology's relationship with the natural world has proven to be a two-edged sword. On one hand, the scale and scope of environmental damage and exploitation would not be possible without modern technology. Yet, on the other hand, clean technology has the potential to help the environment. Comprehending and more deeply appreciating the complexities of the interplay of technology and other variables, particularly population, affluence, and culture, are keys to gaining insight into the interface between humankind and the natural environment.

o (I)llness and Health

Today, there is a growing acceptance of the interconnectedness of human health (both individually and communally) and the health of the natural environment. Beginning with the pioneering work of Rachel Carson [17], much study has been devoted to examining the relationship between ecological imbalances and serious health issues such as the rise in cancers, birth defects, breathing diseases like asthma and emphysema, allergies, and decreased fertility. Darwinian medicine explores the mismatches between evolution—both human and other species—and the shock and challenges to our immune and adaptive systems caused by environmental pollution and a world out of balance.

o (C)ulture

In many ways the culture of modernity is the story of humanity's alienation and detachment from the natural world. Late modernity, hyper-industrialization, and the increasing power of technology have increasingly exacerbated this process to the point where separateness from nature is a basic component of culture itself. Moving into the future, it will be important to consider aspects of culture that are sustainable into the current and future millennia.

o (A)ffluence and Inequality

The rich are able to consume more of everything (especially energy), and thus, have a disproportionate impact on the natural environment. Affluent societies, such as North America and Western Europe, have taken for granted things like automobiles, air conditioning, computers and televisions, a growing consumption of meat, and diverse and varied

foods transported from distant sources. Unequal distribution of natural resources, both at the micro and macro levels, have detrimental effects on the environment. Furthermore, affluent capitalistic economies are based on the dilemma presented by "the treadmill of production." Economies grow by manufacturing more and encouraging greater consumption. As populous societies, like China and India, become more affluent, their consumption patterns will inevitably increase, and, will in turn, make matters more critical.

o (S)cale and time

Environmental problems manifest at all different scales, from the microscopic to the global. When thinking and discussing issues, it is important to keep this in mind. It is often the case that when the quantity or *scale* of a phenomenon changes, its *qualitative properties* also change. It is commonly the case that size of production leads to greater efficiencies from an economic standpoint (offering "economies of scale"), large scales lead to other problems (such as when monocropping is associated with declines in biodiversity) in ecological systems. Time considerations are crucial here as well. Nature may be able to recycle virtually anything—but in what time frame? If that frame is in millennia, humans could not survive. Unequal exchange is not something that only takes place in the here and now. Particularly with the use of modern technology and institutional arrangements, and the power and affluence maldistributions that are in effect, it becomes possible, of course, for wild exploitation in the present, both locally and globally. But by degrading the planet the exploitation takes place across generations as well.

2-9. A CLOSER LOOK AT THE KEY VARIABLES IN THE *POETICAS* MODEL, AND SELECTED CASE STUDIES

2. POPULATION AND DEMOGRAPHY

It bears noting that population is a crucial variable, both in an overall study and in the analysis of its various components. There are many important elements of population that are useful in predicting types of environmental degradation, including urban and rural distributions as well as age and gender distributions.

The interaction of population and demography with other variables make them important factors to consider, yet there are many ways in which these variables can be viewed. *Demography* is the study of large aggregates of people who share some common characteristic(s). When asking demographic questions, researchers collect data, or statistically measure, particular aspects of populations, or groups of people.

Population can be operationalized in a number of ways, such as the total number of people, their spatial distribution, their age and sex distributions, and their interactions with one another and with their environment. Each of these aspects of population has an impact on the ecosystem. The aspect of population measured in a study is important to consider, because how it is defined and measured for a given study (or how it is "operationalized"), can make a difference. For example, studies have shown that increases in rural population tend to lead to deforestation [5,6,17,18,19] but tend not to have much of an effect on emissions of the major greenhouse gas, carbon dioxide, or on the ecological footprint. Increases in rural population and certain kinds of agriculture such as concentrated cattle operations and wet rice paddies do tend to lead to dramatic rises in another greenhouse gas—methane [19]. Increases in urban population, in contrast, do tend to have significant effects on the amount of greenhouse gas emissions (particularly carbon dioxide) and on the overall ecological footprint [20], but have less of an effect on deforestation. It is worthy of note that in each case, population increases affect the environment but modelling for *which* aspect of the environment that is most affected is closely tied to which aspect of population we put into consideration.

2.1 A brief historical overview

One of the most influential writings on population was Thomas Malthus's first essay on the principles of population [21]. This text illuminated the relationship between the population, which was growing geometrically, and the availability of resources, which was growing arithmetically. In that work, Malthus coined a term that has been with us ever since – "*Overpopulation*". He also effectively laid the foundation for our modern framework for discussing the interactions between humankind and ecological systems, and he brought to light our dependence on finite resources [4]. The total world population is still growing rapidly today, and stabilization may not

even be possible within this century. With 7.2 billion people on the earth now, and a predicted 9.6 to 12.3 billion in 2100, it is obvious why Malthus's concerns are relevant even now [22].

On the one hand, advances in agricultural technology have made more food available for the increasing population, sparing humankind from Malthus's expectations. On the other hand, however, many of those technologies, particularly the heavy reliance and overkill of pesticides and herbicides, wind up causing problems downstream and seriously disturbing the balance of Marine ecosystems in particular [23]. A number of researchers are still concerned that Malthus's predictions might come to fruition in the form of mass starvation as the population continues to grow [24].

While it is worthwhile to study, total population does not represent the full story – demographers focus on more than just overall numbers. For instance, fertility and mortality, two of the major subfields of demography, play large roles in the trends we see in population growth. Since 1970, there has been a global decline in fertility, from five children per mother to two and a half, reducing the family size and slowing population growth [25]. While a decline in fertility has been a suggested solution to the population problem, it still may not be enough. With more than two children surviving per mother, the population will continue to increase. Additionally, improvements in living conditions as countries experience development in both medical and agricultural technologies have contributed to lower mortality rates. To phrase it a bit differently, people are living longer—and those longevity increases bring with them further complicating factors. A third factor is what demographers call "*population momentum",* which suggests that populations have a tendency to continue to grow due to a young population structure – which means the largest portion of the population is approaching child-birthing age [26]. This explains, at least in part, why populations in developing countries of Africa and Asia are continuing to grow.

2.2 The Demographics of Modernity, and the Changing Relationship with the Ecosystem

In contrast to the rapidly growing populations in developing countries, developed countries such as Japan, Scandinavia and, to some extent, the United States, face a quite different issue. In these countries where fertility rates have been declining since around 1950, the proportion of elderly people in the population has been rapidly expanding, creating a social imbalance that is without precedent [9]. This trend in Japan has already revealed many impacts of the changing demographics – the labor force has decreased, increasing burdens on the working-age population [27]. In order to combat population growth, some countries have instituted policies that limit the number of children per family. One example is China's one child policy, which had some unexpected demographic consequences and was one of the driving forces behind the aging population in China [28].

In addition to skewed age ratios, limits on the number of children per family has resulted in distorted gender ratios as well. In a culture with a strong preference for males, there has been a disappearance of a large number of female children. This disparity in the number of males and females and the inability of some males to find a partner may even be responsible for mental health problems, crime, and disruptive behavior [29]. In light of these issues, the One-Child Policy in China has been revoked as of October 2015, leaving the city of Shanghai with over 2.7 million people over the age of 65 [28].

While differences in fertility and number of children per family illustrate the various distributions of people across different continents, modernity has also brought about changes in the distributions of people more locally, specifically from rural to urban areas. The "*Green Revolution*" that occurred in the 20th century limited most agricultural production to rural areas, while the "*Urban Revolution*" spurred migration into cities, which struggled to accommodate large crowds of people [30].

Spaces that people live in transitioned from small cities with dispersed homes in which the local community grew and prepared their own food to large buildings structured to hold a multitude of people, most of which have their food grown in a distant location and transported to distributers near them. This spatial and temporal distance between humans and agriculture has shifted production to large-scale operations and created a disconnect between humankind and our surroundings.

The new farm economy has, in many cases, tended to strip rural farmers of their identity and cultural heritage, and it has created an industry with poor implications for both human health and

the ecosystem [31]. These ideas have introduced a predicament while simultaneously redirecting us to our initial one: the determination of how to allocate resources and whether or not the Earth's carrying capacity can support the human population.

One of the most important aspects of the human population is its interaction with the ecosystem. Population's effects are ubiquitous, with particular implications for the planet's carrying capacity. Many of those who still subscribe to Malthusian beliefs today have thus expanded their attention to carrying capacity, or the total population of a given species that can be supported in a specific region without causing permanent damage to the ecological systems on which it relies [32]. This damage is most commonly seen through extracting resources faster than the earth can replenish them and by polluting the ecological systems more quickly than they are purified.

This is especially concerning as the amount of energy that can be harnessed by a given individual, particularly in developed (but increasingly in *developing*) countries, has increased substantially. In previous years, the main energy available to a person was that which their body could produce. Now, oil, coal, and natural gas supply nearly 90 percent of work done in the United States, as compared to the 0.2 percent provided by human muscle power [9].

This, in combination with young populations, is a formidable concern. Any species tends to put the biggest strain on resources when coming into reproductive age and establishing a new niche. While political attempts to restrict population growth have seemed to backfire – there may still be some hope for the population problem. The population growth rate has already peaked in developed countries, particularly in regions such as Northern Europe and Japan, and more recently in parts of the Americas, indicating that following the decline in mortality there tends to be a decline in fertility [9]. If this trend continues in Africa (and there are indications it is beginning to, particularly in some countries, including Zimbabwe and Kenya), then it is likely that the world's overall population growth rate will continue to decline. The increase in education for young women and the promotion of birth control have also shown to be keys in reducing family size in developing countries [9 and 25]. These elements appear to be crucial in controlling population size, and ensuring the survival of the planet, in the future.

The world population is at the highest it has ever been, and it continues to grow. With this growth come many social changes as people begin to aggregate in urban areas and make their living on things other than the land, increasingly relying on technology for much of their livelihood. This shift in the structure of our society, while it has some advantages, also has caused increased alienation from nature and higher levels of ecological degradation.

2.3 Case Study: The *POETICAS* Model with a Focus on Population

In order to take a closer look at population and its interactions with other key variables of the *POETICAS* model, we can delve into some of the questions addressed in Dennis Dimick's [25] article, "As World's Population Booms, Will Its Resources Be Enough for Us?". The focus of this article is the dramatic increase in the amount of people on earth, which now amounts to around 7.2 billion. As Dimick suggests, this may largely be due to the high fertility rates in areas such as sub-Saharan Africa. In this area, mothers are having 4.6 children per family, which adds up as these children go on to start families as well. Along with fertility, there are many dimensions of population that contribute to this trend, including mortality and migration. For example, longer life spans have recently contributed to increases in regional populations even with a consistent birth rate. In addition, migration, caused by the need for individuals to escape political unrest or bad environmental conditions, has had an influence on the fluctuation of population in this region. While population does alter the impact of humankind on nature and the planet, many of the specifics, including its interaction with other social and ecological factors, are crucial to consider.

Certain Organizations, including education, may be key in helping to curb runaway population growth. Increases in educational opportunities available to young women in sub-Saharan Africa, for example, have been instrumental in decreasing the size of families in this region. As individuals are exposed to new and better opportunities, they begin to realize that they can make choices for their future that involve waiting to have children.

As populations increase, they also have a stronger impact on our *Ecology*. As more individuals accumulate, our aggregate consumption of resources increases and begins to outpace the ability of nature to produce or replenish those natural resources. One large concern is the amount of food available; as Dimick mentions, there are around one in eight people who don't have enough to eat each day. This is partly where *Technology* interacts with the population as well. Thanks to technological revolutions in agriculture, we have not yet experienced mass starvation. However, from a different point of view, the technological power each person is able to wield has skyrocketed, which allows more ecological degradation to occur per person. This has led to many ecological issues such as climate change and deforestation.

Technology and population also are intertwined with *Illness and Health*. As medical technology advances, there are many more vaccinations available that fight against diseases common in areas of sub-Saharan Africa, allowing people to live longer and healthier lives. In addition, improved sanitation practices help reduce infant mortality and increase the number of children surviving per family. However, not all kinds of technology or medical healthcare options are readily available to people in this region.

As we continue down the list of variables, we see that while interactions with population has driven many things such as higher technology usage and ecological degradation, some of the other variables may be responsible for the regional trends we see in population growth. For example, *Culture* plays a large role in population growth. Young women in sub-Saharan Africa are surrounded by other women who do not use birth control, have started bearing children at a young age, and continue to have children. This is the normal practice for women in this area, and cultural lag prevents changes in this mindset from occurring quickly.

While culture may promote population growth in this region, *Affluence and Inequality* may only serve to prevent change from occurring. Many people do not have food, adequate housing, or employment. Additionally, individuals in developing countries such as sub-Saharan Africa lack many of the opportunities available to those in developed countries; as Dimick notes, it takes energy (and resources) for people to do homework, keep buildings such as hospitals heated, and to power small businesses.

The interaction of *Scale and Time* with population and the problems it presents become more and more pressing each day as the population continues to grow. Global population growth rates will not level out until areas such as these developing regions in Africa begin to experience declines in fertility.

By taking a close look at this region, we can begin to understand the interactions between population and the other variables in the *POETICAS* model. The consequences of population growth are very complex and dynamic, and the increasing ability of individuals to alter the ecosystem has some stark implications for our planet. Dimick's question of how many people the earth can support becomes more urgent as population and resource consumption continue to intensify, and it illuminates the importance of population as a Master Variable.

3. ORGANIZATIONS AND INSTITUTIONS

Humans are social beings. A number of thinkers, from Pragmatic Philosophers and Biologists to Sociologists and Human Ecologists have pointed out the propensity to live in organizations, facilitated by the ability to use complex arrays of symbols, gives human beings what has been a competitive advantage. Human beings, even (and perhaps especially) people who may think of themselves as "loners" organize much of their thought and behavior and take ethical cues about what is "right" or "wrong" from the organizations and institutions in which they are embedded and enculturated.

Ecologists, social scientists and philosophers study human societies from a wide variety of standpoints. One such stance, the *functionalist* point of view, is so named because of its emphasis on the idea that human society consists of organizations which carry out specific functions in order to maintain social stability [33]. A wide array of thinkers throughout history, from Confucius to sociologist Talcott Parsons, have emphasized the importance of social stability and how individuals are responsible for maintaining the social order by performing their *roles* within social organizations [34 and 35]. Much of the interface between individuals and the social organizations they collectively comprise and function in, is captured in the roles people play.

Although operating with a different set of assumptions and priorities, proponents of

Symbolic Interactionism also make the case that there is an interplay between individuals' actions and social organizations [36 and 37] This interaction between micro and macro level can be explained by the philosophical *principle of emergence* [38], which points out that organizations, as collective phenomena, are created by, but cannot be reduced to individuals' actions [39].

Integration and routinization of organizations, as repetitive human interactions in different social arenas (e.g. families, neighborhoods, marketplaces, etc.) form social institutions [40, 41,42 and 43]. Thus, it is reasonable to question how organizations and institutions, both as products and drivers of individuals' actions, can impact the natural environment.

So much of human activity is channeled through social organizations and institutions that it is not an exaggeration to say that they deal with very nearly the entire array of human activity, many times bringing out the best and the worst in people. A number of scholars focus on the negative effects of social organization, particularly because of their tendency to reify and routinize environmentally destructive activities, and to do them at scale and sustain them over time [44 and 45]. There is also a commonly held belief that environmental problems that are caused and maintained by social organizations and institutions, are best addressed at the institutional level as well [46].

3.1 Considering Particularly Influential Institutions

In the following paragraphs, we will elaborate on a number of social institutions and organizations (i.e. political and governing system, economy, education, religion, and social movements) which we believe are important in terms of their impact on the natural environment and in their capacity to channel solutions to environmental problems.

Since the U.S. presidential election in 2016, there has been a growing concern among scientists and environmentalists about how the new administration will manage to deal with serious environmental problems of our time, especially the interrelated problems of anthropogenically caused environmental change and global warming [47,48 and 49]. However, this is not a new concern and the relationship between the *Polity* and the natural environment has long been a central issue in the literature [50 and 51].

Empirical findings suggest that in a cross-national setting, global institutionalization of natural environmental protection is crucial. This is typically channeled through nation-state level actions, often in concert with non-government organizations (NGOs) as well as through inter-governmental organizations (IGOs). There is evidence that growth in the number of international environmental NGOs and IGOs, particularly after the creation of the *United Nations Environment Programme* in 1972, and increased numbers of nation-states' membership in these organizations, have significantly promoted the process of passing pro-environmental legislation at the country-level [52].

In their active, good faith participation, governments' responsibility is a significant predictor of states' environmental efforts [53]. Alternatively, lack of effective legislations at local and national levels, politicizing and debating on environmental issues, and policies encouraging economic globalization and foreign capital penetration tend to have destructive impacts on the natural environment around the globe [54, 55,56 and 57].

It appears that political systems, at virtually any level of analysis from local to global, can impact the natural environment. While social institutions can be considered as autonomous entities, they consist of individuals. Thus, the political system in the respective nation-states, as well as the cross-cutting political entities of NGOs and IGOs, can be reformed, through individual and collective acts of environmentally knowledgeable citizens, to have a deeper consideration of the natural environment [58 and 59].

Decisions funneled through the *Economy* can have profound effects on the natural environment. One of Karl Marx's lesser known critiques of the capitalist economy is contained in the notion of "*metabolic rift*." [60]. This concept refers to the nature of capitalism that drives human beings towards alienation from their natural environment, for the most part through urbanization and division between city and country. In modern capitalism, agricultural products flow from the countryside into urban areas where the preponderance of mass consumption is concentrated, resulting in depleted rural eras and polluted cities with cumulative wastes, that do not return to natural cycles [61].

From a Marxist perspective, the capitalist economy, with its emphasis on perpetual expansion and generation of more profit, tends to commodify everything, including natural resources [62]. A handful of researchers have argued that commodification and privatization of natural resources will help protection of the environment [63]. However, there is evidence that commodification leads to a degraded natural environment; this effect often is exacerbated by inequality among individuals in terms of having access to, or control over, natural resources [64, 65,66 and 67].

Not all economic organizations have equal impacts on the natural environment. Principally, larger organizations tend to have more negative effects on the natural environment relative to small scale corporations. Existence of several subsidiaries can protect the holding company from legal responsibilities, such as taxes [68]. There is also evidence that companies with complex bureaucratic structures that have headquarters established in countries where environmental regulations are limited, tend to have higher rates of pollution [69]. Research also suggests that within economies, a small number of organizations tend to have greater impacts on the natural environment compared to the majority of companies [70 and 68].

However, within the limitations of capitalism, there are some factors that can drive firms and corporations towards green and sustainable development. For instance, empirical findings suggest that media pressure and social movements can move firms to employ green technologies and change their perception of environmental protection efforts [71 and 72]. Recent findings also suggest replacing destructive competition over profit by collaboration between firms, in terms of co-investing in sustainable innovations, leads to environmental protection and economic growth simultaneously [73]. The destructive effect of the economy on the natural environment can be moderated, or even reversed, if stakeholders and CEOs and Boards of powerful corporations modify their mindsets to move towards green ways of production. In many cases, these green technologies, if done efficiently and well, can be virtually as profitable, and in some cases more so, than would staying with the entrenched, old-fashioned polluting technologies [72].

Another social institution that can have impacts on the natural environment is *Education*. An engaged, ecologically sound education can promote care for the environment in children and youth, helping to nurture a personal and collective sense of competence in thinking ecologically and dealing with the natural environment without degrading it, and inspiring engagement in public issues where the environment is concerned [74]. Environmental education should focus on increasing awareness of problems, evoking sensitivity, changing attitudes--particularly in decreasing alienation to the natural environment, developing skills, and encouraging environmental engagement among individuals and communities [75].

We can distinguish among several different strains of environmental education. While education *about* the environment is, for the most part, concerned with developing knowledge and understanding about the natural environment, education *in* the environment emphasizes activity-based and experimental methods, usually outside the classroom, that can promote personal connection with the environment among students [76]. At a deeper level, education *interacting with* the environment tends to stress ecological connections, as well as responsibility and participation in environmental conservation efforts. Recent empirical findings suggest that receiving environmental education and passing time outside the home, being exposed to nature, predict environmentally friendly behaviors among children that can continue to hold in their adulthood [77 and 78].

Religion is a powerful and influential social institution, affecting the natural environment in many ways [79,80,81]. Lynn White [82] argued that our environmental problems, throughout the world in general and in the developed West particularly, are at least partially rooted in Judeo-Christian concepts of “Domination of man over the earth” and “The Specialness of humankind.” This claim has been widely criticized by some scholars [83] and significantly re-interpreted by others [81]. These notions are not exclusively Judeo-Christian and can be found in Islam as well [84]. However, in the Abrahamic traditions (Judaism, Christianity, and Islam) one can also find seeds of environmentally friendly behavior. As noted most recently in Pope Francis’s Encyclical [85], *Laudato Si*, Saint Francis of Assisi can be seen as a model of Christian environmental conservativism; Sufism, the mystical branch of Islam, particularly because of its emphasis on selflessness and unity, has the potential for promoting environmentally friendly behaviors [82 and 84].

Empirical studies in this line of research are inconclusive. There are findings suggesting that literal belief in certain scriptures of Abrahamic religions, especially Protestant Christianity, lead to less environmentally friendly attitudes [86,87 and 88]. However, a number of other studies point out that there is no significant difference in environmental attitudes between believers in Abrahamic and non-Abrahamic religions [89,90 and 91].

Some researchers have theorized that Eastern religions, such as Hinduism, Buddhism, and particularly Taoism, as well as many American indigenous faiths and traditions, are more environmentally friendly due to their emphasis on an animistic relationship with the nature [92,93 and 94]. However, empirical research on these religions' environmental ethics is scarce [95]. Recent empirical findings suggest that religiosity in general, irrespective of particular religion, can promote pro-environmental behavior to some extent [96].

More generally, there now appears to be evidence that writings and beliefs of virtually any religion or comprehensive belief system, can be, and have been at times, used to justify environmental degradation, as well as ecological stewardship. Put another way, it is inaccurate and misleading to essentialize any given religion as pro- or anti-environmental. Rather, history shows an array of interpretations and justifications for thinking and acting either way, or somewhere along a broad spectrum of possibilities [81 and 84].

3.2 Social Movement Organizations

Social Movements, particularly when they take the form of Environmental Social Organizations (ESMOs), have the capability to evoke sensitivity towards social and environmental problems among citizens and mobilize people and resources geared to help facilitate lasting social changes [97 and 98]. There are several factors that can lead social movements to success, including organizational structure, strategy and tactics, resource mobilization, framing the problem, and political opportunity [99].

However, despite the recent growing number of memberships and increased financial resources, environmental movements have not reached the anticipated point of success, in no small part, due to their failure to prioritize environmental issues in political discourse [100]. Another obstacle environmental movements face, particularly in times such as now when there is acute inequality and control of resources channeled through the powerful and self-interested few, is the emergence of powerful denial counter-movements in the polity. These often are well-funded and orchestrated campaigns focused on discrediting responsible and good-faith science and denying the seriousness, or even existence, of anthropogenic environmental degradation [51, 101 and 102].

To cope with these difficulties and barriers, environmental movements around the world can use the experience of other successful social movements in framing, setting priorities, and mobilizing resources in order to be more effective [100]. For instance, recent developments in the field of information technology, such as social media, can help provide ESMOs with enhanced and effective mobilizing tools [103 and 104].

There is also a possibility of framing environmental issues in discourses of other social movements. For instance, since environmental issues do not affect all individuals equally, these issues can also be framed in the discourse of distributive justice movements, into frames of *environmental justice* [105]. At all levels of analysis, from local to international, the environmental justice movement calls for equal rights of all people, regardless of their power, class, and race, to be protected by environmental and public health laws and regulations [106 and 107]. Recent empirical findings suggest that a diverse set of environmental activists, groups, and NGOs have been able to create a shared discourse of environmental justice around the world, which is becoming increasingly more influential on other social movements [108 and 100].

In this section, we have striven to illustrate how social organizations and institutions can affect the natural environment through a wide array of mechanisms and procedures. While organizations and institutions consist of individuals, they do operate according to principles of emergence, which is to say that organizations and institutions have properties that are not reducible to the individuals in them.

Humans are social beings, and often channel their thought, energy and action through the organizations and institutions of which they are a part. Environmental problems are oftentimes caused by the perversities of these collective

actions. Moving forward, it is important to address them in meaningful ways, and this includes doing significant amounts of work through organizations and institutions.

4. ECOLOGY

While the common discussion surrounding both ecology and the environment focuses on forests, water sources, and air, as well as the degradation of those systems, it often leaves out important parts of the equation. If we are to consider a balanced ecosystem, it is essential to include in our discussion humankind and our relationship with these systems. An ecosystem consists of non-living and living things, all coalescing to create a community of interdependent life forms that support and sustain one another [7]. The relationship between humans and their surroundings has shifted with the rise of modernity, and this shift has brought with it many implications for the ecosystem.

4.1 Humankind and Ecology: Then and Now

By living in harmony with the natural cycle of an ecosystem, its inhabitants can survive indefinitely from the resources available to them. Throughout human history, many cultures have held a reverence for the earth and a deep connection with all of nature, and this mindset can be seen especially through the oral traditions of indigenous tribes. In the "Micmac Creation Story" from what is now the Americas, the first human shaped from the earth must sit, observe nature, and give thanks to it before he is free to explore. When he must kill a fish for survival, he is remorseful, but he learns to respect and appreciate the creatures that are his brothers and sisters [94]. This familial connection with nature has been termed *kincentric ecology*, or the belief that humans and nature are part of an ecological family that shares ancestry and origins [109]. These traditional indigenous beliefs, in which humans come from the world and are kin to all other creatures, stand in stark contrast with the constructs of individualized cultures that have evolved in developed countries today.

Somewhere amidst the process of technological innovation, humans have become disconnected from their surroundings. One of the most efficient definitions of this phenomenon was articulated by Karl Marx (also see Marx and Engels), who termed it "alienation" [110,111 and 112]. This alienation has resulted not only in the separation of humans from one another, but from the labor-filled process of production and the natural environment from which our resources originate. In fact, resource abundance, technological advances, and urbanization have all contributed to the mentality that humans were, and are now, exempt from any responsibilities and unrestrained by the biophysical world [3]. This uninhibited pattern of consumption has led to some consequences which are unaccounted for by human markets and ignored as "*externalities*" [113]. Over time, this has led to an unbalanced ecosystem, which is now faltering under the assaults of humankind. Evidence of this can be seen through devastation of three major elements of natural capital: agricultural soils, which are suffering from erosion, groundwater, which is being overdrawn, and biodiversity, which is dwindling rapidly [8].

4.2 Ecosystems, Overshoot and Imbalance

Ecosystems are resilient and often can survive small imbalances that are typical of the natural cycles of production and consumption. However, when they exceed the limits of the natural biodiversity, such as in the case of CAFOs (concentrated agricultural feeding operations that house thousands of chickens, cattle, or hogs at a time in a small, cramped space), the ability of the land to recover is overwhelmed [7 and 114]. Some ecologists warn of *Overshoot*: of pushing natural ecosystems beyond their limits through the accumulation of small imbalances that eventually reach a tipping point. In articulating the problem of overshoot, William Catton presents two elements of the human-environment interface losing its balance [115]. First, the human population is already too large for the world's renewable resources to support, and the depletion of resources is lowering the carrying capacity of the planet. Second, through the processes of extraction, production and consumption, human activity leads to accumulating harmful, toxic substances faster than the earth can reprocess them back into benign materials. Evidence of Catton's claims can be seen today through the effects of the many changes humans have caused in natural ecosystems.

Some of the most prevalent global changes we see today as a result of human actions include global warming, tropical deforestation, land degradation, and loss of biodiversity [116]. Even

the smallest of thoughtless actions can have widespread and lethal effects on humankind and wildlife. Research can now explain in detail how one molecule of a polychlorinated biphenyl (PCBs) can travel thousands of miles and have fatal outcomes for communities who have done nothing to incur them, such as polar bears of the Arctic or the people of Broughton Island in Canada [117]. Since polar bears are at the top of the food chain, they are subject to the highest amount of chemicals, which may be causing them to have fewer surviving offspring. As predators, the food they consume tends to have "*bioaccumulation*" of toxins, concentrated across trophic levels on the way to them at the top of the food chain. It also tends to stay in the bodies of polar bears and other mammals (people very much included), particularly in fatty tissue such as the breast and the lining of the colon, increasing the likelihood of endocrine disruption, cancers and other maladies. In a stark exemplar of such problems in a human population, consider the case of people of Broughton Island in Canada. They no longer are able to breastfeed due to concerns of poisoning their children, and many have lost their livelihoods and are now shunned as "PCB people". It thus becomes increasingly evident that along with harmful results to animal populations, overshoot and overconsumption of critical environmental resources can and do have detrimental effects on human societies.

Environmental scarcities have been shown to increase stresses, which stimulate other outcomes as well. These include insurgencies, ethnic clashes, urban unrest, and other manifestations of recurring violence [118]. In Jared Diamond's *Collapse*, he recounts the fall of the Maya population, which he theorizes was likely due to the dense population and drought. Over 99% of the population in the southern lowlands was decimated, and Diamond surmises that lives were lost not only from thirst, but also from individuals killing one another in struggles over scarce resources [119].

From his work we can see that imbalances in the ecosystem have serious implications. With the high amount of environmental degradation, pollution, and overall demand for resources today, there is significant cause for concern about the potential of collapse, with the planet no longer able to sustain life to the extent it once could.

4.3 Humankind and Ecology: Moving Forward

As the consequences of these events become more obvious, the effects of global change at least have the potential to encourage people in working toward lasting transformations in the culture, technologies and social organizations that impact the planet so profoundly. From an ecological perspective, perhaps one of the most effective changes we could make is to return to nature and reunite ourselves with our surroundings, as many indigenous cultures strive to do [120]. Many developed countries are full of people suffering from a "*nature deficit disorder*", entrenched in their own culture of consumption and technology, and lacking connection with the outdoors [121].

Over the years, society has had proponents of nature who have helped people wishing to connect with their ecosystems in a powerful way. In the United States, the National Park and Forest systems are significant, not only for people seeking to re-commune with nature, but for the society in general. These parks are available, thanks in no small part, to the vision and efforts of John Muir, who wrote that "going to the mountains is going home" and believed that mountains and rivers were fountains of life [122].

The work of Frederick Law Olmsted and William Hammond Hall in designing urban walking parks such as New York's Central Park, Montreal's Mount Royal Park, and San Francisco's Golden Gate Park, had profound and long-lasting positive effects on the lives of the millions of urban dwellers. Many of these people may not be able to visit National Parks at all, and certainly not on a daily basis. Yet having green space available and close to where people live and work on a daily basis is perhaps now more necessary than ever [123].

The fruits of these and other visionaries can inspire more people to connect with their ecology. This would go a long way toward fostering a culture amenable to unwinding the wicked problems of our planet, from the seemingly localized, to global environmental degradation, that have accrued over time and now come to roost in particular in the Anthropocene Age.

4.4 Case Study: The *POETICAS* Framework with a Focus on Ecology

For a more in-depth understanding of human impact on ecological systems, it is helpful to take a close look at certain regions, such as tropical forests, which have experienced many changes due to human modification of ecosystems. Human impact on the natural world is manifested in a multitude of ways, but most specifically through emission of greenhouse gases, climate change, deforestation, and loss of biodiversity [124 and 125]. Tropical forests are the most richly biodiverse ecosystems on the planet; however, this is being threatened as deforestation and other aforementioned social and ecological factors drive threatened species to the brink of extinction and destroy the functioning of natural ecosystem processes [126]. Through the discussion of *Ecology* and its relationship with other variables in the *POETICAS* model, we can begin to bring together ideas about the impact of humankind on natural systems, specifically in tropical forests, and the implications of these interactions.

Human *Populations* often have a large impact on forest areas. As the population swells, more land is cleared for living space or agricultural land to support the growing number of people in the area. Studies of Latin American forests have shown that with the frontier of migration, deforestation follows closely behind in order to create land for crops – creating perhaps one of the most salient footprints of human modification [127]. With the growing human population, forest land shrinks and available habitats for many species become diminished. Additionally, human *Organizations* have also shown to have many effects on forested land. In Thailand, the government has historically supported causes that led to deforestation, specifically agribusinesses that cleared large forest areas to make paddy fields and companies that built railways through forests and encouraged farmers to settle in those areas. Unfortunately, it was often the ethnic minorities in these areas that were blamed for deforestation despite their contribution being the smallest [128].

As *Technology* has developed, it has become even easier to alter ecosystems, with the ability to strip mine and clear large areas of land without human labor. As forests have been cleared, there has been an increased use of mono-cropping on the new agricultural land, which has also been devastating to biodiversity, as well as having significant consequences for human populations. A famous example is the Irish Potato Famine, which occurred due to the lack of biodiversity in strains of potatoes, which were then wiped out by a fungus infestation [113]. Lack of biodiversity can have a large impact on the *Illness and Health* of both plants and animals, humans certainly not excluded.

Further, *Culture* defines the ways that populations think and act towards our ecosystems. Today, when more than 80% of the world's population lives in urban areas or village biomes, the idea of a "natural ecosystem" has become almost obsolete in some tropical regions where the forested landscape has been drastically modified by human activity [129]. In developed nations, many people do not have access to Natural Parks or other forms of nature on a daily basis [123], and our concerns about nature have dropped out of the list of top priorities. This makes ecological problems what some would call an "orphan issue", as leaders of developed countries, or the affluent, place other issues, such as economic success or immigration policies, as top priorities [100].

This idea dovetails with the concept of *Affluence and Inequality* and how they play a large role in the treatment of ecosystems as well. The blame can lie partially on the wealthy policy makers who exploit developing, resource-rich countries, while at the same time environmental degradation, deforestation, while their consequences become externalities [5]. However, the impoverished are not blameless either. One theory of tropical deforestation, the "frontier theory", grows out of a congeries of ideas that many entrepreneurs, companies, and farmers often have little economic opportunity outside of clearing additional land for agriculture [130]. The culture that supports deforestation is a complex one, and the various parts of it, and the economy embedded in it, play a role. The broader point here is that wealth and poverty are complementary, and work in a negative dialectical fashion, against the interests of the environment and the people taking from it.

The *Scale and Time* of ecological changes has become more pressing with the Anthropocene Age, as there are very few areas of the tropics that have remained unscathed by human influence [131]. The rate at which deforestation and global change are currently occurring has situated tropical forests as the prime region for loss of biodiversity, as well as the site for current

and future species extinctions [132]. Even areas which are protected are suffering from human activity nearby, reducing their ability to survive in the long-run [133]. The processes of ecosystems have been compromised by human impact on these areas, and without conservation of these areas and human withdrawal, biodiversity is likely to continue to decrease in coming years.

The complexities of ecosystems are only made more rich when they are considered alongside the other components of the *POETICAS* model. While ecology is a significant element to consider, much like the functioning of an ecosystem itself, it is reliant on many other variables that have the ability to alter the ecological systems, both on the small-scale and global levels. Tropical forests help provide a closer glimpse into the dynamic relationships between these variables, as these forests experience drastic changes due to human organizations, technology, and culture that promote ecological degradation and deforestation. For the future of tropical forests and biodiversity, it is vital that we understand the interactions of these variables and begin to manage the impact humankind has on our landscapes and ecosystems [134 and 135].

5. TECHNOLOGY

Humans, unlike most of the other species living on this planet, tend to change their environment by using manufactured tools, rather than simply adapting to their given situation. Our biological and cultural evolutions, thus, have always been influenced by technological advance [136]. Throughout history, we have been challenged by two major problems: how to acquire sufficient sustenance by innovating our ways of production, and how to manage residuals or wastes of our activities [137]. In this regard, technology can be considered as one of the master variables affecting the natural environment.

The term "*Technology*" may refer to a set of different entities, including innovative artifacts, novel procedures and ways of doing things, and an enhanced knowledge [138]. While there is a debate among scholars on how technology, in terms of an enhanced knowledge, can be distinguished from science [139], one can think of technology as materialized science in its most practical and efficient form [140]. Technology rarely, if ever, operates in a vacuum. Typically, in late modern society, technology involves significant interaction between science and capital, and its effects are deeply tempered by affluence and inequality.

A common trope, that "technology is neutral," can be most misleading, for surely it is anything but neutral. It has the ability to do great good or terrible harm. Technology virtually never affects everyone equally, and to understand its effects beyond the most surface level necessarily involves considering its interactions with other master variables, particularly with Affluence & Inequality [141]. Let us turn now to a discussion of some of the most ubiquitous benefits, as well as perversities, of technology.

In sum then, technological advances have made several improvements to human life throughout history, yet its effects typically are mixed. Discovery of fire, invention of wheels and plows, development of tools, and several other innovations enabled primitive humans to overcome the hostile environment, resulting in the spread of humankind to all corners of the earth [142]. More recently, discovery of antibiotics, such as penicillin, and other drugs, most notably the polio vaccine, decreased mortality rates across societies, contributing to population levels reaching their highest in human history [143,144,256 and 145].

5.1 Considering the Darker Sides of Technology

Karl Marx and Friedrich Engels [111] pointed out in *The Communist Manifesto* that perpetual alteration of instruments of production is one of the distinguishing characteristics of modern capitalist societies. The perpetuity of technological transformation has led to an acceleration of the pace of human life in recent centuries. Yet it is not uncommon for this to lead to individuals' experiencing increased levels of anxiety and frustration relative to people living in pre-modern eras [146]. There is no denying that technology has made modern life easier in some ways. There are downsides as well, coming from the destructive impacts on several aspects of human life and the natural environment [147].

The capitalist economy requires constant growth in order to continue functioning [112]. The process of production needs to be fueled with raw materials extracted from the natural environment. Allan Schnaiberg [148] developed the idea of "the treadmill of production" to explain

how the need for perpetual economic growth in a capitalist society leads people to make withdrawals from the natural environment more readily than stewarding it. This inevitably leads to the "second contradiction of capitalism" set forth by James O'Connor [149,150]: since raw materials are finite, and economic growth is a crucial necessity for capitalism, this economic system involves serious ecological drawdown that will lead to systemic collapse of both the economy and the ecology at some point. While these two processes are intimately intertwined, it does not mean that they will necessarily collapse at precisely the same time. If humankind, in aggregate, continues to consume natural resources for the purpose of economic growth at the current rate, we, as a natural species, might face extinction before witnessing the collapse of the economic system.

Thus, it is dangerous to assume that the second contradiction of capitalism will necessarily help overthrow the economic system which is degrading the natural environment. In fact, as the environment is degraded, and vital resources become even more scarce, the perversities of hyper-demand for life-sustaining resources such as water, could lead to hyper-inflation of prices of the already commodified, limited supply of healthy drinking water. This in turn has other perverse effects, penalizing almost everyone, and particularly the poor who already have limited access. The small class of people who will benefit from this, at least in the short run before this causes total systemic collapse, are the affluent and privileged few who have the luxury, power and access to treat this life-sustaining necessity as an investment. Money is used to make more money, with water, or lack of it, becoming a fungible place-holder—essentially a hostage – in the process.

Technological innovations, paradoxically, have the capacity to deal with environmental problems in two possible ways: 1) innovative green technologies can provide alternative processes of production with less destructive effects on the natural environment: and 2) they also can help us clean up what we have done to nature.

Recent empirical findings suggest that technological innovations can play a significant role in reducing environment pollutant emissions and level of energy consumption [151,152,153 and 154]. Technological advances provide us with more efficient tools and procedures, enabling us to produce more goods with less energy consumption, costs, and pollution. However, this reduction in costs may increase overall consumption of goods, and therefore energy [155,156 and 157]. This phenomenon, famously known as the *Jevons Paradox*, was first introduced by William Jevons [158] in his study of the coal industry in England. It appears that technological advances by themselves cannot solve the problem of environmental degradation unless they are accompanied by policies and regulations to prevent the Jevons Paradox [159]. Recent empirical findings from different parts of the world appear to support this thesis [160 and 161].

Developing "clean" technologies to reduce the level of environmental degradation has always been a concern. A shift to "cleaning technologies" in order to counter effects of previous pollution becomes most critical in the Anthropocene age [162]. Recently, there have been major developments in fields of chemistry, nanotechnology, and biotechnology that can be beneficial, such as cleaning organic and inorganic pollutants from the natural environment [163,164,165,166,167 and 168]. In so doing, it is crucial to keep a sense of balance, and guard against introducing iatrogenic problems, such as setting the stage for an invasive species to take over an ecosystem to which it is introduced in the process of hoping for a quick technological fix.

5.2 Technology in the Balance

Given the preceding discussion, then, technology appears to be a "double-edged sword." It has the potential to be a disaster to the natural environment through such phenomena as the Jevons Paradox and the second contradiction of capitalism, yet it also can promote sustainability by introducing green procedures and ways to clean up the natural environment from pollution.

What, then, determines how technology is used—for the benefit or the detriment of the planet and its inhabitants? Here, we need to look at the powerful effects of other master variables, particularly Culture and Organizations & Institutions, *in conjunction with* Technology. Technology cannot be the ultimate solution, yet its profound effects need to be seriously considered and incorporated into any strategy to deal with environmental problems. It is optimal when this is part of an environmentally conscious culture, in which human social organizations work cooperatively, with people of good faith, aligned to principles of responsible and healthy usage of technology.

Technology is one of the most important factors that policymakers and citizens should take into consideration. It is vital to consider both destructive and beneficial roles that technology can play in helping to relate to the natural environment well. Technology is virtually never neutral, and the illusion that it is, can be dangerous. In sum, technology can be a wonderful servant, or a horrible master. Which of those is largely dependent upon how we handle it, through the cultures and organizations of which we are integral parts.

6. ILLNESS AND HEALTH

In order to stay alive, let alone to thrive, human beings, like other living organisms, have basic biological needs, such as the need for water, air, and nutrition. However far removed from it we are in late modernity, ultimately it is the natural environment that provides us with these necessities.

An intact, robust environment can promote health, while a polluted environment can result in illness and disease. In the following paragraphs, we elaborate on how the natural environment can affect humans' well-being. As a way of making sense of these often complex relationships, we consider some basic tenets of the theory of evolutionary biology and one of its important offshoots— "Darwinian Medicine" [169].

6.1 Basics of Darwinian Medicine

While the theory starts with the commonplace that the process of natural selection has helped the fittest species to the environment to survive and to pass their genes to the next generation, it makes an important set of linkages along the way. To a large degree, being in harmony with the ecosystem has been a prerequisite for being selected by nature to continue living on this earth [170,171,172 and 173]. This was the case until recent centuries, when humankind's manipulation of the natural environment came to a magnitude and scale unforeseen in human history.

As a result of certain profoundly ecologically challenging technologies, such as herbicides and other chemical substances, humans and other species have been dealing with a severe class of problems that, broadly speaking, include "diseases of civilization" such as Type II diabetes, obesity, certain types of cancers, environmentally related birth defects, and a host of other problems [17,174,175,176,118,7].

6.2 The Exponential Growth in Harmful Chemicals in the Post-World War II Period

Yet the introduction of new chemicals to the natural environment, for the most part, came about only in the post-World War II years of 20th Century. In fact, one of the lesser known and perverse legacies of World War II was that leftover chemicals produced for the purpose of war (many of them barely tested beyond the most rudimentary levels) found their way into peacetime civilian markets [117]. At that time, science was limited, in terms of data and method, and unable to prove destructive effects of chemicals on the natural environment.

Chemical companies, enjoying the windfall profits ensuing from the manufacture of toxic chemicals such as DDT, tended to ignore *precautionary principles*, effectively putting the burden of proof on those suggesting that such chemicals can be harmful to the environment and dangerous to human and other life [17,175 and 176]. The growing widespread and barely restrained use of dangerous and largely unvetted chemicals in agriculture and industry, have, in subsequent decades, led to dramatic rises of environment-related health issues, including birth defects, asthma and other allergic and respiratory problems, and an array of cancers [177 and 175].

6.3 Perversities of an Environment Increasingly out of Balance in the Anthropocene Age

In this Anthropocene epoch, particularly because of the widespread use of technologies largely unbridled by concerns for the public good and a collapse of civil society's ability to meaningfully regulate them, pollution of the natural environment is alarmingly intense. Combined with the advent of chemicals increasingly potent at targeting specific organisms in the ecosystem, resulting in non-random extinction and loss of biodiversity [178].

Biodiversity is crucial for regulating ecosystems, and its loss can cause severe problems and illnesses [179]. One of the many perverse consequences of this is the rapid evolution of "exotic species" and "upper strains" that are, for example, immune to the toxins of standard

pesticides. The outcomes are ironic and perverse. As Steingraber [175] points out, crop losses due to infestations now are greater than before the advent of pesticides. The ones who really benefit (and it is a Faustian short-term benefit at best) are those owning stock in chemical companies.

6.4 The Healing Powers of Nature

Degradation and pollution of the natural environment is one of the contributing factors to the emergence of a number of illnesses. Yet when in balance, nature can help serve as a remedy to diseases caused by human civilization [169]. There is evidence that being exposed to the natural environment will help individuals cope with emotional disorders [180]. "Green Exercise," or doing physical activities in peaceful natural settings, has been shown to offer significant benefits to the mental, as well as the physical, health of individuals [181]. In fact, there is evidence that even proximity to green areas, such as parks in urban settings, will stimulate individuals' willingness to do physical activities, resulting in prevention of obesity [182].

Exposure to the natural environment, in addition to its direct effects on individuals' health outcomes, can help to counteract, at least a significant part of, the relationship between lower socioeconomic status and the prevalence of illness [183]. In general, empirical studies suggest that exposure to different elements of the natural environment, such as animals, plants, landscapes, and wilderness, can promote humans' mental and physical well-being [184].

While it sounds dramatic, it is no exaggeration to say that by polluting and degrading the natural environment, humankind has accelerated the process of extinction for a significant number of other living organisms. While what we have done to the ecosystem cannot be undone, at least in the foreseeable future, we still have a chance to preserve what is left of biodiversity, *inter alia*, by ceasing to introduce largely untested new chemicals to the natural environment [175]. This cannot be done unless citizens in general, including business elites and policymakers as well as people whose health and sometimes lives are at stake (all of us, ultimately), are willing to face the seriousness of the problem. Evidence suggests that collaboration of scholars, community leaders, and citizens, at local, national and international levels, is crucial to promoting life-affirming environmental health policies [185].

In this section, we have attempted to show how the intact natural environment can be beneficial to humans' health and how pollution and degradation caused by human activity to the environment can cause serious problems, not only for us but for other species as well. These problems require the attention and priority of action of citizens and policymakers if we want to save ourselves and future generations from dangerous diseases and maladies that, if not addressed, are capable of bringing terrible misery, and perhaps even eventual extinction, upon humanity and other species. There is still time to act, but as life-affirming decisions are delayed or placed on low-priority, that time becomes shorter, even as the cost of avoidance increases exponentially.

6.5 Case Study: The *POETICAS* Model with a Focus on Illness and Health

When Lois Marie Gibbs moved into Niagara Falls, New York, she knew almost nothing about the history of the Love Canal, conceivably the most infamous trash dump on the planet [186]. The area got its name when in 1892 William T. Love proposed building a seven mile long canal connecting the upper and lower Niagara River in order to create a human-made waterfall to be used as a power source. The project remained unfinished due to the Civil War until the Hooker Chemical Company purchased the land at a public auction in 1920 and began to use the uncompleted canal as a dumping ground for chemical by-products [187].

Lois Gibbs was living a happy life until her son, Michael, began to show signs of developing epilepsy, a neurological disorder. Reading Mike Brown's article in the local paper, *Falls Gazette*, she found that some of the chemicals dumped in the canal that goes beneath the school's playground can actually cause damage to the central nervous system [188]. The year 1978 was the beginning point of her life-long crusade. She started going door-by-door, explaining the situation and enlightening other parents whose children were attending the same school and asking for their signature on a petition to the state Department of Health [187]. Her efforts finally resulted in EPA's Superfund program designed to clean up toxic areas [189].

While the Love Canal story serves as an example of how toxicity in the natural environment can adversely affect human health, it also can show how collective efforts of concerned citizens, channeled through Environmental Social Movement Organizations (ESMOs) at the local level, can pressure the polity at national, or possibly international, level to pass legislation in favor of environmental protection. The personal story of Lois Gibbs, a housewife who went to Washington D.C. to create and be the director of the Center for Health and Environment, can also show how culture is an important factor [188 and 7]. Throughout her journey to become a role model of how citizens, especially women, can and should be engaged in public affairs, she faced a significant number of cultural challenges, including being ignored not only by local authorities and politicians but also by members of her own family [187].

This case study can show how a combination of variables, such as health and illness, the natural environment, social organizations, culture, inequality, and so forth, are intertwined and cannot be studied separately. Love Canal turned into a toxic area, causing serious health problems and diseases, due to lack of environmental consciousness and absence, or insufficiency, of environmental regulations in the past century. Driven by the sheer economic incentives without any consideration of the future outcomes, chemical companies and other economic organizations have polluted numerous lands on this planet, threatening public health among several communities.

The story of the Love Canal, however, shows how ordinary folks, concerned with the health of their families and communities, can play a significant role in forcing power institutions, such as the nation-state, to adopt environmentally friendly approaches and policies [190]. Lois Gibbs's story can simply suggest that pursuing the wellness of our own family cannot reach success without also considering the wellness of others. Environmental issues, in the Anthropocene era, are caused by collective actions of people, they are affecting communities of people, and are best addressed by collective efforts of conscious individuals.

7. CULTURE

There are a number of ways to think of human culture. While scholars are virtually unanimous in seeing its importance and centrality to the human condition, they do not all agree on a single definition of culture [191]. A number of thinkers believe that since our biology is incomplete, due to its inability to satisfy our basic need to live in a meaningful world, culture can be considered as the humanly-created counterpart and complement of our natural environment [192,193 and 194].

For our purposes, because of its efficacy and applicability, we will use Burns's [195] definition of culture as a substratum on which human society is built. Culture contains a set of shared values, beliefs and actions organized around an ethical framework that makes it possible for human interactions and institutions to exist and be meaningful [195,196 and 197]. Culture, to a great extent, is affected by the natural environment of the community in which it has been generated, yet it also can have decisive impacts on the natural environment as well, in a variety of ways [198].

The project of modernity, coming into full stride during the industrial era, gave rise to a new type of culture, for the most part in Western societies, which emphasizes individualism, rational ways of thinking and organizing, and a belief in the power of science and technology [199,200 and 201]. This modern culture strives to become dominant throughout the world through a set of processes, such as *Globalization* (the process of increasing economic interactions of individuals, firms, and nation states on a global scale), *McDonaldization* (the process of adopting hyper rational characteristics, such as efficiency, calculability, predictability and control by a society), and *Institutional Isomorphism* (the process through which social organizations and institutions in different societies are becoming more similar, in terms of their structure and function, to each other) [202,203 and 204]. Aspects of this culture of modernity have had destructive and damaging effects on the natural environment [195].

For instance, it is taken for granted, to a large extent, by many politicians and business leaders as well as economists, that if individuals pursue their own selfish interests, the outcome will be beneficial to the society because the "invisible hand of the market" would, according to neo-classical economic theory or "neoliberal" principles, adjust in such a way as to redound to the greater good. However, evidence has shown that if this ever actually worked as in theory (and we are not implying this is the case), this now at

best requires an astonishingly naïve leap of faith. Countless real-world examples have demonstrated how it will more likely lead to a "tragedy of the commons" where natural resources are degraded due to free-riding and benefit seeking of self-centered individuals [205 and 206]. This is further exacerbated by the asymmetric social processes, in which it takes only a very few people acting selfishly to cause significant damage, even when the majority are acting in good faith [207].

Unreflective belief in technology is another aspect of modern culture that can destructively impact the natural environment. Although technology has made our life easier in many ways than it was centuries or even decades ago, scientism, or an unquestioning belief in science without the sobering balance that clearly regards its limitations, can negatively affect the natural environment.

Aspects of the scientific method also bear rethinking in the light of cultural lag. A series of experiments, for example, sometimes tends to isolate phenomena from their natural context to be able to study them. This is true for experimental designs in the "hard" sciences, and also for observational designs in social and behavioral sciences.

In economics, some of the practitioners and consumers of which consider it a science, the natural environment is often assumed to be infinite, and thus treated as an externality which is not properly measured and accounted for [195 and 208]. Statistically, its effects tend to remain unmeasured, and so show up only by proxy as part of the "*error term*" in stochastic models [195]. For much of technology, as well as for significant subfields of science in the late modern era, the natural environment typically is an object of the study in order to expand some aspect of humankind's domination over other species as far as possible [209]. Institutionalization of this ethos into the modern culture, or having an unbridled faith in science and technology without a hard look at some of its limitations and drawbacks—which is more precisely characterized as *scientism*--can be considered as part of the very root system of our catastrophic environmental status today [210].

While some social institutions, such as the polity and the economy, tend to change rapidly, particularly after the industrial revolution, there is also a counter trend in which human culture shows an inertia towards changing. This phenomenon is referred to by sociologists as "*cultural lag*" [211 and 212]. The rate of change in technological innovations is greater than the rate of cultural change. In fact, culture is changing and adopting to new situations, yet not fast enough to catch up with the rapidly changing material conditions. In some cases, it may take decades or even centuries for a culture to completely adapt to a new set of material conditions [195], and in the meantime, other changes inevitably come into play. This can potentially cause decisive problems to the natural environment [213].

The phenomenon of cultural lag often has destructive consequences for the natural environment in several ways. For instance, humans have inherited cultural norms and ethics of the industrial era, such as a type of unconstrained individualism that can and often does edge toward narcissism and alienation [214,215,216,110,217,195].

In earlier periods of human culture, including the growth phase of the industrial period, natural resources were not scarce to the extent that they are now. Also, elements of traditional cultures, such as religious notions of "promised land" or "human mastery over the earth", adopted by the modern culture can, and, when not adapted to the conditions of the Anthropocene, have often led to environmental degradation [195,84 and 82]. In the sense that human "adaptive culture" [211] has not yet caught up with the material reality of these shortages, we have a perverse macro-level case of cultural lag. The relationship towards the natural environment, while it may have been feasible and even sustainable to some extent at earlier times, is now increasingly maladapted and unsustainable [195].

Despite overwhelming forces leading to globalization, cultural lag is something of a counter-force. There thus does remain a significant degree of heterogeneity in cultures of human communities. To a large degree now, what cultural differences exist are as much organized around different moments on the trajectory of modernity as they are about place [195].

Empirical studies show that different cultures around the world often process local and global environmental problems differently and react in dissimilar ways towards these problems [218]. This can be considered as both a threat and an

opportunity for the global natural environment. It is not hard to imagine how a homogenous "Western" culture dominated by individualism and the "fetishism of commodities" could be a calamity to our planet [148]. However, on the other hand, for solving problems like climate change, where international collaboration is necessary, cultural heterogeneity can be a challenge—albeit not insurmountable—on the way to reaching a collective environmental consciousness. For that to be the case, a common set of meaningful and shared symbols is necessary to help build toward a common ethical vision for a sustainable future.

Accordingly, culture appears to be the master variable that decisively impacts the natural environment, directly and also in indirect ways through the other master variables such as technology, social institutions and organizations and scale and time effects. Considering this fact, one can claim that technological and institutional fixes cannot be effective unless they embedded in the broader culture [195]. While there are several possible solutions, at different levels of analysis, to environmental problems of this Anthropocene epoch, it is not unreasonable to think that a major part of addressing wicked environmental problems comprehensively involves developing a culture with the natural environment as a central organizing principle. This would help bring the ethics, institutions, norms, and beliefs, to a place that operates in concert with natural ecological principles.

7.1 Case Study: The *POETICAS* Model with a Focus on Culture

Sociologist Arlie Hochschild is a professor emerita at the University of California-Berkeley. She departs from her comfort zone of Berkley, to visit what she calls "another America." Accompanied by her family members, she moves to Louisiana to develop a *Verstehen* (empathic understanding) of the "other side" of the American political spectrums – far right Tea Party Republicans [219]. Her goal, as she declares in her book, *Strangers in Their Own Land: Anger and Mourning on the American Right*, is to cross the "empathy walls," those that divide humans and put obstacles to deep understanding, making people indifferent or hostile to the others [220].

She draws on what she calls a Great Paradox. According to national records, the "Red States," compared to the "Blue" ones, are suffering from more social problems, including but not restricted to poverty, teenage pregnancy, divorce, obesity, and so forth. As an instance, the average life expectancy in Louisiana is estimated to be 75.7 years, while it is 80.8 in Connecticut. More importantly, red states are suffering from higher levels of industrial pollution [220]. Given this situation, one might suppose that people in these states should support policies intended to make their lives better, however, this simply is not the case. People of these states, for the most part, widely support right-wing politicians who generally show fewer concerns about these problems [220]. This apparent paradox in individuals' political behavior requires cultural explanations.

For each culture or sub-culture, there are central concepts and values [221]. These central concepts unconsciously drive the cognitive process of othering. People of a certain culture, typically, categorize other people based on their relationship to these central values, either as insiders or outsiders. For the case of the Great Paradox, it appears that what Hochschild calls a "Deep Story" is a central concept for those who are living in red states, driving them towards acting against their own interests in the political sphere. The Deep Story suggests that these individuals believe they are being oppressed by the liberal federal government that favors outsiders to their own narrowly defined social circles, such as blacks, immigrants, and more educated middle-class people, over them. They would rather vote for those politicians whom they consider to be insiders, in terms of believing in the same deep story, than voting for those who care more about social and environmental problems from which they are actually suffering [220 and 222].

This is a good example of how culture can affect the natural environment. However, other factors, particularly organizations and institutions, can be highly influential as well. It appears that newly emerged grassroots organizations are putting a significant amount of effort in closing this cultural and political gap between people living in different parts of the U.S. The concentration of these organizations is mainly on encouraging dialogue among ordinary people from any side of the aisle, at the local level and about local, as well as national, environmental concerns [222].

Environmental activists can do better at recruiting people from the other side of the political spectrum for the cause of protecting the natural environment if they truly try to understand the

culture those people are living in, which is probably different than their own in fundamental ways. Thus, efforts like those of. Hochschild in her study of Louisianans can serve as a role model for other environmental activists, and also for those involved in environmental movements and organizations. Despite political and cultural differences, one point is certain--degradation of the natural environment threatens everyone.

8. AFFLUENCE AND INEQUALITY

As societies and the people that compose them become more affluent, it often has effects on their patterns and methods of production and consumption. In addition, the economic principles that many markets today adhere to may be contributing to a growing inequality on a small and large scale. Ultimately, affluence and inequality both have profound environmental effects on our ecosystem.

8.1 Affluence, Inequality and the Operation of World Systems

As overall affluence increases, so do demands on resources and the generation of waste. When the affluence of one group goes up relative to another, this can skew demands for certain environmental resources and the generation of waste such that it benefits the more powerful group and disrupts the balance of ecosystems in the process. This relationship is particularly evident in the interactions between developed countries with advanced technology and developing countries that are experiencing growth in manufacturing [5]. Many of the economic principles that developed countries follow result in exploitation of the natural capital of developing countries in a way that far outstrips the planet's ability to replenish its resources and sustain itself [150 and 223].

A useful method to discuss overall affluence and the operation of world systems was devised by Immanuel Wallerstein, who divided countries into three ideal-types: the core, semi-peripheral, and peripheral nations [224]. Today, core nations include the major powers of Western Europe, the United States, Canada, and Japan, which are more developed and dominate global production. Semi-peripheral countries vary in their strength and connections; this category is made up of nations such as Brazil, Nigeria, Russia, India, Turkey, and China. Other more recent researchers have found a plethora of evidence that the high end of this semi-periphery, known variously as the "semi-core" or focusing on its most prominent exemplars of Brazil, Russia, India and China (or the "BRIC" countries for short) tends to have its own characteristics, different from either the core or the rest of the semi-periphery. It is in these countries where some of the most intense pollution and degradation are taking place [19 and 7]. Peripheral countries consist of less developed nations in Latin America, Africa, and Asia, and they are relatively weaker in the domains of economics and technology. It is not uncommon for a peripheral country to have a dependent relationship with a more developed country or countries, placing them at a disadvantage both in economics and in environmental exchanges [225,255 and 226].

In the area of economics, we can see a relationship between the level of development of a country and its level of environmental degradation. Economist Simon Kuznets recognized a curvilinear relationship between economic growth and income inequality [227], which can be used to predict that the highest levels of pollution should be found in developing, semi-peripheral countries rather than in developed, core countries or peripheral countries [228]. However, what Kuznets's curve fails to account for is the "Netherlands Fallacy": while in many cases, developed countries have lower pollution, they are often the cause of pollution or other types of degradation in developing countries [7].

The ecological footprint, therefore, is a measurement that is essential to consider because it accounts for the impacts that highly developed countries have on developing countries, and it encourages those in developed countries to take a hard look at, and possibly even some responsibility for, the ecological degradation that is occurring in other regions due to their own consumption patterns [229]. The ecological footprint measures the consumption of a various assortment of goods, including fossil fuels, food, and manufactured products. Empirical work on this subject has shown an approximately linear relationship between a country's level of development and their ecological footprint, suggesting that developed countries are responsible for the largest amount of environmental damage [10 and 230].

One reason for this trend is that as technology has advanced in developed countries, there has been increased regulations against pollution. In order to work around these policies, large corporations have employed the law of

comparative advantage by relocating their assembly plants with poor labor compensation and hazardous working conditions to developing countries [231]. In this way, many core, developed countries take advantage of the resource-rich developing countries (and comparable areas in their own countries) by exporting their natural capital and causing poor areas to become polluted. This phenomenon has many names, including recursive exploitation, metabolic rift, and unequal ecological exchange [6,232,233 and 234]. This relationship has many social repercussions, and oftentimes causes the poor to suffer the most from the effects. For instance, Stephen Bunker has discussed how unequal exchange in the Amazon (a very biodiverse space), driven by capitalism and pressures from powerful countries of the world system in search of cheap and rapid profits, has led to progressive underdevelopment and absolute impoverishment of the region [226].

8.2 Domestic Effects of Affluence and Inequality

On a smaller scale, we can also observe this mismatch between sustainable ecology and the large-scale production of modern economies. In developed, capitalist countries such as the United States, many of the instituted economic principles lead to unsustainable ecological practices and contribute to the increasing gap between the wealthy and the poor. Economically, large-scale production is considered to be more efficient than small-scale production. Bringing the logic of industrialization into agriculture, large-scale feeding operations, called CAFOs, were created in order to maximize the output of beef, poultry or pork and to minimize the production time. However, these have been under some criticism due to the inhumane treatment of animals, and they are environmentally draining due to the huge amount of concentrated resources required, including corn, hay, antibiotics, and water [183]. In Kansas alone, an estimated 97 percent of groundwater goes directly to livestock or to irrigation of crops for feeding the animals [235]. The unsustainable practices in this region have led to the depletion of the Ogallala Aquifer, which cannot replenish the water at the speed it is being consumed.

CAFOs are a representation of both large-scale ecological irresponsibility and small-scale ecological inequality. On one hand, they are consuming a large amount of resources and are even leading to desertification in some areas. At the same time, they have also led to many health problems for individuals living near to, and downstream of, the operations. More specifically, the concentration of waste and runoff into streams has caused the natural ecology to become overwhelmed, and people who live downstream of CAFOs are now at a greater risk for cancer and birth defects due to a higher exposure to toxins and pollutants [176]. Often, the people subjected to these living conditions are marginalized populations who cannot prevent such operations from being built near their homes. The idea that underprivileged populations are being taken advantage of is only exacerbated by the fact that the people who control the location of CAFOs and other harmful sites are often politicians or well-connected individuals with access to capital and power. Interestingly, when deciding where these operations should be located, politicians often off-lay the environmental risk onto these marginalized groups in what has been characterized as the “not in my back yard” (or NIMBY) phenomenon [7,260]. This process of recursive exploitation in which the powerful, richer nations or individuals reap the benefits of a high ecological benefit at the expense of the poorer, less connected nations or people, has been replicated again and again on different levels of organization [236].

The marginalized and impoverished are, indeed, much more vulnerable to environmental injustices. Exposure to environmental toxins are differentially experienced by diverse demographic groups, and can vary based on race, ethnicity, gender, and age. Environmental risks are disproportionately experienced by people of color, the poor, and indigenous peoples [237 and 107]. In places where environmental degradation is occurring, there is often social inequality along with it. Toxic waste dumps are often placed near the homes of these people who are not connected or powerful enough to prevent these projects [238 and 239], and minority groups such as blacks and Latinos are found to reside more frequently near environmental hazards than whites [240] even when other factors such as education and income are controlled for. In addition, those in urban areas are susceptible to a higher uncertainty and risk associated with former industrial waste sites [241], and in efforts to externalize pollution costs, chemical companies have been found to take the path of least resistance, which may perhaps victimize the people who do not fully understand how they are being affected [242].

Some proponents of an ecological revolution have suggested that in order to reverse the pattern of exploitation caused by capitalism, there must be a transition in our global economic system away from capitalism and toward a more socialist approach. This approach would shift the focus from production and consumption to genuine social needs; from an ecological perspective, it would focus on sustainable practices and a rapprochement between humankind and the natural environment [233].

Affluence and inequality is an important variable to consider due to its immense impacts on ecology and human interactions. The unequal distributions of natural resources among peoples and nations have detrimental effects on our ecosystems, and the increase of affluence, both on the individual and collective (e.g. nation-state) levels, typically serves to increase consumption patterns. Environmental degradation almost always affects people unequally, and the poor and disenfranchised often suffer the worst of the downstream effects and other consequences.

9. SCALE AND TIME

Perhaps one of the most important things for us to discuss is the scale and time over which ecological and social changes can occur. While some ideas may be efficient on small scales, they often do not play out the same on a larger scale. In addition, we must consider how quickly or slowly changes occur. While nature has the ability to recycle almost anything, some elements take a much longer time span to be broken down or replenished. Our choices can have long-lasting effects on the environment and can either constrain or facilitate the actions of humankind in the future.

9.1 Observations on the Scale of Environmental Problems

Problems can and do occur at all levels of analysis and spread out over time, from the immediate to the very long term. Indeed, environmental problems are not new. Historically, there have been many environmental disasters produced by nature itself, such as asteroids, volcanoes, and hurricanes. However, in our present time and particularly since the Industrial Revolution, humans have had an increasingly large impact on the planet in an unprecedented way [213 and 243]. This era has been named the "*Anthropocene Age*" by Paul Crutzen, who recognized the great acceleration of human impacts on the earth since the 20th century [244]. The Anthropocene Age marks the beginning of environmental disasters caused by human actions.

In the past, human societies have relied on the natural environment and taken many of its seemingly infinite resources for granted. As markets increase in size and consumption of resources, the loss of a healthy environment is regarded as an externality [238]. This has especially become a problem as capitalism has taken hold and inspired the goal of unlimited economic growth [243 and 245]. Many economic principles reveal mismatches between human aspirations and the ability of the planet to sustain them. The principle underlying economies of scale demonstrates one of these mismatches; it relies on the idea that increasingly larger scales of production are more efficient than small-scale production [113]. However, while modern markets commonly rely on commodity chains, or large-scale assembly lines, to create certain products, this often has detrimental effects for ecosystems that function on a small scale. These ecosystems are thrown off-balance as their resources are displaced [246]. The combination of externalizing environmental degradation and increasing scale of consumption chains is particularly concerning as ecosystems begin to falter and collapse. The collapse of societies as they outweigh the amount of resources available to them is a trend that we have seen in the past with isolated populations, such as Easter Island [247]. However, as the scale increases, it threatens a global collapse.

In order to prevent this catastrophe, some have argued for a change in our economic systems. E. F. Schumacher argues that we should alter our approach to be more gentle, with a non-violent spirit, and see that "small is beautiful" [248]. His work calls for the end of excessive consumption and for the rebuilding of economies with a focus on the needs of communities rather than the needs of corporations. By rescaling our approach to a smaller scale, we might be able to conserve resources while also caring better for others. Other academics argue for a "*planetist*" economy, one that would still support market economies but that is more efficient in allocating resources and that has a goal of self-sufficiency [249]. While this represents a slightly different approach, its main focus is still protecting environment, rescaling economics to represent a more local, sustainable relationship between humans and nature, and, therefore, ensuring the future of the world.

9.2 The Interaction of Time and Scale in Environmental Issues

In addition to scale, we must also consider the time frame over which both ecological and social changes unfold. Industrial societies have long behaved as though there are more and more resources which can be discovered, perpetuating the hunt for natural capital. While the earth has the ability to recycle much of its natural resources, this takes time, and there are even some resources which cannot be renewed in annual cycles of organic growth, which humans have hunted down and exhausted in batches [115]. Humans have been consuming in just one year what it takes the planet over a year to regenerate as a result of their insatiable desire to produce and consume [250,257 and 258]. This mindset is the reason why overshoot has occurred, as humans continue to drawdown and steal resources from future generations.

Not only have humans been taking from the earth at a rate that is unsustainable, but the amount of pollution entering the ecosystem exceeds the planet's ability to cleanse itself [259]. Perhaps part of our problem is due to the rapidness of change that we have experienced. Though technology has advanced dramatically in the past century, these advances rarely address the accompanying environmental degradation or waste produced [251]. William Ogburn identified a human phenomenon that often occurs alongside large jumps in technology: cultural lag [212]. Usually, a change in material culture (like new technologies) is followed by a social adaptation to this change; however, this change often takes a long time to occur and can lead to some disruption and social confusion.

However, another part of the problem can certainly be attributed to the selfishness of humankind, as people place individual needs above the collective. In the United States and other developed countries, the use of plastics has become almost ubiquitous. Our oceans have come to represent a tragedy of the commons as an increasingly large amount of garbage builds up due to human production of waste – creating what is now a "Pacific Trash Vortex" that by some accounts has become larger than the state of Texas [206,7] In response to this human characteristic of selfishness, a few have suggested that we take advantage of this by offering people incentives to create less pollution and act in an ecologically responsible way [252]. By inspiring people to feel a communal ownership for nature and for our resources, a tragedy of the commons may be avoided and changed into a "drama of the commons", in which people would internalize a normative system that encourages people only to take one's fair share [253]. However, no matter the psychological or sociological aspects of the human mind that cause us to act in this destructive way, there is no denying that there have been large and rapid changes in the global ecological system.

The actions of humankind do have an impact on the ecosystem, even if those effects may not be immediately evident. In fact, our actions are likely the cause of a much larger response. This idea is called *Enantiodromia*, which is a form of pushback – or an unfavorable reaction which may in fact be more forceful or violent, especially if a tipping point has been reached. This can be seen on a small scale as fertilizers and pesticides have become more common, and in result, the frequency of cancers and birth defects has increased. On a larger scale, enantiodromic processes have been caused by the release of greenhouse gases, and the response has manifested in the form of global warming, desertification, and climate change. In turn, this has caused further issues such as the melting of polar ice caps and the decrease in habitable land for many exotic species. The further that we push nature, the more we should be concerned about the pushback.

The reactions of the environment should encourage us to act with more consciousness about the future. One model of sustainability that emphasizes future generations is associated with the prophecy of the seventh generation of the Mohawk tribe [254]. According to this prophecy, after living with Europeans for seven generations, the Onkwehonwe would see the day that elm trees would die, birds would fall from the sky, fish would die in the water, and humans would grow ashamed of the way that they had treated the earth. If we lived according to this prophecy, we might consider whether a process that may seem like a good idea (fracking, for example) could be extended more broadly unto the seventh generation. If not, it would be wise to rethink its use and find a better alternative beforehand, rather than degrading the environment with it.

Overall, both scale and time are essential to consider as we begin to unwind the web of issues that have been created by thoughtless

actions in the past. While human social causes of environmental degradation were not fully appreciated in the past, we can see now from the speed and scope of these problems that we cannot use ignorance as an excuse for ecologically irresponsible behavior any longer.

10. CONCLUSIONS: UNDERSTANDING AND ADDRESSING ANTHROPOGENIC ENVIRONMENTAL PROBLEMS

No longer is it enough for researchers to simply find problems. In many cases, we know only too well the problems we face. And while it is still a primary duty to educate and publicize those very real dangers, environmental sociology must research and put forward practical solutions to the problem at hand. The sociological imagination can be harnessed to bring forth creative and workable solutions to the immense environmental egoism and alienation. However, until recent times, the human social causes of environmental degradation were not fully recognized. This was, in part, due to the fact that the extent of the ill effects of industrialization had not fully manifested themselves until more recently. At this stage of Late Modernity, we no longer have that excuse.

Classical sociologists shed a great deal of light on many of the problems of Modernity, including inequality. Yet with some exceptions (e.g. Marx's consideration of metabolic rift in his later work), they did not consider the profundity of the relationship between humankind and the natural environment. Sociology has been struggling to catch up, with Environmental Sociology only hitting its stride in the late 20th Century. Much of the work that has been done, while useful, has been, understandably, focused on some aspect of the problem. This paper takes a larger, overarching view, seeking to tie together some of the disparate aspects of the field, and to offer a useful framework to help guide future research, policy discussion and social action.

As society moves into the third millennium, it is crucial to address the two wickedly interrelated master social problems of late modernity: humanity's lack of connectedness with nature, and the inhumanity of social inequality that makes that possible. It is the task of social scientists and human ecologists, and indeed, people of good will, to engage these crucial questions head on, and to lead the way with engaged teaching and research. For humankind to survive and thrive from this point forward, it is incumbent upon all of us to address this crucial set of social problems that ultimately leads back to humankind's relationship with the natural environment and with others.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Duncan, Otis D. From Social System to Ecosystem. Sociological Inquiry. 1964;31: 140-149.
2. Hawley, Amos. Urban society: An ecological approach. New York, Wiley; 1981.
3. Dunlap Riley, William Catton. Struggling with human exemptionalism: The rise, decline, and revitalization of environmental sociology. The American Sociologist. 1994; 25(1):5-30.
4. Dietz, Thomas, Eugene A. Rosa. rethinking the environmental effects of population, affluence and technology. Human Ecology Review. 1994;1(2):277-300.
5. Burns Thomas J, Edward L. Kick, David A. Murray, Dixie A. Murray. Demography, development, and deforestation in a world system perspective. International Journal of Comparative Sociology. 1994;35(3-4): 221-239.
6. Burns Thomas J, Edward L. Kick, Byron L. Davis. A quantitative, cross-national study of deforestation in the late 20th century: A case of recursive exploitation. In Globalization and the Environment, edited by Andrew K. Jorgenson and Edward L. Kick. Leiden, the Netherlands, Brill. 2006; 37-60.
7. Burns Thomas J, Beth S. Caniglia. Environmental sociology: The ecology of late modernity, second edition. Norman, OK., Mercury Academic; 2017.
8. Ehrlich Paul, Anne Ehrlich. Nature's economy and the human economy. Environmental and Resource Economics. 2008;39(1):9-16.
9. Cohen, Joel E. How many people can the earth support? New York, Norton; 1995.
10. Jorgenson, Andrew K. Consumption and environmental degradation: A cross-national analysis of the ecological footprint. Social Problems. 2003;50:374-394.

11. Jorgenson, Andrew K. Population, affluence, and greenhouse gas emissions: The continuing significance of structural human ecology and the utility of STIRPAT. In Dietz, Thomas and Andrew Jorgenson (eds.), Structural Human Ecology: New Essays in Risk, Energy, and Sustainability. Pullman, WA., Washington State University Press; 2013.
12. Jorgenson, Andrew K, Thomas J. Burns. Effects of rural and urban population dynamics and network development on deforestation rates, 1990-2000. Sociological Inquiry. 2007a;77:460-482.
13. Canan, Penelope, Nancy Reichman. Ozone networks: Expert network in Global Environmental Governance. South Yorkshire, UK, Greenleaf; 2002.
14. Ostrom, Elinor. Understanding Institutional Diversity. Princeton, Princeton University Press; 2009a.
15. Commoner, Barry. The Closing Circle. New York, Knopf; 1971.
16. Commoner, Barry. Making peace with the planet. New York, The New Press; 1992.
17. Carson, Rachel. Silent Spring. Boston, Houghton Mifflin Harcourt; 1962.
18. Kick Edward L, Thomas J. Burns, Byron L. Davis, David A. Murray, Dixie A. Murray. Impacts of domestic population dynamics and foreign wood trade on deforestation: a world-system perspective. Journal of Developing Societies. 1996;12(1):68-87.
19. Burns Thomas J, Byron L. Davis, Edward L. Kick. Position in the world-system and national emissions of greenhouse gases. Journal of World-Systems Research. 1997; 3(3):432-466.
20. Jorgenson Andrew K, Thomas J. Burns. The political-economic causes of change in the ecological footprints of nations, 1991-2001: A quantitative investigation. Social Science Research. 2007b;36:834-853.
21. Malthus, Thomas R. An essay on the principle of population. London, J. Johnson; 1798.
22. Gerland Patrick, Adrian E. Raftery, Hana Ševčíková, Nan Li, Danan Gu, Thomas Spoorenberg, Leontine Alkema, Bailey K. Fosdick, Jennifer Chun, Nevena Lalic, Guiomar Bay, Thomas Buettner, Gerhard K. Heiling, John Wilmoth. World population stabilization unlikely this century. Science. 2014;346(6206):234-237.
23. Burns Thomas J. Marine pollution: The causes and scope of the problem. In George Ritzer and Chris Rojek (eds.), The Blackwell Encyclopedia of Sociology. New York, John Wiley & Sons; 2017.
24. Sachs, Jeffrey D. Are Malthus's Predicted 1798 Food Shortages Coming True?. Scientific American. September 1; 2008.
25. Dimick Dennis. As World's Population Booms, Will Its Resources Be Enough for Us?. National Geographic. September 21; 2014.
26. Bongaarts John. Demographic consequences of declining fertility. Science. 1998;282(5388):419-420.
27. Jones, Randall S. The economic implications of Japan's aging population. Asian Survey. 1988;28(9):958-969.
28. Muramatsu Naoko, Phyllis B. Mitzen, James R. Burton, Ahmad R. Djangi, Xinqi Dong, Nancy Flowers, Joseph T. Monahan, Andrew Teitelman. China's One Child Policy and U.S. Long Term Care. Journal of the American Geriatrics Society. 2016;64(9):61-62.
29. Bulte Erwin, Nico Heerink, Xiaobo Zhang. China's one-child policy and 'the mystery of missing women': Ethnic minorities and male-biased sex ratios. Oxford Bulletin of Economic & Statistics. 2010;73(1):21-39.
30. Angotti, Tom. Food systems and the urban-rural divide. Towards a Holistic Revolution in the 21st Century. Appetite. 2011;56(2):517.
31. Kalen Sam. Agriculture, food, and environmental policy. Natural Resources & Environment. 2011;26(1):3-7.
32. Bates, Diane C. Population, demography, and the environment. In Twenty Lessons in Environmental Sociology, Ed. By Kenneth Alan Gould and Tammy Lewis. New York, Oxford University Press. 2009;107-124.
33. Ogburn, William F. Handbook of sociology. New Delhi, Eurasia Pub. House; 1979.
34. Frederickson H. George. Confucius and the moral basis of bureaucracy. Administration & Society. 2002;33(6):610-628.
35. Parsons Talcott, Edward Shils. Toward a general theory of action. New York, Harper & Row; 1962.
36. Snow David A. Extending and broadening Blumer's conceptualization of symbolic interactionism. Symbolic Interaction. 2001; 24(3):367-377.
37. Mead, George H. The philosophy of the present. Chicago, Open Court; 1932.
38. Simmel Georg. Sociology: Inquiries into the construction of social forms. Leiden, Brill; 2009 [1908].

39. Sawyer, R. Keith. Emergence in sociology: Contemporary philosophy of mind and some implications for sociological theory. American Journal of Sociology. 2001; 107(3):551-585.
40. Purnomo, Eko Priyo, Anand PB, Jin-Wook Choi. The complexity and consequences of the policy implementation dealing with sustainable ideas. Journal of Sustainable Forestry. 2018;37(3):270-285.
41. Gray, Barbara, Jill M. Purdy, and Shahzad Ansari. From interactions to institutions: Microprocesses of framing and mechanisms for the structuring of institutional fields. Academy of Management Review. 2015;40(1):115-143.
42. Ostrom, Elinor. A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science. 2009b;325: 419-422.
43. North, Douglass C. Institutions. Journal of Economic Perspectives. 1991;5(1):97-112.
44. Bazerman, Max H, Andrew John Hoffman. Sources of environmentally destructive behavior: Individual, organizational and institutional perspectives. Research in Organizational Behavior. 2000;21:39-79.
45. Hoffman, Andrew J, Marc J. Ventresca. Organizations, policy and the natural environment: Institutional and strategic perspectives. Stanford, CA., Stanford University Press; 2002.
46. Jennings, P. Devereaux, Andrew John Hoffman. Institutional theory and the natural environment: Building research through tensions and paradoxes. in Greenwood, Royston, Christine Olivier, Thomas B. Lawrence, and Renate E. Meyer (eds.), The Sage Handbook of Organizational Institutionalism. London, Sage; 2017.
47. Pierson, Paul. American hybrid: Donald Trump and the strange merger of populism and plutocracy. The British Journal of Sociology. 2017;68(1):105-119.
48. Toumey, Chris. Science policy in the days of Trump. Nature Nanotechnology. 2017; 12(10):934-935.
49. Samet, Jonathan M, Thomas A. Burke, Bernard D. Goldstein. The trump administration and the environment-heed the science. The New England Journal of Medicine. 2017;376(12):1182-1188.
50. Dunlap, Riley E, Chenyang Xiao, Aaron M. McCright. Politics and environment in America: Partisan and ideological cleavages in public support for environmentalism. Environmental Politics. 2001;10(4): 23-48.
51. Dunlap, Riley E, Aaron M. McCright. Challenging climate change: The denial countermovement. In Dunlap, Riley and Robert J. Brulle (eds.), Climate Change and Society: Sociological Perspectives. NY, Oxford University Press; 2015.
52. Hironaka, Ann. The globalization of environmental protection: The case of environmental impact assessment. International Journal of Comparative Sociology. 2002;43(1):65-78.
53. Frank, David John, Ann Hironaka, Evan Schofer. The nation-state and the natural environment over the twentieth century. American Sociological Review. 2000;65(1): 96-116.
54. Bager, Alex, Carlos E. Borghi, Helio Secco. The influence of economics, politics, and environment on road ecology in South America. In Van der Ree, Rodney, Daniel J. Smith, and Clara Grilo (eds.), Handbook of road ecology. Chichester, West Sussex, Wiley Blackwell; 2015.
55. McCright, Aaron M, Riley E. Dunlap. The politicization of climate change and polarization in the American public's views of global warming, 2001–2010. The Sociological Quarterly. 2011;52(2):155-194.
56. Hirsch, Philip. Globalisation, regionalisation and local voices: The Asian Development Bank and rescaled politics of environment in the Mekong region. Singapore Journal of Tropical Geography. 2001;22(3):237-251.
57. Baek, Jungho, Won W. Koo. A dynamic approach to the FDI-environment nexus: the case of China and India. East Asian Economic Review. 2009;13(2):78-160.
58. Bäckstrand, Karin. Civic science for sustainability: Reframing the role of experts, policy-makers and citizens in environmental governance. Global Environmental Politics. 2003;3(4): 24-41.
59. Frank, David John, Wesley Longhofer, Evan Schofer. World society, NGOs and environmental policy reform in Asia. International Journal of Comparative Sociology. 2007;48(4):275-295.
60. Foster, John Bellamy. Marx's theory of metabolic rift: Classical foundations for environmental sociology. American journal of sociology. 1999;105(2):366-405.

61. Moore, Jason W. Environmental crises and the metabolic rift in world-historical perspective. Organization & Environment. 2000;13(2):123-157.
62. Castree, Noel. Commodifying what nature? Progress in Human Geography. 2003; 27(3):273-297.
63. Liverman, Diana. Who governs, at what scale and at what price? Geography, environmental governance, and the commodification of nature. Annals of the Association of American Geographers. 2004;94(4):734-738.
64. King, David A, William P. Stewart. Ecotourism and commodification: protecting people and places. Biodiversity & Conservation. 1996;5(3):293-305.
65. Kopnina, Helen. Commodification of natural resources and forest ecosystem services: Examining implications for forest protection. Environmental Conservation. 2017;44(1):24-33.
66. Barlow Maude, Tony Clarke. Excerpt from blue gold: The fight to stop the corporate theft of the world's water. In Caniglia, Beth S., Thomas J. Burns, Rachel M. Gurney, and Erik L. Bond (eds.), Rise of Environmental Consciousness: Voices in pursuit of a sustainable planet. San Diego, CA, Cognella; 2016.
67. Shiva, Vandana. Excerpt from stolen harvest. In Caniglia, Beth S., Thomas J. Burns, Rachel M. Gurney, and Erik L. Bond (eds.), Rise of Environmental Consciousness: Voices in pursuit of a sustainable planet. San Diego, CA., Cognella; 2016.
68. Perrow, Charles, Simone Pulver. Organizations and markets. In Dunlap, Riley and Robert J. Brulle (eds.), Climate Change and Society: Sociological Perspectives. NY, Oxford University Press; 2015.
69. Prechel, Harland, Lu Zheng. Corporate characteristics, political embeddedness and environmental pollution by large US corporations. Social Forces. 2012;90(3): 947-970.
70. Freudenburg, William R. Privileged access, privileged accounts: Toward a socially structured theory of resources and discourses. Social Forces. 2005;84(1):89-114.
71. Vasi, Ion Bogdan, Brayden G. King. Social movements, risk perceptions, and economic outcomes: The effect of primary and secondary stakeholder activism on firms' perceived environmental risk and financial performance. American Sociological Review. 2012;77(4):573-596.
72. Bansal, Pratima. Evolving sustainably: A longitudinal study of corporate sustainable development. Strategic Management Journal. 2005;26(3):197-218.
73. Niesten, Eva, Albert Jolink, Ana Beatriz Lopes de Sousa Jabbour, Maryse Chappin, and Rodrigo Lozano. Sustainable collaboration: The impact of governance and institutions on sustainable performance. Journal of cleaner production. 2017;155:1-6.
74. Chawla Louise, Debra Flanders Cushing. Education for strategic environmental behavior. Environmental Education Research. 2007;13(4):437-452.
75. Hungerford, Harold R, Trudi L. Volk. Changing learner behavior through environmental education. The Journal of Environmental Education. 1990;21(3):8-21.
76. Tilbury, Daniella. Environmental education for sustainability: Defining the new focus of environmental education in the 1990s. Environmental Education Research. 1995; 1(2):195-212.
77. Otto, Siegmar, Pamela Pensini. Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behaviour. Global Environmental Change. 2017;47:88-94.
78. Evans, Gary W, Siegmar Otto, Florian G. Kaiser. Childhood origins of young adult environmental behavior. Psychological Science. 2018;29(5):679-687.
79. Cobb, John B. Is it too late? The theology of ecology. Denton, TX, Environmental Ethics Books; 1995.
80. Bube, Paul Custodio. Ethics in John Cobb's Process Theology. Atlanta, Scholars Press; 1988.
81. Burns, Thomas J. Reconsidering Scripture in Late Industrial Society: Religious Traditions and the Natural Environment. In Caniglia, Beth S., Thomas J. Burns, Rachel M. Gurney, and Erik L. Bond (eds.), Rise of Environmental Consciousness: Voices in pursuit of a sustainable planet. San Diego, Cognella; 2016
82. White, Lynn. The historical roots of our ecologic crisis. Science. 1967;155(3767): 1203-1207.
83. Hitzhusen, Gregory E. Judeo-Christian theology and the environment: Moving beyond scepticism to new sources for

environmental education in the United States. Environmental Education Research. 2007;13(1):55-74.
84. Hekmatpour, Peyman, Thomas J. Burns, Tom W. Boyd. Is Islam pro-or anti-environmental? Interpretations and implications. Journal of Asian Research. 2017;1(1):92-110.
85. Francis, Pope. Laudato Si: On care for our common home. Vatican City, Libreria Editrice Vaticana; 2015.
86. Schultz, P. Wesley, Lynnette Zelezny, Nancy J. Dalrymple. A multinational perspective on the relation between Judeo-Christian religious beliefs and attitudes of environmental concern. Environment and Behavior. 2000;32(4):576-591.
87. Hand, Carl M, Kent D. Van Liere. Religion, mastery-over-nature, and environmental concern. Social Forces. 1984;63(2):555-570.
88. Eckberg, Douglas Lee, Jean Blocker T. Christianity, environmentalism, and the theoretical problem of fundamentalism. Journal for the Scientific Study of Religion. 1996;35(4):343-355.
89. Hayes B, Marangudakis M. Religion and environmental issues among Anglo-American democracies. Review of Religious Research. 2001;42(2):159-174.
90. Kanagy Conrad L, Hart M. Nelsen. Religion and environmental concern: Challenging the dominant assumptions. Review of Religious Research. 1995;37(1): 33-45.
91. Wolkomir Michelle, Michael Futreal, Eric Woodrum, Thomas Hoban. Substantive religious belief and environmentalism. Social Science Quarterly. 1997;78(1):96-108.
92. Dwivedi OP. Satyagraha for conservation: A Hindu view. In Pojman, Louis P. (Ed) Environmental Ethics: Readings in Theory and Application. Belmont, CA., Wadsworth/ Thomson; 2005.
93. Narayanan, Vasudha. Water, wood, and wisdom: Ecological perspectives from the Hindu traditions. Daedalus. 2001;130(4): 179-206.
94. Bond, Erik. Native voices, the indigenous view of environmentalism: Tribe, nature, and kinship. In Caniglia, Beth S., Thomas J. Burns, Rachel M. Gurney, and Erik L. Bond (eds.), Rise of Environmental Consciousness: Voices in pursuit of a sustainable planet. San Diego, Cognella; 2016.
95. Gifford Robert, Andreas Nilsson. Personal and social factors that influence pro-environmental concern and behaviour: A review. International Journal of Psychology. 2014;49(3):141-157.
96. Bhuian, Shahid Nakib, Sujeet Kumar Sharma, Irfan Butt, Zafar U. Ahmed. Antecedents and pro-environmental consumer behavior (PECB): the moderating role of religiosity. Journal of Consumer Marketing. 2018;35(3):287-299.
97. Snow, David A, Robert D. Benford. Ideology, frame resonance, and participant mobilization. International Social Movement Research. 1988;1(1):197-217.
98. Brulle, Robert J, Robert D. Benford. From game protection to wildlife management: Frame shifts, organizational development, and field practices. Rural Sociology. 2012; 77(1):62-88.
99. Caniglia, Beth Schaefer, Robert J. Brulle, and Andrew Szasz. Civil society, social movements, and climate change. In Dunlap, Riley and Robert J. Brulle (eds.), Climate Change and Society: Sociological Perspectives. NY, Oxford University Press; 2015.
100. Burns, Thomas J, Terri LeMoyne. How environmental movements can be more effective: Prioritizing environmental themes in political discourse. Human Ecology Review. 2001;8(1):26-38.
101. Aldy, Joseph E. Real world headwinds for Trump climate change policy. Bulletin of the Atomic Scientists. 2017;73(6):376-381.
102. Rosner, David. Health, Climate Change, and the Descent of Science-Based Policy. The Milbank Quarterly. 2017;95(1):36-39.
103. Lee, Francis LF. Internet, citizen self-mobilisation, and social movement organisations in environmental collective action campaigns: Two Hong Kong cases. Environmental Politics. 2015;24(2):308-325.
104. Pang, Natalie, Pei Wen Law. Retweeting# world environment day: A study of content features and visual rhetoric in an environmental movement. Computers in Human Behavior. 2017;69:54-61.
105. Harlan, Sharon L, David N. Pellow, J. Timmons Roberts, Shannon Elizabeth Bell, William G. Holt, Joane Nagel. Climate justice and inequality. In Dunlap, Riley and Robert J. Brulle (eds.), Climate Change and Society: Sociological Perspectives. NY., Oxford University Press; 2015.

106. Brulle, Robert J, David N. Pellow. Environmental justice: Human health and environmental inequalities. Annu. Rev. Public Health. 2006;27:103-124.
107. Pellow, David Naguib, Robert J. Brulle, Eds. Power, Justice, and the Environment: a Critical Appraisal of the Environmental Justice Movement. Cambridge, MA., MIT Press; 2005.
108. Martinez-Alier, Joan, Leah Temper, Daniela Del Bene, Arnim Scheidel. Is there a global environmental justice movement?. The Journal of Peasant Studies. 2016; 43(3):731-755.
109. Salmón, Enrique. Kincentric ecology: Indigenous perceptions of the human-nature relationship. Ecological Applications. 2000;10(5):1327-1332.
110. Marx, Karl. Economic and Philosophic Manuscripts of 1844. Moscow, Progress Publishers; 1982 [1932].
111. Marx Karl, Friedrich Engels. The communist manifesto. London, Penguin; 1967 [1848].
112. Marx, Karl. Capital: A critique of political economy. London, Lawrence & Wishart; 1977 [1867].
113. Burns Thomas J, Thomas K. Rudel. Meta-theorizing structural human ecology at the dawn of the third millennium. Human Ecology Review. 2015;22(1):13-33.
114. Edwards Bob, Anthony E. Ladd. Environmental justice, swine production and farm loss in North Carolina. Sociological Spectrum. 2000;20(3):263-290.
115. Catton, William R. Jr. Overshoot: The ecological basis of revolutionary change. Urbana, Univ. of Illinois Press; 1980.
116. Buttel, Frederick H. Social Institutions and Environmental Change. In the international handbook of environmental sociology, Edited by M. R. Redclift and Graham Woodgate. Cheltenham / Northampton, Edward Elgar. 1997;83-96.
117. Colborn, Theo, Dianne Dumanoski, John Peterson Myers, Margaret Murden. Our stolen future: Are we threatening our fertility, intelligence, and survival?: A scientific detective story. New York, Penguin; 1997.
118. Homer-Dixon, Thomas F. Environment, scarcity, and violence. Princeton, Princeton University Press; 1992.
119. Diamond, Jared. Collapse: How Societies Choose to Fail or Succeed. New York, Viking; 2005.
120. Wildcat, Daniel R. Red Alert! Saving the planet with indigenous knowledge. Golden, CO., Fulcrum Publishing; 2009.
121. Louv, Richard. Last child in the woods: Saving our children from nature deficit disorder. Chapel Hill, NC, Algonquin Books; 2008.
122. Muir, John. The wild parks and forest reservations of the west. Our National Parks. 1898;1-4.
123. Rybczynski, Witold. A clearing in the distance: Frederick Law Olmsted and America in the 19th century. New York, Simon and Schuster; 1999.
124. Hughes, J. Donald. An environmental history of the world: Humankind's changing role in the community of life. 2nd ed. New York, Routledge; 2009.
125. Gardner, Toby A, Jos Barlow, Navjot S. Sodhi, Carlos A. Peres. A multi-region assessment of tropical forest biodiversity in a human-modified world. Biological Conservation. 2010;143(10):2293-2300.
126. Laurance WF. Averting biodiversity collapse in tropical forest protected areas. Nature. 2012;489(7415):290-294.
127. Carr, David. Population and deforestation: Why rural migration matters. Progress in Human Geography. 2009;33(3):355-378.
128. Delang, Claudio O. The political ecology of deforestation in Thailand. Geography. 2005:90(3):225-237.
129. Ellis, Erle C, Navin Ramankutty. Putting people in the map: Anthropogenic biomes of the world. Frontiers in Ecology and the Environment. 2008;6(8):439-447.
130. Rudel, Thomas K, Jill Roper. The paths to rainforest destruction. World Development. 1997;25:53–65.
131. Kareiva Peter, Sean Watts, Robert McDonald, Tim Boucher. Domesticated nature: Shaping landscapes and ecosystems for human welfare. Science. 2007;316:1866–1869.
132. Bradshaw, Corey JA, Navjot S. Sodhi, Barry W. Brook. Tropical turmoil: A biodiversity tragedy in progress. Front. Ecol. Environ. 2009;7:79–87.
133. Wittemyer, George, Paul Elsen, William T. Bean, Coleman O. Burton, Justin S. Brashares. Accelerated human population growth at protected area edges. Science. 2008;321:123–126.
134. Harvey, Celia A, Oliver Komar, Robin Chazdon, Bruce G. Ferguson, Bryan Finegan, Daniel M. Griffith, Miguel Martínez-Ramos, Helda Morales, Ronald

Nigh, Lorena Soto-Pino, Michiel Van Breugel, Mark Wishnie. Integrating agricultural landscapes with biodiversity conservation in the Mesoamerican hotspot. Conservation. Biology. 2008;22:8–15.
135. Gardner, Toby A, Jos Barlow, Robin Chazdon, Robert M. Ewers, Celia A. Harvey, Carlos A. Peres, Navjot S. Sodhi. Prospects for tropical forest biodiversity in a human-modified world. Ecology Letters. 2009;12(6):561-582.
136. Ambrose, Stanley H. Paleolithic technology and human evolution. Science. 2001: 291(5509):1748-1753.
137. Ruttan, Vernon W. Technology and the Environment. American Journal of Agricultural Economics. 1971;53(5):707-717.
138. Bijker, Wiebe E, Thomas P. Hughes, Trevor Pinch, Deborah B. Douglas. The social construction of technological systems: New directions in the sociology and history of technology. Cambridge, MIT Press; 2012.
139. Pinch, Trevor, Wiebe Bijker. Science, relativism and the new sociology of technology: Reply to Russell. Social studies of science. 1986;16(2):347-360.
140. Volkov, Heinrich N, Paul Grigorieff. Society in the technical age. Diogenes. 1966; 14(55):16-27.
141. Burns, Thomas J, Andrew K. Jorgenson. Technology and the environment. In Bryant, Clifton D., and Dennis L. Peck (eds.), 21st Century Sociology: A Reference Handbook. Thousand Oaks, CA, Sage; 2007
142. Golding, Edward J. A history of technology and environment: From stone tools to ecological crisis. London; New York, Routledge; 2017.
143. Quinn, Roswell. Rethinking antibiotic research and development: World War II and the penicillin collaborative. American journal of public health. 2013;103(3):426-434.
144. Baicus, Anda. History of polio vaccination. World Journal of Virology. 2012;1(4):108.
145. Kardos Nelson, Arnold L. Demain. Penicillin: The medicine with the greatest impact on therapeutic outcomes. Applied Microbiology and Biotechnology. 2011; 92(4):677.
146. Wajcman, Judy. Life in the fast lane? Towards a sociology of technology and time. The British Journal of Sociology. 2008;59(1):59-77.
147. Bowers, Chet A. The paradox of technology: What's gained and lost? Thought and Action. 1998;14(1):49-57.
148. Schnaiberg, Allan. The environment: From surplus to scarcity. New York, Oxford University Press; 1980.
149. O'Connor, James. On the two contradictions of capitalism. Capitalism Nature Socialism. 1991;2(3):107-109.
150. O'Connor, James. Natural causes: Essays in ecological Marxism. New York, Guilford; 1998.
151. Liu, Yansui, Yang Zhou, Wenxiang Wu. Assessing the impact of population, income and technology on energy consumption and industrial pollutant emissions in China. Applied Energy. 2015; 155:904-917.
152. Yin, Jianhua, Mingzheng Zheng, Jian Chen. The effects of environmental regulation and technical progress on CO2 Kuznets curve: Evidence from China. Energy Policy. 2015;77:97-108.
153. Napp TA, Gambhir A, Hills TP, Florin N, Fennell PS. A review of the technologies, economics and policy instruments for decarbonising energy-intensive manufacturing industries. Renewable and Sustainable Energy Reviews. 2014;30: 616-640.
154. Horbach, Jens, Christian Rammer, Klaus Rennings. Determinants of eco-innovations by type of environmental impact—the role of regulatory push/pull, technology push and market pull. Ecological Economics. 2012;78:112-122.
155. Freire-González Jaume, Ignasi Puig-Ventosa. Energy efficiency policies and the Jevons paradox. International Journal of Energy Economics and Policy. 2015;5(1): 69.
156. Amado, Nilton Bispo, Ildo L. Sauer. An ecological economic interpretation of the Jevons effect. Ecological Complexity. 2012;9:2-9.
157. Vivanco, David Font, Will McDowall, Jaume Freire-González, René Kemp, Ester van der Voet. The foundations of the environmental rebound effect and its contribution towards a general framework. Ecological Economics. 2016;125:60-69.
158. Jevons, William S. The coal question. London, Macmillan and Co.; 1865.
159. Alcott, Blake. "Jevons' paradox." Ecological economics. 2005;54(1):9-21.
160. Gunderson, Ryan, Sun-Jin Yun. South Korean green growth and the Jevons

paradox: An assessment with democratic and degrowth policy recommendations. Journal of Cleaner Production. 2017;144: 239-247.
161. Tal, Alon. Overcoming Jevons paradox: Improving the sustainability of Israel's transportation policies. Environ Pollut Climate Change. 2017;1(4):139-150.
162. Clark, Judy, Philip Lowe. Cleaning up agriculture: Environment, technology and social science. Sociologia Ruralis. 1992; 32(1):11-29.
163. Pilon-Smits, Elizabeth AH, John L. Freeman. Environmental cleanup using plants: Biotechnological advances and ecological considerations. Frontiers in Ecology and the Environment. 2006;4(4): 203-210.
164. Fujishima Akira, Xintong Zhang, Donald A. Tryk. Heterogeneous photocatalysis: from water photolysis to applications in environmental cleanup. International Journal of Hydrogen Energy. 2007;32(14): 2664-2672.
165. Tratnyek, Paul G, Richard L. Johnson. Nanotechnologies for environmental cleanup. Nano Today. 2006;1(2):44-48.
166. Singh, Shailendra, Seung Hyun Kang, Ashok Mulchandani, Wilfred Chen. Bioremediation: Environmental clean-up through pathway engineering. Current opinion in biotechnology. 2008;19(5):437-444.
167. Van Aken, Benoit. Transgenic plants for phytoremediation: Helping nature to clean up environmental pollution. Trends in biotechnology. 2008;26(5):225-227.
168. Ibañez, Sabrina, Melina Talano, Ornella Ontañon, Jachym Suman, María I. Medina, Tomas Macek, Elizabeth Agostini. Transgenic plants and hairy roots: Exploiting the potential of plant species to remediate contaminants. New biotechnology. 2016;33(5):625-635.
169. Nesse, Randolph M, George C. Williams. Why we get sick: The new science of Darwinian medicine. New York, Vintage; 1994.
170. Darwin, Charles. On the Origin of Species. New York, Sterling; 2008 [1859].
171. Williams, George C. Adaptation and Natural Selection; a Critique of Some Current Evolutionary Thought. Princeton, NJ., Princeton University Press; 1966.
172. Dawkins, Richard. The Selfish Gene. Oxford, Oxford University Press; 2016 [1976].
173. Godfrey-Smith, Peter. Philosophy of Biology. Princeton, Princeton University Press; 2016.
174. Koh, Lian Pin, Robert R. Dunn, Navjot S. Sodhi, Robert K. Colwell, Heather C. Proctor, and Vincent S. Smith. Species coextinctions and the biodiversity crisis. Science. 2004;305(5690):1632-1634.
175. Steingraber, Sandra. Living downstream: an ecologist looks at cancer and the environment. London, Virago; 1998.
176. Steingraber, Sandra. Living downstream: A scientist's personal investigation of cancer and the environment. 2nd ed. Philadelphia, DaCapo; 2010 [1977].
177. McCormick, Sabrina. The sociology of environmental health. In Gould, Kenneth A. and Tammy L. Lewis. (eds.), Twenty Lessons in Environmental Sociology. New York, Oxford University Press; 2009.
178. Purvis, Andy, Paul-Michael Agapow, John L. Gittleman, Georgina M. Mace. Nonrandom extinction and the loss of evolutionary history. Science. 2000; 288(5464): 328-330.
179. Rook, Graham A. Regulation of the immune system by biodiversity from the natural environment: An ecosystem service essential to health. Proceedings of the National Academy of Sciences. 2013; 110(46):18360-18367.
180. Bowler, Diana E, Lisette M. Buyung-Ali, Teri M. Knight, Andrew S. Pullin. A systematic review of evidence for the added benefits to health of exposure to natural environments. BMC Public Health. 2010;10(1):456.
181. Barton Jo, Jules Pretty. What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. Environmental Science & Technology. 2010;44(10):3947-3955.
182. Björk Jonas, Maria Albin, Patrik Grahn, Hanna Jacobsson, Jonas Ardö, John Wadbro, Per-Olof Östergren, Erik Skärbäck. Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. Journal of Epidemiology & Community Health. 2008; 62(4):62-69.
183. Mitchell Richard, Frank Popham. Effect of exposure to natural environment on health inequalities: An observational population study. The Lancet. 2008;372(9650):1655-1660.

184. Frumkin, Howard. Beyond toxicity: Human health and the natural environment. American Journal of Preventive Medicine. 2001;20(3):234-240.
185. Minkler Meredith, Victoria Breckwich Vásquez, Peggy Shepard. Promoting environmental health policy through community based participatory research: A case study from Harlem, New York. Journal of Urban Health. 2006;83(1):101-110.
186. Newman, Richard S. Love canal: A toxic history from colonial times to the present. New York, Oxford University Press; 2016.
187. Reed, Jennifer. Love canal. Philadelphia, Chelsea House; 2002.
188. Gibbs, Lois. Love Canal: My story. Albany, State University of New York Press; 1982.
189. Gibbs, Lois. Citizen activism for environmental health: The growth of a powerful new grassroots health movement. The Annals of the American Academy of Political and Social Science. 2002;584(1): 97-109.
190. Switzer, Jacqueline Vaughn. Environmental activism: A reference handbook. Gurgaon, Shubhi Publications; 2005.
191. Kroeber, Alfred Louis, and Clyde Kluckhohn. Culture: A critical review of concepts and definitions. Papers. Peabody Museum of Archaeology & Ethnology, Harvard University. 1952;47(1):223.
192. Herskovits, Melville J. Economic anthropology; a study in comparative economics. New York, Knopf; 1952.
193. Berger, Peter L. The sacred canopy; Elements of a sociological theory of religion. Garden City, NY, Doubleday; 1967.
194. Berger, Peter L, Thomas Luckmann. The social construction of reality. London, the Penguin Press; 1967.
195. Burns, Thomas J. Culture and the Natural Environment. In Alpina Begossi and Priscila F. Lopes (eds.), Current Trends in Human Ecology. Newcastle upon Tyne, U.K., Cambridge Scholars Press; 2009.
196. Wuthnow, Robert. Meaning and moral order: Explorations in cultural analysis. Berkeley, University of California Press; 1987.
197. Handel, Warren. Ethnomethodology: How people make sense. Englewood Cliffs, NJ., Prentice Hall; 1982.
198. Altman Irwin, Martin M. Chemers. Culture and environment. Cambridge, Cambridge Univ. Press; 1993.
199. Taylor, Charles. Two theories of modernity. The International Scope Review. 2001; 3(5): 1-9.
200. Weber, Max. The protestant ethic and the spirit of capitalism. London, Unwin; 1985 [1904].
201. Weber, Max. Economy and Society: An Outline of Interpretive Sociology, 2 vols. Edited by G, Roth and C. Wittich. Berkeley and Los Angeles, University of California Press. 1978 [1921].
202. Hopper, Paul. Understanding cultural globalization. Cambridge, UK., Polity; 2012.
203. Ritzer, George. McDonaldization: Chicago, America, the World. Thousand Oaks, Sage; 2003.
204. DiMaggio, Paul J, Walter W. Powell. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. In Powell, Walter W. The New Institutionalism in Organizational Analysis. Chicago, University of Chicago Press; 2010.
205. Shrader-Frechette, Kristin. Individualism, holism, and environmental ethics. Ethics and the Environment. 1996;1(1):55-69.
206. Hardin, Garret. The tragedy of the commons. Science. 1968:162(3859): 1243-1248.
207. Coleman, James S. The asymmetric society. Syracuse, NY, Syracuse University Press; 1992.
208. York, Richard. Metatheoretical foundations of post-normal prediction. In Dietz, Thomas and Andrew Jorgenson (eds.), Structural Human Ecology: New Essays in Risk, Energy, and Sustainability. Pullman, WA., Washington State University Press; 2013.
209. Gould, Stephen J. Ever since darwin. New York, Norton; 1992.
210. Bonnett, Michael. Normalizing catastrophe: Sustainability and scientism. Environmental Education Research. 2013; 19(2):187-197.
211. Ogburn, William F. Social change with respect to culture and original nature. New York, Viking Press; 1927.
212. Ogburn, William. The hypothesis of cultural lag. In Parsons, Talcott., Edward Shils, Kaspar D. Naegele and Jesse R. Pitts. (eds.), Theories of Society: foundations of modern sociological theory. New York, Free Press; 1961 [1932].

213. McNeill, John Robert. Something new under the sun: An environmental history of the twentieth-century world. New York, W.W. Norton; 2000.
214. Freud, Sigmund. On Narcissism: an Introduction. New Haven, Yale University Press; 1991 [1914].
215. Lasch, Christopher. The culture of narcissism: American life in an age of diminishing expectations. New York, Warner Books; 1979.
216. Durkheim, Emile. The division of labor in society. New York, Free Press; 1964 [1893].
217. Fromm, Erich. The sane society. New York, Rinehart; 1955.
218. Adger, W. Neil, Jon Barnett, Katrina Brown, Nadine Marshall, Karen O'brien. Cultural dimensions of climate change impacts and adaptation. Nature Climate Change 2013;3(2):112-117.
219. Johnson, Lenore M. Knight. Strangers in their own land: Anger and mourning on the American right. Christian Scholar's Review. 2017;47(1):85-89.
220. Hochschild, Arlie R. Strangers in their own land: Anger and mourning on the American right. New York, the New Press; 2016.
221. Burns, Thomas J. Rhetoric as a framework for analyzing cultural constraint and change. Current Perspectives in Social Theory. 1999;19:165-186.
222. Hochschild, Arlie Russell. A response to William Davies' "A review of Arlie Russell Hochschild's strangers in their own land: Anger and Mourning on the American Right (2016: New York: New Press, 351 pp)". International Journal of Politics, Culture, and Society. 2017;30(4):421-423.
223. Antonio, Robert J. Climate Change, the Resource Crunch, and the Global Growth Imperative. In Current Perspectives in Social Theory, edited by Harry F. Dahms. Bingley, UK, Emerald. 2009;3-73.
224. Wallerstein, Immanuel. The modern world-system: Capitalist agriculture and the origins of the european world-economy in the sixteenth century. New York, Academic Press; 1974.
225. Frank, Andre Gunder. Dependent accumulation and underdevelopment. New York, Monthly Review Press; 1978.
226. Bunker, Stephen G. Modes of extraction, unequal exchange, and the progressive underdevelopment of an extreme periphery: The Brazilian Amazon, 1600-1980. American Journal of Sociology. 1984;89(5):1017-1064.
227. Kuznets, Simon. Economic Growth and Income Inequality. American Economic Review. 1955;45(1):1-28.
228. Torras, Mariano, James K. Boyce. Income, inequality, and pollution: A reassessment of the environmental Kuznets curve. Ecological Economics. 1998;25(2):147-160.
229. Wackernagel, Mathis, William Rees. Our ecological footprint: Reducing human impact on the environment. Gabriola Island, BC, Canada, New Society Publishers; 1996.
230. Jorgenson, Andrew K. Uneven processes and environmental degradation in the world economy. Human Ecology Review. 2004;11:103-113.
231. Leonard, H. Jeffrey. Pollution and the struggle for the world product: Multinational corporations, environment, and international comparative advantage. Cambridge, Cambridge University Press; 2006.
232. Moore, Jason W. Capitalism in the web of life: Ecology and the accumulation of capital. London, Verso; 2015.
233. Foster, John Bellamy, Brett Clark, and Richard York. The ecological rift: capitalism's war on the Earth. New York, Monthly Review Press; 2011.
234. Jorgenson, Andrew K. Unequal ecological exchange and environmental degradation: A theoretical proposition and cross-national study of deforestation, 1990-2000. Rural Sociology. 2006;71(4):685-712.
235. Sanderson, Matthew R, Scott Frey R. From desert to breadbasket … to desert again? A metabolic rift in the high plains aquifer. Journal of Political Ecology. 2014; 21:516-532.
236. Clausen, Rebecca, Brett Clark. The metabolic rift and marine ecology: An analysis of the ocean crisis within capitalist production. Organization & Environment. 2005;18(4):422-444.
237. Bullard, Robert. Dumping in Dixie: Race, class, and environmental quality. 3rd ed. Boulder, Westview; 2000.
238. Pellow, David N. Resisting global toxics: Transnational movements for environmental justice. Cambridge, MA., MIT Press; 2007.
239. Brown, Phil. Toxic exposures: Contested illnesses and the environmental health

movement. New York, Columbia Univ. Press; 2007.
240. Crowder, Kyle, Liam Downey. Interneighborhood migration, race, and environmental hazards: Modeling microlevel processes of environmental inequality. American Journal of Sociology. 2010;115(4):1110–1149.
241. Elliott, James R, Scott Frickel. The historical nature of cities: A study of accumulation and hazardous waste accumulation. American Sociological Review. 2013;78:521–543.
242. Grant, Don, Mary Nell Trautner, Liam Downey, and Lisa Thiebaud. Bringing the polluters back in: Environmental inequality and the organization of chemical production. American Sociological Review. 2010;75(4):479–504.
243. Heinberg, Richard. The end of growth: Adapting to our new economic reality. Gabriola Island, Canada, New Society; 2011.
244. Crutzen, Paul J. Human impact on climate has made this the 'Anthropocene age'. New Perspectives Quarterly. 2005;22(2): 14-16.
245. Meadows, Donella H, Jorgen Randers, Dennis L. Meadows. Limits to growth: The 30- year update. White River Junction, VT., Chelsea Green; 2004.
246. Clark, Brett, John Bellamy Foster. Ecological imperialism and the global metabolic rift: Unequal exchange and the guano/nitrates trade. International Journal of Comparative Sociology. 2009;50(3-4): 311-334.
247. Ponting, Clive. A new green history of the world: The environment and the collapse of great civilizations. Rev. Ed. New York, Penguin; 2007.
248. Schumacher EF. Small is beautiful: Economics as if people mattered. New York, Harper; 2010.
249. Cobb, John B. Economics of planetism: The coming choice. Earth Ethics. 1991; 3(1):1–3.
250. Walker, Brian, David Salt. Resilience thinking: Sustaining ecosystems and people in a changing world. Washington, D.C., Island Press; 2006.
251. Gille, Zsuzsa. Actor networks, modes of production, and waste regimes: Reassembling the macro-social. Environment and Planning A. 2010;42(5): 1049-1064.
252. Ridley, Matt, Bobbi Low. Can selfishness save the environment? Human Ecology Review. 1994;1(1):1–13.
253. Ostrom, Elinor. Governing the commons: The evolution of institutions for collective action. Cambridge, UK, Cambridge Univ. Press; 1990.
254. Caniglia, Beth S, Thomas J. Burns, Rachel M. Gurney, Erik L. Bond. Rise of environmental consciousness: Voices in Pursuit of a Sustainable Planet. San Diego, Cognella; 2016.
255. Bunker, Stephen G, Paul S. Ciccantell. Globalization and the race for resources. Baltimore, Johns Hopkins University Press; 2005.
256. Hunter, Lori M. The environmental implications of population dynamics. Santa Monica, CA., Rand Corporation; 2000.
257. York, Richard, Eugene A. Rosa, Thomas Dietz. STIRPAT, IPAT and ImPACT: Analytic tools for unpacking the driving forces of environmental impacts. Ecological Economics. 2002;46(3):351.
258. York, Richard, Eugene A. Rosa, Thomas Dietz. Footprints on the earth: The environmental consequences of modernity. American Sociological Review. 2003;68(2): 279-30
259. Nash, Linda. Inescapable Ecologies: A History of Environment, Disease, and Knowledge. Berkeley, CA., University of California Press; 2007.
260. Mitchell, Misha. Cries from the CAFOs: A case for environmental ethics. Journal of the Legal Profession. 2014; 39(1):67-85.