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Break the cycle of environmental degradation: A commentary

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Abstract

Humans have unique abilities among all other living creatures. They have the ability to move about in many different ways and in many different terrains. They have the power of making choices. They have the ability to think ahead and plan ahead. They have the ability to make use of objects in their environment to assist them in their quests. Collectively they have the ability and power to dominate and modify their environment and other living creatures in the environment to advance their causes. They have the ability and power to harness natural resources and energy and interact collectively to change the world they live in. They are able to see and assess the consequences of their actions and take action to make necessary changes on what they have found or have done. This collection of characteristics makes them powerful, formidable and dangerous. In the context of this exploration we will marvel at their achievements, celebrate their undeniably exceptional advances, and examine the destructive environmental consequences of their actions, some unanticipated and some ignored. In this commentary, we will look at a local microcosm that illustrates the consequences of environmental neglect and abuse and its inevitable impact on human health, and the subsequent realization and revitalization by collective community action. We will cover a brief history of human habitation on the planet and the associated environmental degradation, accompanied by what has been done to address the process, and recommend a, constructive approach to breaking the cycle of environmental degradation toward the promise of a positive future for our planet in good ecological balance with health and well-being for generations to come.

Introduction

This commentary was inspired by a symposium entitled 'Envisioning community based solutions to environmental health disparities' held during the 13th Annual Break the Cycle of Children's Environmental Health Disparities Conference in Atlanta, Georgia, in April 2018. The symposium focused on a waterway in

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northwest Atlanta called Proctor Creek. The Proctor Creek area was once a pristine site with clean, clear water, rich with natural flora and fauna. The creek had once been the source of food, recreation, and pride for the local community but, over time, through economic, social, cultural and political neglect, the community became impoverished, houses and neighborhoods fell into disrepair, and the creek became polluted with sewage runoff, bacteria, chemicals and debris to the extent that it was no longer a source of pride, but of shame.

After many years of tireless grass-roots, collective community effort and advocacy, positive change eventually came from many different social, economic and political trajectories. Urban flight reversed and was replaced by urban renewal, awareness of the impact of the natural and built environment grew, and collaboration among local residents, citizen's advocacy groups, university schools of public health, the business community and political representatives proliferated. These collective forces came together to clean up the area and restore it to its former source of pleasure and pride (1). Although this scenario is local to the Atlanta area, it is representative of similar scenarios and patterns that currently play out in many cities and towns in the United States (US) and around the world offering a lesson on how to break the cycle of environmental degradation.

This commentary will attempt to briefly review our human history of settlement on this planet, with our tendency for exploitation and abuse of our environment, examining critical events in our recent past that have been transformative in breaking the cycle of environmental degradation and reclaiming a clean and healthy environment for ourselves, for future generations and for the ecological balance of our planet.

Proctor Creek

Proctor Creek is a watershed fed by many minor tributaries before it joins the Chattahoochee River, which is a tributary of the Apalachicola River, a relatively short river formed by the confluence of the Chattahoochee and Flint rivers, emptying from Florida into Apalachicola Bay in the Gulf of Mexico. The modern settlement of the Proctor Creek area was comprised predominantly of African American families in the early part of the 20th Century on the west side of the growing and bustling city of Atlanta. By mid-Century, the west side of Atlanta had evolved into a culturally rich African American community, home to the largest complex of historically black colleges and universities in the Southeast US. This area was also a major focal point in the Civil Rights Movement of the 1950s and 1960s with a lengthy list of notable leaders who have called the watershed home, including WEB Dubois, Dr Martin Luther King, Jr, Maynard Jackson, and Julian Bond (2).

With the dramatic growth of the city of Atlanta in the last quarter of the 20th Century, and the associated changes in economics and demographics, infrastructural challenges in dealing with sources of water and sewage disposal had to keep pace with the growth. As has been the case with so many human settlements, the use of natural waterways has been co-opted to serve the interests of the settlements, not only as a source for personal and collective consumption of water and, in places, the irrigation of crops, but also for the disposal of wastes and, in the case of larger waterways, the transportation of goods. Proctor Creek, being a relatively small waterway, was not suited to transportation of cargo but was inevitably used for the disposal of sewage and other debris of human settlement. As the city of Atlanta grew, especially from the late 1970s, and more dramatically after the Olympic Games in the mid-1990s, so did the amount of waste that was channeled into the Creek, resulting in increasing pollution including human waste, particularly enterocolic pathogens. Although sewage treatment plants were developed, they had limited capacity, with the consequence that major storms often created overflow from the sewage systems into the combined drainage systems, and the contamination of the Creek continued and accumulated (3).

Over time, with changing demographics associated with political, economic and environmental forces, Proctor Creek neighborhoods experienced advancing impoverishment. Progressive contamination of the waterways caused by neglect and abuse of the area, with increased illegal dumping of refuse into the waters the Creek and its tributaries, worsened the environmental degradation. The

accumulation of trash coupled with the bacterial contamination and pollution of the water contributed to the degradation of the neighborhoods and their communities. People who could leave did, while those who remained experienced increasing poverty with limited resources. As happens in many poor and unpoliced neighborhoods, the houses fell into disrepair to the point of becoming uninhabitable, with the void filled by the socially destructive combination of drugs, prostitution and crime. As a consequence, not only was the land and water polluted, but the built environment and the culture became a toxic mix of dystopian elements. Proctor Creek neighborhoods and communities became unhealthy and unsafe. Not only were the dwelling structures in disrepair, but the tax base was depleted, leading inevitably to the compromise of the institutions that support the growth and development of children such as schools and other cultural community centers. The resultant effect on the children was a substantial undermining of their opportunities to learn, which compromised their opportunities for gainful employment in the future.

By 2010, the population in the area around Proctor Creek was greater than 13,000, over 80% of whom were African American. A Health Impact Assessment for the County performed by the Region 4 of the US Environmental Protection Agency (EPA) (3) revealed that the most common emergency room visits for adults were for mental and behavior disorders, asthma and assault, with the most common causes of death being hypertension, mental and behavior disorders and human immunodeficiency virus (HIV)/ acquired immune deficiency syndrome (AIDS). For children, emergency room visits were most often for unintentional injury (3).

As happens with low income, minority and often disenfranchised communities, there is limited social and political capital, so desires and attempts by the local communities to make changes and improve the situation through an appeal to local municipalities and government often go unheeded and even unanswered. As a result, not only is the situation perpetuated, but aggravated, resulting a spiral of physical degradation along with social and emotional despondence and despair, that perpetuates the cycle of environmental health disparities across generations (4).

Fortunately, human beings are endowed with innate qualities of resilience and determination to survive and to care for their young (5). For Proctor Creek communities, this was manifest in local citizens coming together to advocate for positive change, for a cleaner and healthier living space. Over the course of years, advocacy groups grew in number, size and influence, and connected with universities and businesses to make significant progress in reaching relevant organizations and members of the Atlanta business community as well as local political representatives (1). This collective action has resulted in ongoing revitalization of the Proctor Creek watershed, along with other major gentrification projects in inner city Atlanta such as the Atlantic Station, an upscale business, residential and social complex, the largest urban Brownfield redevelopment program of that time, which was built on an abandoned factory, foundry and steel mill (6); and, more recently, the Atlanta Beltline Project, a residential, business and reactional project, which was developed on an abandoned railroad track (7). Both of these revitalization projects have been instrumental in bringing city residents of all ethnicities and socioeconomic strata together in common cause, and represent vibrant examples of breaking the cycle of environmental degradation in a local area, with lessons for tackling much of what remains to be done to restore a safe and healthy environment with benefits to all.

The EPA considers a healthy environment in the context of an overarching principle of Ecosystems Services, which refers to those benefits to health and well-being that humans receive from nature, including our food and water, security, and economy(figure 1). It requires that we remain conscious and aware of the links between our surrounding environment and our well-being when we are engaged in making decisions about developing community infrastructure, to managing the land surrounding our communities (8).

Human presence on the planet

Human beings, known as Homo Sapiens, the genus of animals with knowledge and wisdom, emerged onto the planet tens of thousands of years ago. While the exact date is not clear, it is relatively recent in the history of the earth and its other inhabitants. Over the course of human history, there are landmarks and

milestones that create a compelling historical narrative. The domestication of animals and plants to serve human needs was one such milestone that, through the lens of extended time, was associated with changes that transformed the ways humans lived as individuals, families, communities and societies. The continued and growing opportunities for previously unimaginable creativity and industry, where advances in knowledge, the sharing of knowledge, ideas, and technological innovations, have resulted in the remarkable improvements in living conditions for the people of the time with increasing likelihood for survival of the individual and the collective. In the meteoric rise to power and domination of this planet, the history of the species is littered with artifacts that document this journey through time.

The earliest times are recognized by the discoveries of stones and bones that had been fashioned as tools for the survival for groups of individuals, because, after all, the species lives and thrives in groups. The groups could be of different sizes, the smallest being those of families or clans, that would hunt and forage for food. The earliest artifacts in stone are those presumably used for hunting and processing of animals successfully caught in the hunt. With the advent of agriculture some 10-20,000 years ago, the groups became larger and the impact on the environment became greater (9). The debris of the larger groups became more plentiful and varied as the need for shelter, equipment for agriculture, and for domestication animals grew. The nature of an agricultural community is such that not all people are involved all the time in planning for or actively seeking food, resulting in free time for creativity and productivity, which further added to the number of objects produced in that society. Indeed, it was the production and proliferation of artifacts in these societies that have enabled archeologists and anthropologists to extrapolate how the societies might have looked, lived and functioned. One of the earliest examples of environmental degradation was a consequence of repeatedly farming on a particular plot of land, which results in depletion of nutrients, that lowers the yield and contributes to soil erosion with negative effects on the natural flora and fauna in the settled area (10). It is likely that early farming communities became aware of this phenomenon, as reference to it appears in the Biblical texts where there is a directive to work the land for six years then let it rest for a year, which will increase its yield (11, 12).

The critical human need for water for personal consumption as well as for agriculture dictated that the early societies necessarily settled near sources of water, such as rivers, streams, or lakes. Two obvious examples in western history are the civilizations of Mesopotamia, which settled and flourished between the Tigris and Euphrates rivers, and in Egypt where the Nile provided water for agriculture, for human consumption, for transportation to support the society's physical and economic needs, and to serve as a domain for deities for society's spiritual needs. Bodies of water, particularly those that flow, also served in the convenient disposal of waste, inevitably resulting in the pollution and degradation of the water source with the risks of bacterial contamination. We know today from societies and communities living near water sources into which waste is disposed, that infectious diseases are a major health hazard, and that the most vulnerable are infants and young children who succumb to diarrhea, with consequent dehydration which is a major contributor to death, especially in low resource countries in Africa and Asia to this day (13, 14).

In early agricultural times, communities were relatively small by today's standards, so the degrees of pollution and contamination may have been at a relatively modest scale. However, by the time of the Roman civilization in the western hemisphere and at a similar time in China approximately 2,000 years ago, city states had become quite large and sophisticated in the spheres of administration, engineering, architecture, politics and warfare, with the result that they were able to support larger populations. The city of Rome was built by the river Tiber, which provided the water and accepted the waste of the Roman society. Predictably, when the Roman population grew, more water was required, and more waste generated, which was channeled to the Tiber. As a result, the Tiber became dangerously polluted with a high concentration of bacteria and other toxins associated with the waste of the day (9). In order to satisfy the water needs of the people of Rome, engineers created aqueducts to bring clean water from the north to the city which became available to the

population through the many fountains for which Rome is famous. The Romans, through their engineering ingenuity, not only channeled water from sources at higher elevations through a system of aqueducts, but developed a pipe system to carry the water to the fountains for domestic use for drinking as well as in their famous baths. They also developed toilets and sewage draining systems, which emptied into the rivers and the ocean. Roman pipes were constructed primarily from lead (15), which is a potent neurotoxin, particularly for children. So, not only would lead be found in the water for drinking and other domestic uses, but lead would also accumulate in the waste water that went into the Tiber. In addition, the pipes needed to be manufactured, which required fire and smelting. Lead fumes would inevitably be released into the air, eventually settling to the ground and found in the soil and sediment in the rivers. Furthermore, lead particulates were carried by winds far from the smelting source, to be found 2,000 years later in the analysis of a core of ice extracted from the subarctic ice cap in Greenland (16). To this day, despite the banning of lead from gasoline and paint, it remains an environmental hazard as a result of the legacy of using lead pipes, recently creating a crisis involving lead-contaminated drinking water from the Flint river in Michigan (17).

Interestingly, the fall of the Roman Empire in 476 CE coincided with the ice core becoming relatively clean again, but not for too long. By the 16th century, the ice core reveals that the air on earth once again became contaminated and polluted with lead and other metals. That occurred when the Spanish Conquistadors defeated and subjugated the native peoples of South America and began to mine and extract silver and gold on a large scale. Their use of large fires in smelting released the fumes of metal into the South American air that also found its way into the ice caps hundreds of miles away in the Andes (18). These examples of the Roman and the South American mining and metallurgic practices provide evidence that pollution is not confined to local areas, but can be wide-spread, particularly where air and water are contaminated.

Another example of contamination of the air came from the large-scale domestication of livestock, presumably to feed the growing affluent populations with meat and milk and its products, such as cheese. Herding of domestic animals probably began around a similar time to the development of agriculture as a way of life and a way of supporting larger groups of people. Records on the condition of polar ice caps document a dramatic increase in the presence of methane gas around 2,000 years ago (19). This increase was associated with the expansion in size of societies during the Roman Period, which coincided with growth in Chinese civilizations at the same time. The increase in the presence of methane is considered to be a result of the emission of gases by the domestic livestock (20). This period of high methane production subsided somewhat as the civilizations of the time fell to less organized groups. It rose again when greater degrees of social order were re-established during the middle ages and progressively through modern times as the growth in size of settled communities required more food. This necessitated the development of more agricultural lands and more livestock to feed the people, which in turn, resulted in the release of more methane gas. While low ambient levels of the gas may not play an appreciable role in modifying the climate, the larger amounts and concentrations in the air that have accumulated over the past half century have had a substantial and escalating effect on our climate as one of the ‘greenhouse gases’ (21).

Industrial revolution

For the early centuries of writing, accessibility of reading matter was confined to the elite and educated. This changed dramatically with the invention of the printing press making written material readily available and accessible to the ordinary citizen in intelligible common vernacular, resulting in a burst of creative and cumulative advances in knowledge and technology. This all came together along with beginning of science and scientific experimentation that was ignited after the renaissance in Western society following the oppressive middle ages. The invention of machines and the establishment of factories in the late 18th and early 19th Centuries across Europe gave rise to the industrial revolution, which changed the course of human history.

In England, the plentiful presence of coal gave fuel to the fires of industry which was characterized by productivity and prosperity. The ideas, inventions and practices generated at that time were shared between countries and cultures to bring similar success and wealth to those countries. But, along with the dramatic changes that brought success, there were unanticipated social, economic and environmental changes that were no less dramatic. The large-scale transformation of the society from being primarily agricultural to having a strong industrial base resulted in the movement of people from the rural areas into the cities where there were greater economic opportunities. This mass migration disrupted centuries of culture, community and socioeconomic balance to create a society with much wealth as well as much poverty now concentrated in the cities, such as London, as captured so effectively in the novels by Charles Dickens.

At an environmental level, the burning of coal created significant air pollution which caused rampant respiratory problems, particularly among the poorer citizens who lived in the middle of this smoky toxic mix of pollution and poverty. The consequences of air pollution on health was noted relatively early in the process of industrialization, particularly in the United Kingdom where laws were progressively developed from as early as 13th Century when the use of coal in London was prohibited as being “prejudicial to health”, but really took off in the mid-19th Century to address the problem of coal burning and pollution (22). However, it took an environmental disaster in London in December, 1952, when 4,000 people died as a result of smog trapped in a thermal inversion, to bring about England's Clean Air Act in 1956 (9). The phenomenon of the industrial revolution with its advances in technology, transportation and mass manufacturing as well as its unintended negative consequences, was not confined to England or Europe but was also advancing significantly in the US as well. On October 26, 1948 in the small industrial town of Donora, Pennsylvania, a weather anomaly in the form of a thick fog trapped malodorous toxic waste emissions from the town's zinc smelting plant and stayed on the ground for five days (9). Twenty people died and 7,000 were hospitalized with respiratory problems. The Donora disaster brought air pollution into focus in the United States, and paved the way for the Clean Air Act, established in 1970, and then amended in 1977 and 1990 (23). One of the goals of the Clean Air Act was to address the public health and welfare risks from certain widespread air pollutants by setting pollutant standards coupled with directing the states to develop implementation plans, applicable to controlling industrial sources of pollution, in order to achieve these standards (24). The pollution and health related problems as a result of industrialization and the use of fossil fuels are by no means over. Air pollution dramas continue to occur around the world, most recently observed in rapidly industrialized areas in China and India. Air pollution from industrial sources consisting of gases and particulates not only leads to acute and chronic respiratory and other illnesses in exposed populations including impact on reproductive health (25), but also contributes significantly to greenhouse gases and broader environmental consequences manifesting in climate change (26).

Smoke from coal-fired power plants also releases sulfur dioxide and nitrogen oxides into the air, which mixes with water and results in acid rain (27). Corrosive and deadly to plants and trees, acid rain falls and drains into rivers, streams and lakes where it accumulates, polluting the water and altering the ecology by damaging the flora and fauna and rendering the water undrinkable in some areas. Furthermore, toxic by-products of coal burning, including mercury, are precipitated by rain and drain into waterways where, through biological transformation, the mercury enters the food chain and is consumed by fish where it bioaccumulates. Subsequent human consumption of mercury-infected fish can be toxic, especially to children and pregnant women, and can result in significant neurological damage (28). The EPA regularly issues fish advisories that recommend which fish are to be avoided and which are safer to eat (29).

The relationship between the presence of mercury in fish and neurological damage of children became clear in the mid-1950s when an epidemic of children with severe neurological disorders was being seen in the clinics of the Chisso Chemical Corporation in Minamata Bay, Japan. The disorders were eventually linked to the consumption of fish from the Minamata Bay, which were heavily contaminated with mercury. The mercury found in the fish was a result of the

discharge of tons of mercury-containing waste into the Minamata Bay by the Chisso Chemical Corporation. There were an estimated 900 deaths attributed to the mercury poisoning and over 2,000 people who directly suffered from mercury poisoning (30). This awareness has led to international efforts to reduce mercury levels in our environment through the Minamata Convention on Mercury (31).

This scenario has played out in the Great Lakes region of the US, which contains about one-fifth of the world's fresh surface water supply and nine-tenths of the US supply. Because the Lakes are part of a chain on the St. Lawrence waterway situated between the US and Canada and feeding into the Atlanta Ocean, it has been ideal for shipping and transportation. For these reasons many factories and industries were established along the banks of the river and lakes so that the products of industry could be readily loaded onto large ocean-going vessels and shipped to harbors anywhere in the world. These industries discharged large quantities of toxic waste into the rivers and Great Lakes, creating substantial pollution, with the result that swimming and fishing in the rivers and lakes were prohibited (32). The extent of pollution reached epic proportions in Lake Erie, the fourth-largest of the Great Lakes and the eleventh-largest globally if measured in terms of surface area. Lake Erie seemed to be more contaminated than the other Lakes, in part because of the location of industries along its shores, but also because the Lake is shallow and consequently less resilient. In addition to heavy contamination of Lake Erie, the Cuyahoga River, that runs through Cleveland, Ohio on the banks of Lake Erie, became so contaminated with a mix of pollutants, that it caught fire, presumably because of the oil slick on the surface of the river with other toxic chemicals and flammable debris from indiscriminate dumping of waste from steel factories, sewer disposals and larger scale littering saturating the river (33). The Cuyahoga river did not just catch fire and burn once, it happened 13 times, the last time was in 1969. Although the fire of 1969 was not the most destructive or costly, for a variety of reasons, it was of high profile and, as a result, ultimately led to the passage of the Clean Water Act in 1972 (34). This Act established the basic structure for regulating pollutant discharges into the waters of the US, and gave the EPA authority to implement pollution control programs such as setting wastewater standards for industry, and maintaining existing requirements to set water quality standards for all contaminants in surface waters (35).

Chemical revolution

During World War II (1939-1945), there was a compelling stimulus to science in the development of weapons of war and destruction on a diabolically grand scale. Each side in the conflict developed new technologies to gain military advantage in the seemingly endless battles that raged around the world. Innovations in machinery, aviation, metallurgy, explosives, chemicals and ultimately nuclear energy surged, and with these efforts came newer technologies that, after the end of the war, were turned to civilian commercial use and function in the new peacetime societies. Rapid development of the chemical industry led to newer chemicals and mass production to meet the needs of the recovering and fast-growing post-war societies. All this activity helped to fuel the economy and bring increasing standards of living to many parts of the world, especially industrialized countries, while other, poorer parts of the world continued to suffer from societal disruption, ongoing conflicts, droughts, famines and exploitation, particularly for natural resources to feed the industrial needs.

One such chemical in this revolution was dichlorodiphenyltrichloroethane (DDT), which was designed to kill insects that plagued the crops of the farming industries (36). This new pesticide was very effective and became widely distributed and used on a mass scale, being sprayed on large agricultural areas, often by airplane with 'crop dusters.' It was also used in suburban areas to promote greener lawns and, significantly in large parts of the world where insect borne diseases, like malaria, were endemic (37). Therefore, not only did DDT help to increase agricultural yield but dramatically reduced the morbidity and mortality from malaria for people living in heavily insect-infested areas, particularly in the continents of Africa, Asia and Latin America. Unfortunately, the mass production and indiscriminate and injudicious use of DDT (and other chemicals), with the widespread dumping of the waste

byproduct of chemical production, led to the chemicals leaching into the soil and waterways where they flowed into the rivers and streams and became part of the food cycle, having unintended consequences on the health of flora and fauna, from insects to birds, fish, amphibians, mammals and humans (36).

In 1962, environmental scientist Rachel Carson wrote the book "Silent spring", an exposé condemning the indiscriminate use of long-lasting pesticides in general, and DDT in particular (38). Her carefully researched material and its masterful presentation were the driving force behind the emerging environmental movement in the US and around the world. It is believed that many pollution control laws were influenced by "Silent spring". The use of DDT in many nations was subsequently banned. Globally, the use of DDT is limited and currently approved only for control of insect-borne diseases such as malaria, while safer alternatives are being researched. Despite the banning of DDT in the US, birds continue to die from DDT in the soil where the chemical company that had manufactured the pesticide was located in Michigan (39).

The widespread use of insecticides on crops has also had the unexpected and untoward effect of indiscriminately killing other insects that are beneficial to agriculture, particularly bees and other pollinators. The potential loss of this group of insects could have a dramatic impact on food production. The phenomenon of dramatic losses of bee populations known as Colony Collapse Disorder is, as yet, unclear and, according to the EPA, not exclusively the result of poisoning with pesticides (40), and that climate change may be playing a significant role as well (41).

The story of DDT plays out in a similar pattern for millions of different chemicals that have been manufactured over the years, many of which have been demonstrated to be toxic to animals and humans, and tend to remain in the soil, water or even air, long after manufacture has ceased. These chemical compounds are called 'persistent organic pollutants' (POPs) because they are not readily biodegradable and can bioaccumulate in ecosystems, particularly in the food chain. POPs can be toxic to humans leading to increased cancer risk, reproductive disorders, alteration of the immune system, neurodevelopmental and neurobehavioral disorders, endocrine disruption, genotoxicity and increased birth defects (42). Just as with DDT, the POPs are of international concern as the chemicals are distributed globally. This challenge was addressed in the Stockholm Convention of 2001, the goal of which is 'to protect human health and the environment from POPs' (43).

Another distinct benefit to humans of the chemical revolution has been the discovery of increasingly effective medications in the treatment of human and animal diseases. This has been particularly effective at a global scale in the development of vaccines against infectious diseases and the use of antibiotics that treat infectious diseases. The proliferation of increasingly potent antibiotics has been beneficial in treating the most recalcitrant infectious agents. At the same time, however, widespread and often indiscriminate and, at times, injudicious uses of antibiotics by prescribers, has led to increasing resistance to existing antibiotics among bacteria and other microorganisms. The current challenge in modern hospitals is dealing with drug resistant bacteria, so-called 'multi drug resistant organisms' (MDRO), most notably the methicillin resistant staph aureus (MRSA) (44).

Antibiotics are also used in mass quantities in livestock farming to reduce risk of infection and promote healthier growth among the animals. This large-scale use of antibiotics in animals and widespread use of chemicals in agriculture, used to enhance human food supply, has played a part in modifying the human microbiome (45). Connections are now being made between microbiota dysbiosis and a variety of different diseases such as rheumatoid arthritis, inflammatory bowel disease, type 1 diabetes, atopy, and obesity (46). Over time, there are likely to be more conditions identified that are linked to the disturbance of the human microbiome.

Among the most useful yet concerning products of the chemical revolution are plastics (47). The term "plastic" is derived from the Greek word "plastikos", meaning fit for molding. It is an apt term because the products of the chemical process of polymerization of basic carbon-based material are multiple in form and function. Plastics are used expansively in items in everyday use, from clothing to utensils to components of medical equipment, machinery and building materials, even spaceships. Indeed, our modern society is wedded to the use of plastics and plastic

products. The problems for the environment come from several different levels of manufacture, use and after-use. In the manufacture, there are releases of harmful chemical compounds into the air. After-use and disposal of plastics, however, have created an environmental catastrophe. Because they are not biodegradable, they remain in our environment unchanged as pollutants in their original forms, as microplastics or larger pieces, such as plastic bottles and grocery bags. Although there is some recycling, most of used plastic products are found in waste sites like trash dumps, where they may become part of landfill, slowly degrading over millennia, or washed into waterways and into the oceans (48). Each year, an estimated 18 billion pounds of plastic waste enters the world's oceans from coastal regions where they can be ingested by small and large sea creatures endangering their lives and killing individual animals, as well as threatening species (49). There is currently an estimated 100 million tons of plastic debris in our oceans at present, 80-90% of which has come from land-based sources which could have been recycled (50). The use and disposal of plastic material is one of the challenges of our times. It is critical that we reduce consumption of single-use plastic objects; which is an appeal to consumers and manufactures to restrict the use or plastics, and for policy makers to pass laws regulate the use of certain plastics. The bigger challenge is the cleanup and removal of plastic debris particularly from shorelines (51) and of the massive floating islands of plastic in the world's oceans (52).

Waste disposal

The impact of gravity and the relatively porous nature of the earth's soil results in accumulation of chemicals and substances in the soil and, with rains, they are likely to seep into the water table beneath the surface and into the rivers and streams. When the amount of chemical pollutant is great, the potential saturation of the soil can be correspondingly great and last for a long time, posing significant risks to life for people and animals. One such example was given above in relation to the scenario of the birds dying as a result of DDT poisoning if they lived near the site of the DDT plant which had been abandoned decades earlier (39).

Figure 1. Ecosystems services – conceptual framework for a healthy and supportive environment (8).

Another dramatic example of this scenario took place at Love Canal in New York in the late 1970s, which has been described as one of the most appalling environmental tragedies in American history (53, 54). In the early part of the 20th Century, William T Love imagined a model community in New York, on the edge of Niagara Falls and dug a canal to supply water power to what he envisioned would be a combination of industrial and residential areas in the community. Unfortunately, his dream was not fulfilled, and the empty canal was then filled with approximately 21,000 tons of toxic chemical waste from the Hooker Chemical Company. The city of Niagara Falls then built houses and an elementary school on the site. Over the years, the underground containers filled with of chemical waste corroded and, in 1977, after record rainfall, chemicals leaked into the soil. Dissolved chemicals leached into people's homes, backyards, and playgrounds, resulting in serious adverse health effects in the community, with high rates of birth defects and miscarriages.

As a result of this tragedy, the US Congress enacted the Comprehensive Environmental Response, Compensation and Liability Act to address toxic waste dumps (55). This became known as the Superfund Program which is designed to protect human health and the environment by cleaning up polluted sites, make responsible parties pay for cleanup work, involve communities in the Superfund process, and return the Superfund sites to productive use (56). In addition, in 1995, the EPA launched the Brownfields program "to empower states, communities, and other stakeholders in economic redevelopment to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse" land which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant (57). Examples of the Brownfields programs were given earlier in the discussion on the revitalization of the city of Atlanta with the Atlantic Station and Beltline projects (6, 7). Of note is that as part of the decision criterion for the Atlanta Beltline Brownfield redevelopment project, was a health-impact assessment conducted to look at how the proposed changes could affect access and equity, environmental quality, safety, social capital, and physical activity in a way that would maximize health benefits and reduce negative impacts (58). The findings were ultimately incorporated into the design of the project to fulfill the EPA Ecosystems Services model (Figure 1) (8).

The disposal of waste is not necessarily confined to a neighboring location or regional site. Because of the large-scale generation of toxic waste by industrialized countries, it had become a practice to transport waste from the high resource industrial countries to low resource poor countries adding to their toxic burdens (59). Although historically, there has been relatively limited regulation on this transaction, the EPA notes that several international agreements address transboundary transportations of hazardous waste including the Basel Convention (60), the Organization for Economic Cooperation and Development (OECD) Council Decision, and local and regional agreements such as exist between the United States and Canada, Mexico, Costa Rica, Malaysia, and the Philippines (61).

Nuclear age

In addition to the proliferation of chemical production during and after World War II, there was the discovery that the phenomenon of nuclear fission could be applied to and used in weapons of mass destruction, far greater than had been previously imagined. The testing of these devices took place in the desert in the Southwest US, on tropical islands in the Pacific Ocean and in the atmosphere, resulting in such powerful explosions that it surprised and shocked even the scientists charged with developing them (62). Neither did scientists predict the destructive impact of the radiation released from these atomic devices on plant and animal life far from the site of the explosion. At test locations in the Pacific, not only was there total destruction of ecology of the islands, but the inhabitants of the islands were subjected to dangerous levels of radiation, and they remain displaced and disenfranchised to this day as they continue to suffer adverse health consequences (62, 63). The use of the atomic bomb by the US during the war resulted in the almost total destruction of the Japanese cities of Hiroshima and Nagasaki and the immediate death of all citizens near the epicenters

of the explosions, as well as the deaths of those within range from acute radiation sickness. Those further away from the epicenter suffered long-term adverse health consequences (64).

The adoption of the nuclear option in war then became part of the weapons manufacture and proliferation in the US and in the Union of Soviet Socialist Republics (USSR), or the Soviet Union. These two so-called Super Powers accumulated nuclear stockpiles for more than four decades following the end of World War II, which posed an existential threat to human survival. The threat of mutual annihilation, so-called 'Mutually Assured Destruction', or the appropriate acronym MAD, was a term attributed to John Von Neuman (65), one of the prominent scientists of the time and part of the team that developed the hydrogen bomb. This insanity came to an end with the mutually agreed limitations in use of nuclear weapons, starting with the Strategic Arms Limitations Treaties (SALT) between the leaders to the US and USSR (66). The United Nations Office for Disarmament Affairs enacted a number of treaties progressively addressing the control of nuclear weapons, including the Treaty on the Non-Proliferation of Nuclear Weapons in 1968 and, most recently, the Treaty on the Prohibition of Nuclear Weapons in 2017 to prevent destruction of life and the environment (67).

After the dramatic use of the Atomic Bomb and its consequences, attention was turned to peaceful use of nuclear energy in the generation of electricity, and nuclear power plants were developed in the 1950s by both the USSR and the US (68). Once hailed as a safe source of energy, human exploration of nuclear power has come with substantial and dramatic risk. In April 26, 1986, a sudden surge of power during a reactor systems test destroyed Unit 4 of the nuclear power station at Chernobyl, Ukraine, in the former Soviet Union, releasing massive amounts of radioactive material into the environment (69). The consequent mortality and morbidity of the disaster resulted in the deaths of 28 workers in the first four months with another 106 workers received high enough doses to cause acute radiation sickness. In the immediate aftermath of the disaster many children in the area drank milk contaminated with radioactive iodine, which resulted in a high rate of thyroid cancers among the children among other long term adverse health effects on the population. However, it was the long-term psycho-social impacts on residents and evacuees from the disaster that has been the greatest realization, with findings of higher rates of depression, alcoholism and anxiety, with negative self-assessments of health, as well as unexplained physical symptoms (70).

There have been other nuclear accidents of a similar nature, such as the Three Mile Island commercial nuclear power plant partial meltdown in 1979 in the US (71), and, in 2011, following a massive earthquake and tsunami affecting Japan, the Fukushima Nuclear Reactor was damaged resulting in release of radioactive material (72). Neither of these accidents had the same consequences as the Chernobyl disaster, but they certainly raised alarm and concern of the risks of nuclear power plants.

Overall, the resultant increase in atmospheric radiation and radioactive isotopes from all sources has the potential for adverse health outcomes, especially for children (73). Furthermore, the disposal of hazardous radioactive waste remains a grave concern in avoiding human exposure and reducing the likelihood of environmental damage especially to flora and fauna. There are very clear criteria for how the waste is stored, depending on the half-life of the particular radioactive material and the levels of waste, being low, intermediate or high, which determines how and where the waste is stored. Although the criteria are accepted globally, each country is responsible for its own details of management (74).

Soil degradation

Soil degradation of the land likely began in early agricultural times when repeated farming of the same plot of land resulted in degradation of the quality of the soil. This phenomenon was recognized in biblical writings, with the requirement to work the field for six years and letting the land rest on the seventh, or Sabbatical year (11, 12). There is speculation that the Akkadian Empire that once ruled the region between the Tigris and Euphrates rivers may have collapsed as a result of soil exhaustion and desertification, the process of making a desert of previously fertile soil (75).

Soil degradation and desertification is of grave concern in sub-Saharan Africa, as it seriously depresses food production and, along with other dramatic unpredictable climate events, like droughts and floods, increases the likelihood of food insecurity and famine (76). Famine can lead to restive populations and large-scale emigration to find food and work, which can destabilize not only the local and neighboring communities, but beyond country borders as famine-affected refugees (77). In recent years wars, drought and famine have caused refugee migration from Africa to Europe, which has dramatically altered political and social dynamics within and between countries, and appears likely to play out again as the impact of climate change will continue to affect weather patterns and hence agriculture and food production (78).

The other major impact on the quality of soil by human activity is the process of deforestation which has dramatically increased in pace and magnitude (see Figure 2) (79). The consequences of deforestation, particularly in the large rain forests of Brazil and equatorial Africa, not only results in degradation of the soil causing erosion, but increases the risk of desertification (80). Furthermore, natural forests in Indonesia have been destroyed by burning, for mining and natural resources as well as for monoculture of palm oil groves for the yield of the fruit (81). This large-scale deforestation and widespread destruction of critical vegetation in our ecological balance has drastically reduced the natural source of carbon dioxide consumption and oxygen generation resulting in an increase in atmospheric carbon dioxide which is a major contributor to climate change. In addition, as a result of the disruption of the local ecology, there is an increased risk of forest fires which further aggravate the situation (82). The changes in natural forests especially rain forests are sadly also resulting in a reduction in biodiversity with extinction of endangered species of plants and animals (83).

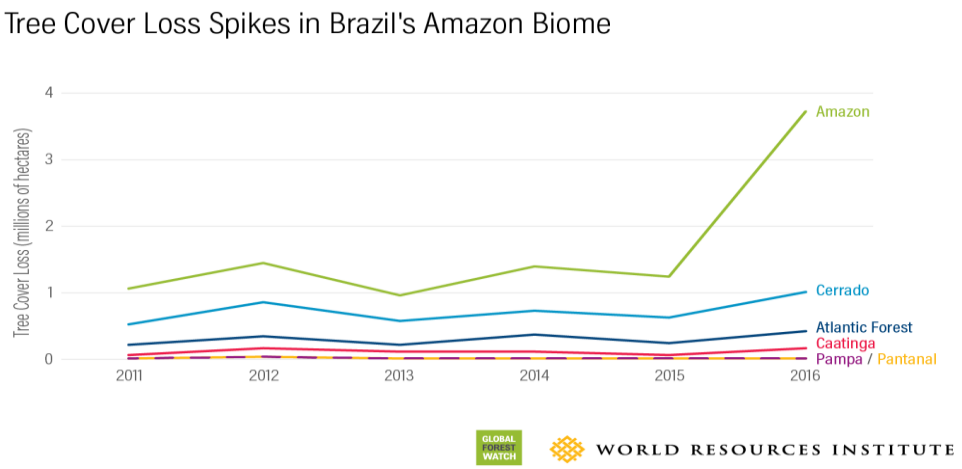

Figure 2. Global tree cover loss rose 51 percent in 2016 (79).

Climate change

The rather narrow range of atmospheric temperatures on Earth has resulted in the proliferation of plant and animal life in the waters of the rivers, lakes and oceans, as well as on the land and in the air. For all life on this planet there is a temperature range from summer to winter and day to night for comfortable survival and maintenance of the Earth's homeostatic and current ecological character.

Over the course of the past two millennia, but particularly in the past 150 years, and rapidly accelerating in the past 70 years, human activity has progressively and cumulatively changed the climate on earth by the burning of coal and other fossil fuels, particularly in industry, by the emissions of exhaust gases from the consumption of gasoline as a result of the increasing number of motor vehicles, by the emission of methane gas from livestock, and by deforestation. At present there is overwhelming evidence that we are experiencing dramatic climate

change associated with global warming that is distinctly related to human activity (84).

According to NASA's Goddard Institute for Space Studies (GISS), the average global temperature on Earth has increased by about 0.8° Celsius (1.4° Fahrenheit) since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15-0.20°C per decade see Figure 3 (85).

As the world population of humans increases exponentially, there is a greater impact on the earth, with the result that the land, waters and atmosphere are becoming attenuated, and the natural flora and fauna of the Earth's biosphere are increasingly threatened. At the same time, there is a growing need to assure adequate food production and a critical need to feed the increasing number of people in the world. This is a compelling reason to take action reverse current trends to a more settled ecological homeostasis.

The other aspect of climate change and warming of the planet, is a more dramatic change in the occurrence, frequency and intensity of extreme weather phenomena, such as hurricanes, floods, snowstorms, and even wildfires (86). Not only do these disasters cause destruction and devastation to the built environment and cause loss of lives, but the after effects on the natural environment, disruption of populations, and the financial costs, take their toll as well. The concern is that, as the global temperature increases so will these extreme weather phenomena and the cumulative consequences particularly on health, with significant implications on development of related policy (87).

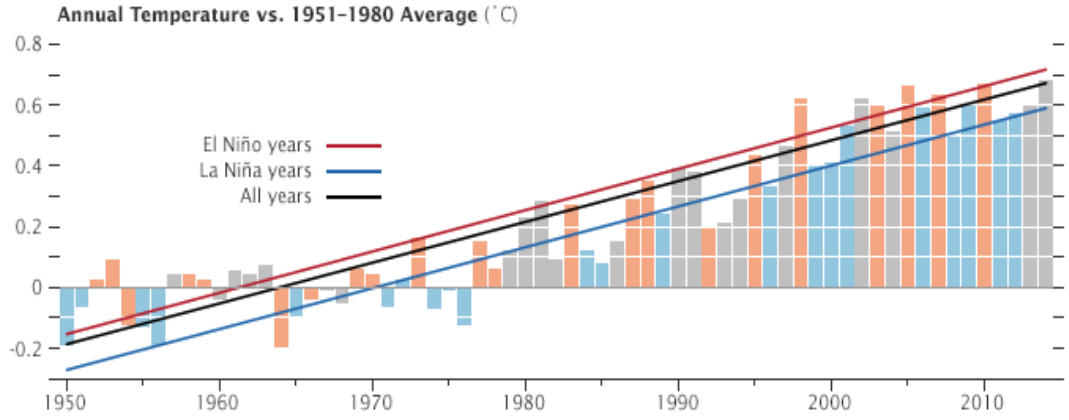

Figure 3. Annual temperature from 1951-present vs average between 1951-1980 (85).

Breaking the cycle

This exploration of the cycle of environmental degradation began with an examination of the microcosm of Proctor Creek in an Atlanta neighborhood. The lessons of the Proctor Creek experience demonstrate the critical importance of a consortium of concerned participants with an understanding of the situation, with ideas on how to break the cycle, with financial resources and a with a commitment to work together to make changes for the good of all (1).

Just as the citizens of the Proctor Creek community took action to clean up their creek and restore an environment that is clean, pleasant and healthy, there are a multitude of similar efforts at so many levels in neighborhoods, towns, states, countries and globally that have successfully broken the cycle of environmental degradation and restored a healthier ecological balance. In many places, these efforts have enhanced opportunities for healthier physical, emotional and social activities for the citizens, characterized by the EPA as Ecosystems Services (see Figure 1). Figure 4 represents a conceptual model of how the natural environment becomes degraded and how efforts to break the cycle and to reverse the trend towards a more natural and healthy ecological balance.

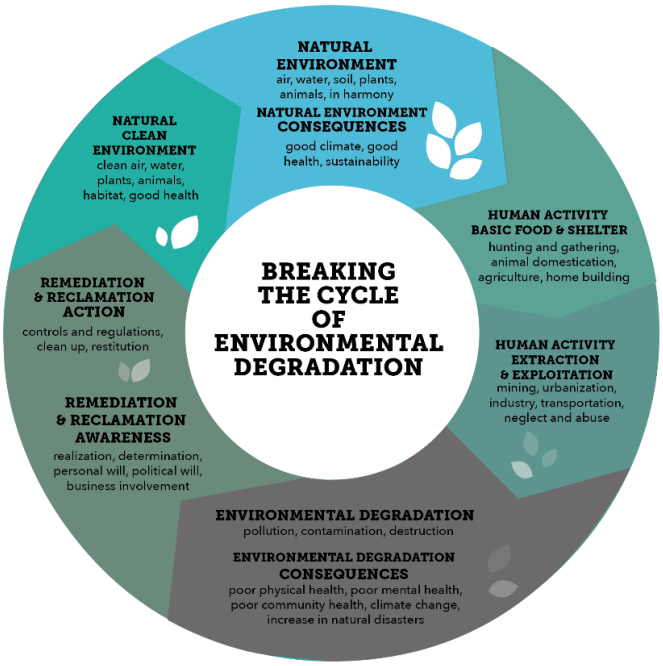

Figure 4. Diagram depicting the process of environmental degradation followed by regeneration through environmental stewardship at many levels.

Efforts to break the cycle can and do occur at many different levels including starting with a personal commitment to reduce waste by not using single use plastics, by driving cars that do not use fossil fuels, by recycling, and many other changes to personal behavior that are sensitive to the environment, and by extending the commitment to local community action, and advocating national and international governing bodies to likewise take up the charge and develop strategies to make positive changes and laws to assure maintenance and compliance with the standards expected for a healthy environment. Each organization and agency, government or Non-Governmental Organization (NGO), or international body, plays a significant role in the process. The greater the number of entities involved, and the greater the interaction and coordination among them, and the greater the resolve, the greater will be the impact on improving the health and well-being of all living beings and of the ecological balance of our planet. In this context, three examples of bodies whose missions and visions to make a difference are worthy of our support are offered for consideration.

The United States Environmental Protection Agency (EPA)

The mission of EPA is to protect human health and the environment. EPA's Strategic Plan identifies the measurable environmental and human health outcomes the public can expect from EPA and describes how we intend to achieve those results (88).

In 1970, as a result of heightened public concerns about deteriorating city air, natural areas littered with debris, and urban water supplies contaminated with dangerous impurities, the EPA was formed. At the time, given the dramatic environmental realities of air pollution, water pollution and pollution of the soil, President Richard Nixon requested billions of dollars of funding for a rather far reaching and visionary set of challenges:

- setting national air quality standards and stringent guidelines to lower motor vehicle emissions;
- launching federally-funded research to reduce automobile pollution;
- ordering a clean-up of federal facilities that had fouled air and water;

- seeking legislation to end the dumping of wastes into the Great Lakes;
- proposing a tax on lead additives in gasoline;
- forwarding to Congress a plan to tighten safeguards on the seaborne transportation of oil; and
- approving a National Contingency Plan for the treatment of oil spills.

In order to achieve these goals, the EPA was created and given the following mandates (89):

- The EPA would have the capacity to do research on important pollutants irrespective of the media in which they appear, and on the impact of these pollutants on the total environment.
- Both by itself and together with other agencies, the EPA would monitor the condition of the environment, biological as well as physical.
- With these data, the EPA would be able to establish quantitative "environmental baselines", critical for efforts to measure adequately the success or failure of pollution abatement efforts.
- The EPA would be able, in concert with the states, to set and enforce standards for air and water quality and for individual pollutants.
- Industries seeking to minimize the adverse impact of their activities on the environment would be assured of consistent standards covering the full range of their waste disposal problems.
- As states developed and expanded their own pollution control programs, they would be able to look to one agency to support their efforts with financial and technical assistance and training.

In the almost 50 years since its inception, the EPA has played a significant role in improving the quality of our environment, with cleaner air, cleaner water and strategies to clean up polluted lands. It has also responded to the impact of natural disasters such as Hurricane Katrina in New Orleans, and man-made disasters such as the 2001 destruction of the World Tarde Centers in New York. It has also worked collaboratively with international organizations to help make positive changes in the environment around the world. Significantly, it has worked with the international community to address the challenges of climate change, despite the changing stances of the leadership in the US. It is expected to continue to be a force for environmental health in the full sense, not only of human health, but health of the planet (90).

The world body: United Nations (UN) and World Health Organization (WHO)

Both the UN and the WHO are intimately involved in improving the environment towards improving the health of all people in the world.

The WHO's Health and the Environment (91) program mandate is to support Member States to improve health outcomes linked to environmental risks such as:

- Unsafe water and inadequate sanitation
- Poor indoor and outdoor air quality
- Exposure to toxic or hazardous waste and chemicals
- Climate change

The 2017 annual report of the UN Environment states:

"Throughout the past year, UN Environment campaigned on many fronts against the spiraling pollution of air, water and land around the world. Climate change, wildlife crime, micro-plastic pollution and land degradation are just a few examples of environmental ills that affect the health and well-being of communities and economies, global efforts to achieve the Sustainable Development Goals and even the security of nations."

United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty adopted in 1992 and signed at

the Earth Summit in Rio de Janeiro, Brazil to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (92)

The UNFCCC serves as the foundation of an evolving global climate effort and sets a long-term objective of avoiding dangerous human interference with the climate system. Toward that end, the agreement:

- commits all nations to take steps to mitigate greenhouse gas emissions;
- establishes the principle of "common but differentiated responsibilities and respective capabilities" (CBDRRC), recognizing that countries vary in their contributions to climate change and capacities to address it, so their obligations will likewise vary; and
- commits developed countries to assist developing countries in reducing emissions and coping with climate impacts.

There have been a number of international meetings, initially in Kyoto, Japan in 1995, where the Kyoto Protocol was developed, followed by the Paris Agreement in 2015 and most recently in Katowice Poland in 2018. Although these successive conferences have affirmed the commitment of participants to respond to the real and immanent dangers of climate change, there are so many competing factions among different nations and within each of the countries, that there remains much to do as the time slips away.

Conclusion

Over the millennia of human habitation on this planet, humans have multiplied and conquered the land, seas and air. In the process, we have exploited the Earth's natural resources and irrevocably altered the quality of the natural environment to the detriment of almost all living beings. Human-caused environmental degradation has been progressive and cumulative and creates an existential threat to all life on the planet that must be addressed. Rising global temperatures and consequent ecological changes are scientifically irrefutable. In this commentary, some of the more dramatic elements, episodes and disasters have been presented and discussed with meaningful responses at local, national and international levels being highlighted.

The continued threat of environmental degradation to our health and, arguably, to human existence and the deepening disruption of the ecology of our planet, compel further, intensified and sustained action. Historically, we have been more reactive than strategic in our approach, responding to environmental disasters and the loss of life. While these responses have been, in many instances, demonstrably effective, they fall short of a broader approach to environmental degradation with a longer view. Our objective must be to avoid the disaster and our public policy and practice must be informed by science and dedicated to environmental recovery.

In order for humans to continue to flourish on Earth, we must acknowledge the link between the environment and health, human health and the health of all other living species, and on the ecological health of our planet. We must continue to reverse the trends of environmental degradation and the local, regional, national and international realities that accompany it. As shown in in Figure 4, actions can be taken by individuals, groups of individuals or by larger organizations and agencies to break the cycle of environmental degradation and improve the quality of our environment to assure the health and viability for all species in our current ecological system. We must build on successes of and lessons learned by previous generations, dedicate ourselves to the depth of contributions we will make, and leave a legacy and a positive direction for the generations who will follow us. *It is not incumbent upon on any one of us to finish the task, but neither are any of us free to absolve ourselves from it (93).*

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