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Article

New Findings in Environmental Science and Their Implications for Christians

Dorothy Boorse

The interdisciplinary field of environmental science involves research designed to monitor large-scale environmental changes, better understand how the created world works, and describe the effects of humans on the rest of the natural world. Many of the cutting-edge environmental science findings raise questions for people of faith. Some of those questions can be connected to the ideas of natural limits, unintended consequences of actions, and the ethics of how humans interact with ecosystems. Here several of the questions environmental science research raises for Christians are connected to recent research. This article operated as a call for papers; the papers in this issue of the journal, as well as what questions they might address, are described.

> O God, enlarge within us the sense of fellowship with all living things, even our brothers the animals, to whom thou gavest the earth as their home in common with us. We remember with shame that in the past we have exercised the high dominion of man with ruthless cruelty so that the voice of the earth, which should have gone up to thee in song, has been a groan of pain. May we realize that they live, not for us alone, but for themselves and for thee, and that they love the sweetness of life.
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> —St. Basil the Great, Bishop of Caesarea (329–379)

A quick glance at the news shows that the environment is often a topic. The threat of a volcanic eruption in Iceland, a drought in California, and the discovery of thousands of methane seeps on the ocean floor, not only shows us that the environment is dynamic, but also that scientists are constantly developing better models of how the world works. New findings in environmental science, especially those that are of interest to faith communities, are not usually about some striking new discovery about fundamentals of the natural world. However, meta-analyses, large integrative models and cutting-edge studies on the effects of human activity on the rest of the natural world, such as a recent study of marine organisms that investigated the effects of warming waters on marine migration, are common. Environmental science integrates the scientific disciplines of chemistry, physics, biology, ecology, earth science, atmospheric science, geology, and others to address the complex context of life on Earth. It is broader than ecology and includes areas such as environmental health. It also includes the "built" environment (e.g., indoor spaces for ventilation, lighting, lead in paint, spills) and the environmental studies of policy, economics, and engineering. We might organize the issues that this broad array of investigation and method addresses by considering limits, unintended consequences, and ethics.

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Limits

While there is cause for concern about human impacts on many ecosystems and natural processes, marine changes are particularly dramatic and disturbing for anyone concerned about the environment. For many years, people treated the oceans as giant repositories of human effluent. Trash was dumped there, agricultural runoff made its way there, sewage outfall pipes moved sometimes-untreated human waste and dumped it into harbors. Coastal wetlands were dredged, drained, filled, and built upon; estuaries were overharvested; and oceanic predators were removed. All of these actions had reactions. The Grand Banks, the large cod fishing area off Newfoundland, was fished out and closed in 1992.[1] Whaling, along with the killing of other marine mammals, was largely made illegal after the decimation of these populations. More than 400 dead zones (areas of low oxygen that kill fish) occur throughout the world's oceans.[2] Overfishing still harms food web health, the decreasing pH of ocean water affects plankton, and warming is altering currents, melting ice, and raising sea levels.[3] These stressors threaten extinction for some marine species and harm for human flourishing.

Marine systems are just an example. Terrestrial and freshwater systems have similar stories. At the root of these problems is the cumulative impact of many people, doing a lot of human activities. Are there too many people? Using too much? Are there limits to the amount of the earth's primary productivity we can use? The question of limits can be a thorny one for people from the Judeo-Christian tradition. This may be the most important question that environmental science raises, and it is not a new one. The 1968 essay "The Tragedy of the Commons" by Garrett Hardin described the natural degradation of unregulated common pool resources.[4] In the Mangel et al. paper, "Principles for the Conservation of Wild Living Resources," the authors make a case about what happens not only to unregulated resources, but also to any over-used resource we want to protect.[5] Their first principle might seem obvious,

> Maintenance of healthy populations of wild living resources in perpetuity is inconsistent with unlimited growth of human consumption and demand for those resources.[6]

Scientists have said similar things repeatedly. A statement signed by representatives of the National Academy of Sciences of the United States of America and fifty-seven other national academies of science, in October 1993, said,

> In our judgment, humanity's ability to deal successfully with its social, economic, and environmental problems will require the achievement of zero population growth within the lifetime of our children.[7]

One of the most comprehensive overviews of human and global limits is the 2009 article by Rockström et al. in the journal *Ecology and Society*, "Planetary Boundaries, Exploring the Safe Operating Space for Humanity."[8] In this article, thirty researchers representing twenty-seven institutions describe a vast analysis of what is currently known about anthropogenic pressures on Earth systems. They look at nine potential boundaries-borders past which human activities cannot take us without risk of catastrophic change. Their analysis suggests values for seven of those limits: climate change (measured either as actual temperature change or as change in carbon dioxide levels), ocean acidification, stratospheric ozone, changes to global nitrogen and phosphorus cycles, global freshwater use, land system change (measured as a percent of ice-free land under crop use), and the rate at which biodiversity is lost. The authors were not able to determine limits for two other boundaries: chemical pollution and atmospheric aerosol loading. Of the seven for which they estimated a boundary, the authors estimated that we have already passed three: climate change, biodiversity loss rates, and the flux (rate of change) of the nitrogen cycle. If this is the case, societies and ecosystems may be resilient enough to recover if human society limits itself and changes sufficiently to put itself back inside those boundaries.

Are Limits Even Real?

Not everyone accepts limits. Some Christians have argued that God would simply not allow us to be badly harmed by our own actions, particularly by an accumulation of otherwise benign activities. Theologian Wayne Grudem is quoted as saying,

> It does not seem likely to me that God would set up the world to work in such a way that human beings would eventually destroy the earth by doing such ordinary and morally good and necessary things as breathing, building a fire to cook or keep

> warm, burning fuel to travel, or using energy for a refrigerator to preserve food.[9]

Conservative pundit Rush Limbaugh recently claimed, "If you believe in God, then intellectually you can't believe in man-made global warming."[10] His reasoning was that "you must be either agnostic or atheistic to believe that man controls something he can't create." That is, Limbaugh believes that, because God creates, humans cannot change global phenomena.

The late evangelical radio personality Charles Colson interpreted concern about overpopulation as a failure to recognize human value in the eyes of God. Were we to fully understand our God-given abilities to solve problems, he believed, we would be content with the knowledge that humans will be able to solve any problems that arise from increasing consumption and population.[11]

Certainly, the Bible gives us reason to see God both as sovereign and as a great provider in our time of need. We are to trust God, who says, "ask and it shall be given you" (Matt. 7:7). "Consider the birds of the air," we are enjoined, "they do not sow or reap … yet your heavenly father feeds them" (Matt. 6:26). Jesus miraculously fed the five thousand (Luke 9:10–17) and did many other miracles. Could this mean that we should not worry about the natural consequences of human consumption?

To conclude that it is impossible for humans to cause serious environmental problems is not responsible. The Bible is full of cautions about being wise with resources, and living back from the edge, living with some margin. We are to keep the Sabbath, give a tithe of our income, and allow the poor to glean in our fields. Isaiah 5:8 suggests that there ought to be limits, saying, "Woe to you who add house to house and join field to field, til no space is left and you live alone in the land."[12]

Scale

The newest findings in environmental science often focus on discovering the scale of ecosystem changes. Either changes are more rapid than we had understood, or more extensive. The authors of a recent report on fragmented island mountaintops in a man-made lake in Thailand found that species diversity dropped much more rapidly than expected because of the fragmentation.[13] Isolated populations were too small to survive, and one by one they went locally extinct.

The IPCC report on climate change released September 27, 2013, is another effort to describe the scale of global changes due to human activities.[14] These regular reports reflect the increasing understanding of climate scientists that human actions dominate the warming of the globe. Of course, the earth has different climates at different times. However, the pace of change is so rapid, these experts warned, that we are making changes that will be difficult for humans to adapt to. It is clear that scientists believe we are crossing important planetary boundaries, but it is less clear exactly what will result.

Other reports suggest that large-scale use of chemicals, including medications such as antibiotics, has effects both on the environment and on human health. Scientific studies do not always find the same result. One recent study showed not only that microbes in soil in a wetland into which wastewater was released were resistant to sixteen antibiotics, but that bacteria in a nearby pond into which the water was not released were resistant to a number of antibiotics as well.[15] On the other hand, in some drylands, treatment with wastewater has not been shown to increase antibiotic-resistant bacteria.[16] In yet another study, antibiotic resistance has been shown to be increasing in soils and is a cause of human disease.[17] Some of these findings suggest that wide-scale use of antibiotics alters soil ecosystems in ways we are just beginning to understand.

The Effect of the Fall …

For Christians, thinking about limits may prompt questions about the effect of human sin on nature. Some people reason that if current nature is radically different from what God intended, because it was cursed as a result of the Fall, then changes we make to the natural world may not be as negative as we think. Christians sometimes conclude that many unpleasant parts of the natural world (limits included) came from the Fall. Not just absolute limits to the total amount of human resource use, but aging, physical death, cold, heat, parasites and predators, hurricanes, earthquakes, and even entropy are

credited to the effects of the curse on the ground, described in Genesis 3:17.

One Christian website claims,

> In much the same way that God allows evil people to commit evil acts, God allows the earth to reflect the consequences sin has had on creation. Romans 8:19–21 tells us, "The creation waits in eager expectation for the sons of God to be revealed. For the creation was subjected to frustration, not by its own choice, but by the will of the one who subjected it, in hope that the creation itself will be liberated from its bondage to decay and brought into the glorious freedom of the children of God."
>
> The fall of humanity into sin had effects on everything, including the world we inhabit. Everything in creation is subject to "frustration" and "decay." Sin is the ultimate cause of natural disasters just as it is the cause of death, disease, and suffering.[18]

Frank Sherwin, at the Institute for Creation Research, echoes the sentiment.

> Obviously, predation and parasitism were not part of God's "good" creation. Instead, they resulted from the Fall and the Curse, and creation biologists observe certain creatures interacting with each other in a host of fallen ways such as parasitism, predation, and competition. This was not always the norm, of course.[19]

Thus, in the minds of some, without the Fall, the earth would be a relatively static place in which animals were not eaten, humans were not subject to anything that could cause injury or harm, radioactive decay would not have occurred and the second law of thermodynamics would not be in place.[20]

As appealing as it might be to view the pre-sin world as a perfect place in which our views of what we like and dislike are upheld, the information that we have about the world suggests that the earth is very old and that, long before humans appeared, organisms had the same range of feeding strategies and niches that they do now. These ideas are reviewed by numerous authors in the literature on science and faith.[21]

Predators, parasites, and pathogens appear throughout the fossil record, long before humanity.[22] Many genes in humans have ancient viral origins.[23] Evidence from geology and astronomy paints a picture of an early earth that is an exciting, dangerous place, full of molten rocks, asteroids, and volcanoes.[24] As the earth formed its present shape, conditions became more conducive for life. Typically then, Christian views of a static "good" creation are coupled with young-earth hypotheses that do not accept such scientific findings as accurate. For those who believe that the earth is old and that modern science is correct about the geologic record, a view that all natural causes of harm result from the Fall is misplaced.[25] Additionally, the Bible suggests that God is honored by predators, storms, and events such as earthquakes. He is glorified by having created the leviathan (Job 41:1–9), storms (Ps. 135:7, Jer. 10:13), and mountains (Ps. 65:6, Amos 4:13); giving food to lions (Ps. 104:21); and causing mountains to tremble (Ps. 104:32). Both scientifically and theologically, it is hard to see that "natural evil" is a result of the Fall.

One of the reasons this question matters is the need to conserve large predators. Ecologists know that the loss of top predators can disturb an ecosystem at levels disproportionate with the number of individuals involved. One example of this is the loss of sharks. In fact, removal of the largest marine predators has sometimes allowed smaller predators to thrive, even wiping out their own prey.[26] Ecologists have also noted the importance of disturbances such as floods and fires in maintaining ecosystem processes. Fire-adapted plants, such as the short-leaved pine, require fires to germinate. The vast forests of the southern US have altered with modern fire-suppression strategies, producing monocultures of other species.[27] Sharks and forest fires, wolves and volcanoes do not always lend themselves to human enjoyment, and yet they are critical to maintaining the health of communities.

While calling all unpleasant features of the natural world "evil" may not be upheld by science or theology, there is certainly evidence that creation is "groaning." Humans do affect the rest of the natural world, often exacerbating problems that trouble us. Weeds and marine-fouling organisms increase as we move opportunistic organisms around the globe.[28] Droughts are worse as we lower water tables by using arid-region aquifers for water-intensive activities such as fracking.[29] Deforestation causes deserts to spread, dust storms to carry away needed soil.[30] One interpretation is that the world is cursed because of us, when we overuse it.

Unintended Consequences

Because environmental sciences are a nebulous interface of disciplines, and because the world is so convoluted, research findings in environmental science often involve revelations of complexity, interconnectedness, and the unintended consequences of actions. One example is the unexpected impact of changes brought about by modern life on human health. While not entirely environmental, such effects link the environment in which we live to other areas of our lives.

The epidemic of obesity that is increasing the frequency of chronic conditions such as diabetes, heart disease and cancers, is well known. Traditional approaches have identified individual decisions to eat more and exercise less as the culprit in obesity. Several new findings, described in a recent article in the journal *Aeon,* show the impact of unexpected and synergistic effects.[31] Although they play a role, new research suggests that individual decisions are only one part of the story. Metabolism is also controlled by environmental factors, including some that turn genes on and off, that is, part of the "epigenetic control" of DNA. Discoveries that lab animals on portion-controlled diets are also experiencing increased weights for the same amount of food suggest a more complex relationship between energy intake and fat storage than originally understood. Researchers have identified some factors that may play a role in obesity by lowering metabolism. These factors include chemical pollutants, indoor lights, and temperature-controlled buildings. These aspects of the modern world have many positives, but they may contribute to unintended consequences in health.

Another example of complex interactions is the downside of massive irrigation efforts. Around the world, water development projects have increased food production and improved human life, especially in rural areas. However, irrigation projects are often not sustainable. If they are not maintained, they may lead to leakage or over-evaporation of water and regional water loss, especially to downstream users. Irrigation projects can cause salinization and water-logging of soils as well as the release of mercury from soils. Irrigation ditches and dams contribute to an increase in malaria and schistosomiasis, which regionally increased in prevalence ten-fold after the building of the Aswan Low Dam in Egypt.[32]

Uncertainty

Such research findings raise questions about how we should deal with decision making in uncertain circumstances. For example, we might wonder what risks are reasonable to take and how various "goods" should be weighed if we lack information. In the environmental sector, the *precautionary principle* is often cited as one possible approach. This principle states that when it is scientifically plausible that an action might be harmful, although findings have not yet reached scientific significance, it is reasonable to put the burden of proof on the person proposing the action, to show that it is benign. Unfortunately, such an approach also slows innovations that turn out to be harmless.

Cutting-edge research often focuses on remediating problems caused by other actions we have taken. Carbon dioxide sequestration is only one of several technological concepts that might be a part of slowing climate change. But the search for a silver bullet, a "technofix" that will save us from the natural consequences of over-use of resources or overproduction of pollution, is problematic. Technologies allow us to do things that were once impossible. Recent breakthroughs in agriculture, for example, suggest ways to make silage in small batches.[33] New techniques allow us to purify water in novel ways.[34] New technologies such as bioremediation, biofuels from algae, microbial breakdown of oil, and the addition of biochar to soils, hold promise to remediate human-caused environmental degradation as well. Cutting-edge science is full of these small-scale and applied projects, which often bring hope.

However, many of our problems arise when small actions are scaled up. For example, new research into the effect of nanoparticles in the environment shows that the newest material technologies are negatively affecting soils.[35] Single-walled carbon nanotubes are used to strengthen materials such as plastics. When such tubes make their way into waste, they can end up as part of the biosolids portion of the sewage treatment system. There they are incorporated into materials that are spread onto fields in order to increase fertility. In one study, researchers found that nanotubes in the soil lowered the metabolism of soil microbes and altered their community structure.[36]

"Playing God?"

To produce technology is a human drive that can honor God and help us care for our neighbor. Could humans even improve on what God created, since some people think we are "co-creators with God"?[37] That is a theological question as we move into uncharted territory. Today, scientists consider creating new species, cloning the extinct species (such as the mastodon), engineering more genetically modified (GM) crops, controlling equipment with our brains, even merging humans and machines. Some of these come under the purview of environmental sciences. "Geo-engineering" solutions involve new technologies designed to solve problems on a global scale, such as climate change. Seeding the oceans to increase productivity, spraying seawater in the air to whiten clouds, and even putting giant reflectors into space have all been suggested.[38] These actions may alter the fundamental functions of ecosystems and raise the question, "what levels of change are reasonable for humans to make to alter the earth?"

Ethics

American television audiences of the 1980s and 1990s saw terrible pictures of the effects of a drought in Sub-Saharan Africa. Gaunt children with protruding bellies lay slackly in their mothers' arms as one of the most severe droughts in recorded history ravaged the Sahel. Refugees lined up for aid from the Red Cross and UN. Fundraisers such as Band Aid in the UK and the hit single *We Are the World* brought a realization of drought and its effects to a prosperous western world. The loss of trees, overgrazing, cyclic periods of drought, and increasing desertification co-occurring with increasing populations were blamed for the desperate plight of the world's poorest.

Research in 2013, however, tells an amended story. Yes, droughts are typical of the Sahel. Yes, increasing numbers of people there cut down trees for fuel and grazed domestic animals and in turn promoted the spread of deserts. But there is more to the devastating drought than that. Aerosols (small air-borne particles) produced by the US and Western Europe as a result of industry, polluted the skies, causing a cooling in North America and Europe. This local cooling deflected a belt of tropical rain-filled winds southward, leaving dry Central Africa and parts of South America and South Asia while increasing rain in regions immediately south of the belt, including Northeast Brazil and Africa's Great Lakes region.[39] Such findings highlight questions we might have about ethics and justice.

One type of environmental science research is that of monitoring current status, and projecting what changes may occur in the future for a wide array of environmental variables such as deforestation, over-fishing, desertification, species loss, and water availability. We use such estimates to craft policies designed to preserve ecosystem functions and goods. For example, the massive Millennium Ecosystem Assessment (ME) of 2005 was a multiple-year effort to assess the current state of the world's ecosystems and to describe the pressures they are under.[40] An assessment of that scope may not be repeated for decades, and the ME will undergird decision making about the use of ecosystems for years to come. Managing ecosystems even when all the data are not clear is the norm, and the approach has to be a flexible one, something called "adaptive management."[41] The problem, however, is actually two-fold. Not only is it hard to assess current ecosystem conditions and what is most likely to happen (data uncertainty), but we also have to have some vision of what *ought to be* (an ethical question).

When we ask questions of "ought," we are asking how we define what is right and good. What are we trying to preserve? Should we protect all species? If we all did the right thing, what would the world look like? These questions relate to the theological ideas of the effect of sin and the role of humans in the world. When we ask what ought to be, some people may believe that we are trying to approximate the world prior to the Fall; others, that we are trying to approximate depictions of heaven from the scriptures. Still others may believe what ought to be is something else altogether. Common environmental ethical frameworks include *consequentialist* perspectives (we determine what is right by the end results). One example is utilitarian ethics, which attempts to identify the greatest good when everyone is considered. Deontological ethics focuses on right action based on duty and rights. Other philosophers divide ethical frameworks by what is at the center: anthropocentric views place humans at the center; theocentric views, God at the center; and ecocentric views, the ecosystem at the center. Other frameworks

exist.[42] A Christian environmental stewardship ethic views humans as caretakers of the world on behalf of God and accountable to God for its health. This point of view is the basis of a rich literature on environmental stewardship.[43]

Ethical assumptions underlie many of the quandaries posed by modern environmental science. In his book, *How Many People Can the Earth Support?*, demographer Joel Cohen describes this dilemma.[44] There is no clear scientifically discernible number of humans the earth can support, he concludes, because the number actually depends on how much equality and justice we demand, and what types of sacrifices we want to make in order to have more people. Do we want a vegetarian world? One in which most people cannot travel? One with water rationing? One in which no one can be very wealthy but no one is terribly poor? These decisions are not easy to agree upon and are not scientific. Fundamentally, they are questions of values and ethics.

Justice

In many ethical systems, one principle is that of justice. Environmental justice is a whole field in the social sciences that comes out of inequalities in environmental quality experienced by different groups. The most noteworthy concern in environmental justice is that often the people who suffer environmental degradation are not the people who benefitted from whatever action caused the degradation. There are many examples of environmental injustices. Researchers report from Texas, for example, that autism rates are higher around coal-fired power plants.[45] This is probably caused by pollutants found in fly ash. African Americans are more likely to live in urban areas with poor air quality which makes them more vulnerable to the health effects of a heat wave.[46] People of color are more likely to live near a Superfund site in the United States.[47] Climate change effects are most dramatic on low-lying countries and those with large populations already in poverty, not those who produce the most per capita emissions.

The decisions we make today will limit or expand the choices our children and grandchildren have. This means that all environmental policies contain an element of *intergenerational justice*.[48] People alive today do not have the opportunity to see a passenger pigeon, to hunt bison, or to eat fish caught in many contaminated rivers because of decisions made by prior generations. The next generations may lose the choice to see tigers, to eat certain kinds of meat, or to live in many coastal zones because of choices we are making now. Environmental science can point out likely outcomes, but it is ethics that will help us decide what our obligations to future generations are.

Hope

While not all of the cutting-edge research in the environmental sciences necessarily is about environmental problems, the overwhelming nature of changes to ecosystems and their services dominates the science. As a result, lay people sometimes find scientific findings to be discouraging, and scientists also fight depression. Mental distress resulting from concern about the environment is prevalent. People of faith could have a voice in dealing with new distressing scientific findings.[49]

Environmental science—that most interdisciplinary field—gives us new insights into the scales, complexities, unintended consequences, and ethical dilemmas posed by the sweeping environmental changes that occur as humans live—both as part of and as alterers of the natural world. These insights, in turn, raise questions for Christians, who need to leap into the fray with theologically sound answers.

Continuing the Discussion

In this issue of *PSCF*, various authors address a number of the questions that new findings in environmental science raise for Christians. Sluka and Simonin talk about the limits of fisheries, what can be done with overfishing, and our hope for a solution. Srokosz discusses the possibility of geoengineering, both what is being considered and the ethics. Warners, Ryskamp, and Van Dragt compare a Christian stewardship ethic with what they propose: a metaphor of environmental reconciliation. Their case study of the Plaster Creek Stewards highlights the importance of linking environmental science with the social sciences. The selection ends with a pair of papers on climate change. Morton asks how we should make environmental management decisions when there is scientific uncertainty; by way of example, he cites changes in the pace of surface temperature warming. Ackerman also discusses making decisions under conditions of scientific uncertainty, but disagrees that surface temperature warming

offers a good example of uncertainty, particularly within the big picture of climate change.

Acknowlegments

Many thanks to all the authors who submitted pieces for possible inclusion in this theme issue. It is regrettable that we could not include them all; many topics raised in this invitational essay were not addressed, such as human population growth, effects of nano-technologies, and the connections between economics and both environmental degradation and protection. Essays that carry on the needed conversation will undoubtedly be most welcome at the journal for future issues. Thank you to very patient authors and numerous reviewers, and to James Peterson, the editor of *PSCF*.

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