PERSPECTIVES on Science and Christian Faith

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In This Environmental Sciences Theme Issue …

"The fear of the Lord
is the beginning of Wisdom."
Psalm 111:10

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Perspectives on Science and Christian Faith

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Perfection Is Elusive

James C. Peterson

Some of you have a collector version of the September 2014 issue of *PSCF*.

Authors strive to offer publication-ready copy to the journal, yet there are always arguments that need more explanation, missing information, infelicities … that require attention. They are noted and revised in substantial number by the peer reviewers and the editor. The examination by fresh eyes always spots points in need of address. The goal is to present text that conveys compelling arguments in a way that is transparent to those important ideas under discussion. Errors should not be allowed to detract from the content. Yet sometimes it is just before or during final typesetting that our sharp-eyed managing and manuscript editors make a last-minute catch of an error or infelicity. Those are corrected as well and then editors and authors have another go with the galleys to sign off before final printing. With all this meticulous scrutiny, despite the breadth and depth of content over hundreds of double-column pages a year, the journal is published remarkably error free. That is something one does not notice when it is done well.

But perfection is elusive. To make the journal easier to read on mobile devices, a new software package was adopted last summer for typesetting. The transition was challenging but accomplished with aplomb. Yet a surreptitious complication slipped in. At the last stage before printing, the new program for typesetting inexplicably reversed the sequence of the lettering in some Hebrew words on page 132 of the September issue. So no, it was not a witty play on the article's discussion of sequence, nor a literary allusion to Leonardo da Vinci who wrote his personal notes in mirror image, nor even a tribute to those of our members who happen to be dyslexic. It was a mistake.

While I do read Hebrew, I did not notice the switch in the galleys. Focused on page structure and content at that point in the process, I knew how the words should read and scanned them as they should be, rather than as they were. How embarrassing. One of the jobs of proofreading galleys is to notice when something in the print is awry. The author had turned in a fine manuscript with the Hebrew of course in good order, and such remained in place until the last point in the process. No one else noticed the change during proofing of the galleys. But, of course, once the issue was sent out, the emails starting streaming in from those of our readers who know their Hebrew. I turned to the page and, to my horror, saw that they were quite right. The error was immediately corrected, but not before quite a few of you received your now collector editions. Granted, the reverse lettering of a few Hebrew words on one page will not add as much value as the upside down Jenny biplane on the US postage stamp that now fetches more than one million dollars per instance.

I take some consolation that so many of you read through the journal immediately upon receiving it, and that a striking number of you are attuned not only to the sciences, but also to the scriptures such that you noticed a few words in Hebrew with their spelling reversed. Such an erudite audience keeps the people who make this journal, sharp and grounded.

Again sorry for the error. No doubt some other mistake will happen in a future issue. It will hopefully be distant and hard to find. Note this is not said as a challenge to an *errata* treasure hunt! But you can be sure that when another error somehow slips in some day, it will not be a word of Hebrew with its letters in reverse order.

James C. Peterson, *editor*

Dorothy Boorse

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.
>
> —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.

Dorothy Boorse is a professor of biology at Gordon College, Wenham, MA. She joined the faculty in 1999 after completing a BS in biology (Gordon College), MS in entomology (Cornell University) and PhD in oceanography and limnology (University of Wisconsin-Madison). Her research with students is in wetland ecology and invasive species. Dorothy is also interested in environmental ethics. She was lead author on "Loving the Least of These: Addressing a Changing Environment," a report on poverty and climate change published by the National Association of Evangelicals (2011), and is a co-author of an environmental science textbook. She lives in Beverly, MA, with her husband and their two children.

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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Marine Capture Fisheries—A Call to Action in Response to Limits, Unintended Consequences, and Ethics

Robert D. Sluka and Paul Simonin

Robert D. Sluka

Paul Simonin

Millions of coastal communities depend upon the sea for their livelihoods and/or a significant portion of their protein intake. Yet there has been relatively little response globally from Christians involved in development, research or aid. In this context, we examine three critical questions regarding marine capture fisheries: (1) Are there limits to exploitation? (2) Are there unintended consequences to fishing? and (3) Is it ethical to eat fish? We seek to answer these three questions through recent examples from the fisheries literature, the authors' own research and examination of biblical texts. We conclude that marine capture fisheries in many places are at or beyond a point of crisis – we have reached or surpassed limits. The ways in which we have fished have had unintended, or intentionally ignored, consequences. And there are many ethical and theological issues that we have only begun to consider as a Christian community.

Humans and Fishing

The world's oceans cover about 71% of the planet's surface, contain over 97% of the planet's water, and are home to millions of species, many yet undescribed. Humanity has been intrinsically connected with the sea for centuries,[1] with upwards of 16% of the world's animal protein currently coming from fish.[2] When referring to "fisheries," we are specifically referring to the human-ecological system, involving both people and aquatic animals or ecosystems, in which people capture marine organisms primarily for food. Recent research suggests that only by recognizing and working within a framework which incorporates humans into ecosystems (often called socio-ecological systems) can we sustainably harvest the abundance of the ocean.[3]

Currently, human reliance on fish varies regionally, with some nations relying primarily on terrestrial animal protein for food, while others rely more on marine life, such as Indonesia, where upwards of 70% of the nation's animal protein comes from fish. Overall, the world's capture fisheries harvest plateaued in the early 1990s at about 85 million metric tons, and increases in fish availability since then have been due to increasing aquaculture production. Aquaculture supplied about 64 million metric tons of fish in 2011,[4] and is estimated to now supply roughly half of the world's fish. Currently, with

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our human population at seven billion people, these overall levels of fish consumption is about 18.8 kg of fish per capita per year on average.

We have tried to examine marine capture fisheries by engaging with Boorse's article regarding recent topics in environmental science.[5] Specifically, we address the issues of limits, unintended consequences, and ethics in regard to fisheries. This is not a review article on marine capture fisheries—there are a number of textbooks that would be useful for that purpose.[6] However, the issue of marine capture fisheries has received relatively little attention by Christian writers.[7] Additionally, we have not examined in detail the ways other environmental issues, such as climate change and terrestrial pollution, interrelate with capture fisheries. Our foci here are to examine whether capture fisheries' catches have reached limits, to highlight some of the unintended consequences of fishing, and to describe some of the ethical issues in this area. Using current research, we show that there is hope for the ocean and that now is the time for the Christian community globally to actively engage with this important issue.

Are There Limits to Fishing?

Limits

In the realm of fisheries, the question of limits can be addressed on a number of scales. On a global level, most evidence supports the conclusion that current fish catch amounts are at or above the level that is sustainable in the long term.[8] In other words, globally, we are harvesting at a rate at or above the limit of what the ocean can produce. Despite this, fishing effort has continued to increase in recent years, similar to the steady increase in effort since 1950. Over the past twenty-five years, though, global fish catch has not increased despite these fishing pressure increases, again signalling that we have reached a limit.[9]

Clearly, human population globally, and especially near coasts, will have a major impact on fisheries. This effect occurs through both the interrelated factors of climate change and pollution, as well as through direct consumption of marine products. For example, several successful fisheries and livelihood development projects have, due to overpopulation, incorporated reproductive health programs into their projects.[10] Many changes are already needed to restore fisheries to their previous abundance, and even more dramatic management and societal changes will have to take place as human population increases further.

However, the story is more nuanced when we zoom in to a regional scale. In wealthier parts of the world, overfishing has taken place and continues,[11] but management changes, in some cases, have altered these trends.[12] For example, in the US, the 1996 Sustainable Fisheries Act amendment to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), the US's primary marine fisheries management legislation, more clearly defined "overfishing" and required the rebuilding of overfished stocks within specified time frames. A 2014 National Academies review committee found that overfishing has halted in twenty-three of thirty-six stocks originally subject to overfishing (i.e., fishing mortality has been reduced) and that 43% of stocks are no longer overfished (i.e., fish stock biomass has increased; ten stocks are now officially rebuilt and five are rebuilding). The committee necessarily focused only on stocks assessed quantitatively, but this included the nation's most economically important fisheries. The US stock-rebuilding approach is similar to that being used in Canada, Australia, and New Zealand. Compared to these countries, a larger proportion of European Union fisheries are overfished, though this proportion is decreasing. The sustainability of developed-world fisheries is thus a mixed and complicated landscape, but it would be incorrect to paint an entirely bleak picture and state that all of the world's fisheries are in crisis.

In much of the non-Western world, though, data are lacking, and the data that exist suggest severe overfishing is happening in many places, and particularly in smaller-scale fisheries.[13] For example, in the Wakatobi region of SE Sulawesi, Indonesia, as in many coral reef artisanal fisheries, hundreds of species of fish and invertebrates are harvested; therefore, species-specific stock assessments and comparatively well-funded management of the kind done in temperate regions are simply not feasible.[14] Data suggest that catches have declined significantly in the Wakatobi and that species have been extirpated from regions where they were once abundant.[15] Thousands of similar communities and coastlines exist around the tropical developing world, and evidence suggests similar declines in species abundance and diversity in these regions also.[16]

Another indication that we have reached a limit for fish catch in some regions has been labeled "fishing down the food web."[17] Historically, it has seemed easiest and most desirable to catch a few large fish rather than hundreds of small fish of equal total biomass. However, these kinds of large predatory fish (e.g., tuna) are less abundant in terms of overall biomass and individual abundance than smaller fish that feed lower on the food web (e.g., herring). Using these species as examples, it is sustainable to catch a few tuna each year, and nations (e.g., Japan) have done so for centuries. However, when more and more tuna or other high-trophic-level species are caught, they rather quickly become overfished, and fishers have no choice but to either charge exorbitant prices for the few large individuals they catch—as is currently happening for tuna—or switch to catching more abundant lower-trophic-level species. This trend of switching from piscivorous (fish-eating) high-trophic-level species to lower-trophic-level species has been observed in the Northern Hemisphere particularly, over at least the past sixty years, and is evidence of overfishing and switching to less desirable species from a consumer's perspective.[18]

Species extinction is a final obvious threshold commonly discussed for terrestrial and avian species. Though estimates vary, evidence now suggests that humans have indeed caused the extinction of numerous marine organisms, though there is typically a fifty-year time lag between a species' last sighting and its designation as extinct.[19] In reality, it is likely impossible for humanity to know how many marine species we have caused to go extinct. However, the vulnerability of specific marine species to human-driven extinction varies for a number of reasons. We now know, for instance, that longer-lived, later-maturing species are much more susceptible to human-driven extinction than other species.[20]

Managing Fisheries within Our Limits

The Christian relief and development community has done laudable work in the realm of agricultural relief and development, but we may need to think more deeply about how we can best serve those who rely, to varying degrees, on nonagricultural food sources such as fish. To our knowledge, few Christian agencies have attempted to serve coastal communities through trying to contribute to management and restoration of marine capture fisheries. Activities will need to include partnering with management agencies, local scientists, and community leaders; utilizing the best science to focus on reducing the number, size, and type of fish caught; and changing the use of damaging fishing gear.

When we think about managing a resource, government regulation often comes to mind. However, broader than simple government control, marine fisheries governance should be seen as a complex mix of government, market, and cultural institutions as well as individuals who guide fishing activity in most regions. Within this framework, there are a number of useful management tools that may be used to direct fishing pressure in an attempt to not reach fishing limits. We will examine individual choices in the ethics section and address other aspects here.

The general challenge that must be addressed is the fact that the ocean and animals living within it are a common property resource. In other words, no one individual owns it or them, and the benefit to one individual of taking more than his or her share is greater than the cost, which is shared among all users, thus leading to a "tragedy of the commons" if proper management is not undertaken.[21] Privatizing the resource in some way is thus one major means of managing fisheries, and it attempts to make users or those who benefit from use also pay the costs of overuse. Current examples of fisheries privatization schemes include "individual transferable quotas" and other free-market approaches.[22]

Other fisheries management techniques can generally be classified as restrictions on effort, usually in the form of gear, time, space, or some combination thereof. Gear restrictions include limits on the type of nets or boats used. Time restrictions include annual fishing "season" regulations or daily restrictions in some cases. These two are combined in some scenarios, and certain types of fishing gear can only be used during certain parts of the year, often to protect reproductively active fish or spawning aggregations. In the Bahamas, for example, Nassau grouper (*Epinephelus striatus*), one of the principle targeted finfish, is in serious decline regionally and is on the US's endangered species list. While there have been numerous protection measures implemented over the years, only recently has the Bahamian government responded to the science suggesting that closure of the fishery during annual spawning aggregation times should be implemented.[23] Throughout

the rest of its range, most previous spawning aggregations of this species have been fished to the point where they do not form any longer.[24] These aggregations have recently received significant scientific attention, and new methods and management advice are available for those species which congregate to spawn.[25]

Space restrictions have become more and more popular in recent years, mostly in the form of what are called marine protected areas (MPAs). This type of marine spatial planning limits human activity within an MPA to protect a certain species, or community of species, or spawning ground, et cetera. These MPAs are not only used as biodiversity protection tools, but can also facilitate livelihoods through tourism, for example. They are also fisheries restoration tools because fish grow larger in MPAs and, since egg production is exponentially related to fish body size, reproduction greatly increases and overflows into surrounding areas through buoyant larval transport on ocean currents.[26]

A final issue worth mentioning is that in the wealthy developed world, money can be invested in scientific assessments of fish populations and marine ecosystems, and these data fed into management plans. The same cannot be said for much of the developing world where scientific data are few or nonexistent, and money is often not available for management.[27] In a recent survey of trends in regional fisheries management successes and failures, the Indian Ocean basin scored worst in terms of compliance with United Nations fisheries management recommendations;[28] it is also a region governed primarily by developing nations. This region and other somewhat less developed areas like it (e.g., Southeast Asia) are also regions of particularly high biodiversity, leading to what some have termed a "hotspot" of fisheries management and conservation need.[29]

The Unintended Consequences to Fishing

Trophic Cascades—An Example

One of the more significant sets of findings in recent years has been a better understanding of the unintended consequences fishing has on nontargeted species. These effects are due not only to ecological interactions resulting from reductions in target populations but also to the unintended impact of fishing gear. There are both top-down and bottom-up effects which are linked through complex, multispecies interactions in trophic webs that can dramatically alter the composition of marine communities.[30]

Trophic cascades occur when the removal of targeted species in a food web causes changes in the characteristics or abundances of other species at lower trophic levels. At its most simple level, the removal of a predator releases prey abundance from predation pressure and can thus result in an increase in the abundance of that prey. One of the better-studied systems demonstrating trophic cascades in tropical marine ecology is found in Kenya. Fishing pressure is intense in coastal Kenya. Marine National Parks were created to provide refuge from fishing, and those in Kenya are some of Africa's oldest, created over forty years ago. In this ecosystem, fishermen target triggerfish (Pisces: Balistidae) which are predators of sea urchins. Urchins are grazers and control macroalgal growth. Algae compete with coral for space and, in the absence of predators, can come to dominate space on a reef. As expected and predicted, cessation from fishing resulted in recovery of targeted species including both triggerfish and herbivorous fish which feed on macroalgae, and thus sea urchin populations declined. Sea urchin population decline was sigmoidal, not linear, indicating some resistance to increased predation, but also showing an eventual succumbing to that pressure. This process was surprisingly slow—full recovery did not appear to occur until more than twenty years after fishing stopped.[31]

This case study of recovery of coral reef ecosystems where fishing has been banned through the creation of a marine protected area indicates that though there was a recovery of previously fished populations, it is unclear whether these systems recover to historic pre-fished conditions, or move toward some other stable state.[32] This new ecosystem may, in terms of trophic structure, be similar to what we might expect in a "natural" system, but the relative abundance and diversity of species at different trophic levels may be very different from that present before fishing took place.[33] Differential responses within trophic cascades between the Kenyan example and Caribbean trophic cascades[34] indicate the complexity of the situation and show that recovery in different trophic groups is at least regionally specific.[35]

The take-home message is that ecological restoration may not be as simple as removing a particular pressure on an ecosystem and allowing it to return to its "natural" state. The unintended consequences of large perturbations to systems, such as intense fishing pressure, may be that these ecosystems are altered permanently. A famous example of this is the collapse of Atlantic cod populations (*Gadus morhua*) off the northeast coast of North America and the subsequent lack of recovery despite decreases in fishing pressure.[36] At a species abundance and diversity level, removing fishing pressure does not necessarily result in a restoration to previous states. This process is long and can contain unexpected changes in species composition. Additionally, these results are region and habitat dependent.

Habitat Modification and Bycatch—Trawling as an Example

Fishing gear itself can have unintended consequences. A focus on monospecific fishing has led, for example, to significant consequences of shrimp fisheries on turtle populations. The extent and diversity of nontargeted species caught while targeting certain species (called bycatch) has become much better understood. The magnitude of bycatch in some cases is very high, for example, on average 62% of the total catch in some shrimp fisheries.[37] The extent of damage is still unknown, but recent evidence suggests rare, long-lived species such as seabirds, sharks, and marine mammals are unintentionally caught in significant numbers as nontargeted species, threatening their populations.[38]

Trawling is a fishing technique whereby a large net is pulled behind one or several boats. Bycatch is a major problem for trawling as the nets are relatively unselective and much of this unintended catch is discarded as not desirable, thus catching and killing fish unnecessarily. Large nets are held open by heavy wooden doors, and the mouth of bottom trawls is kept on the bottom by weighted chains. These bottom trawl nets are then scraped along the sea floor, removing most of what is in their path—including not-targeted, structure-forming animals such as sponges and corals. Areas of the bottom have been described as looking like a parking lot after trawlers have fished in the area for significant periods of time. Though effective at catching certain species, those species' habitat, including structure that formerly protected juveniles from predation and allowed prey populations to survive, is destroyed. Removing fish and destroying the habitat's ability to support future fish populations in this way thus amplifies the effect of fishing and contributes significantly to fisheries collapse.

Using Aid in Unintended Ways—Mosquito Net Fishing

Another example of unintended consequences relates to the use of resources for fishing which had originally been intended for other purposes. Recently, one of our churches focused their Lent appeal on raising funds to buy mosquito nets for a project in Africa. Malaria ravages many communities in that continent, and Christians have rightly sought to alleviate this menace. However, once these nets have holes in them and aid agencies replace them, the old nets are put to other uses, such as fishing. Mosquito net fishing has become a big problem in many countries as the small-mesh nets catch fish down to a very small size. These can be juvenile fish that spend the beginning of their life in nutrient-rich shoreline and mangrove habitats.

Unpublished, recent research near A Rocha Kenya's field study centre found that coastal communities were using these old mosquito nets for fishing.[39] However, it was not at the expense of malarial protection—there were plenty of new nets available such that anyone who wanted to sleep under one could. Small children practiced fishing with these old nets and, at certain times, particular fish species were targeted with them. However, there was also a group of young men, with little access to resources of their own, who used these nets as an important part of their fishing arsenal. We are not suggesting that organizations stop donating mosquito nets to prevent malaria. However, one must realize that there may be unintended consequences to aid and that, in this case, there is a need to think clearly through not only the distribution but also the collection of these nets such that our aid can be more holistically effective.

Aquaculture: Part of the Problem and Part of the Solution

Recent global data on fisheries and aquaculture suggest that fisheries and aquaculture are quickly becoming equivalent in their contribution to world marine food production.[40] Is fish farming the answer

to marine capture fisheries issues? We are now able to keep in captivity, spawn, and raise from larvae many marine fish. Yet, sometimes, the cure can be as bad as, or worse than, the illness.

While acknowledging that aquaculture is a necessary and, in many cases, efficacious supplement to marine capture fisheries, it is important to understand the limits and issues regarding its implementation. These problems include the spread of fish diseases through overcrowding, habitat destruction for farm construction, poor food conversion efficiencies when raising top-level predators, and ethical issues such as the export of luxury protein to developed countries from areas of protein deficiency.[41] Fish may also problematically escape into the wild from cages.[42]

Community-based aquaculture is an important recent innovation, especially when combined holistically with conservation programs. These aquaculture programs are run by means of local authority structures, usually with the outside technical help of an international NGO. For example, throughout the Indo-Pacific, sea cucumbers have been fished to the point of commercial extinction in most places.[43] Demand from Asian markets has driven prices up to the point where there is incentive to hunt even the last individual. Recent research has focused on farming the most popular target species to restore wild populations while also meeting demand.[44] An international NGO called Blue Ventures has developed a community-based aquaculture project in Madagascar where local communities benefit from the high prices of sea cucumbers by growing them in family- and community-owned grow-out pens in the ocean.[45] This is combined with education focused on the ecology and conservation of these habitats and on the development of protected areas, such that remaining resources are receiving lower fishing pressure and are being restored to previous levels.[46]

Restoration Ecology—Coral Reefs as an Example

It is possible to restore these habitats that have been destroyed by harmful fishing gear. Obviously, the methods and means are habitat dependent, and we will here discuss only one hopeful example based on our experience. The authors have both seen firsthand the destruction that dynamite fishing causes on coral reefs of the Coral Triangle. This is an area of high biodiversity focused in a triangular region that covers portions of Malaysia, Indonesia, Papua New Guinea, Timor Leste, Solomon Islands, and the Philippines. Fishing has become so intense in parts of this region that many fishers have resorted to using homemade dynamite bombs, which get dropped onto the reef, explode, and kill fish, causing the catch to float to the top of the sea. Underwater, though, the structure of the reef is devastated.[47]

Off the eastern tip of Sabah, Borneo, work in a marine park has focused on beginning to restore these reefs—giving them a helping hand. The coral fragments created in explosions move with tides and currents, making it difficult for corals to settle without assistance. Local governing authorities and a UK-based NGO have worked toward establishing metal frames secured to the ocean floor where small pieces of live coral can attach, grow, and eventually cover the frames, creating new coral structures.[48] Aquaculture is also being used to release overfished species, such as giant clams, into a national park that was created to protect these habitats. Additionally, education and aid projects aimed at the local sea nomadic communities (Bajau), who fish these species, round off a holistic restoration project. This is a long-term, very difficult, and expensive route to take. Protection from habitat destruction in the first place would be much more effective. However, where there has been devastation, there is also hope, and new technology and practices such as coral transplantation can assist.

Given What We Know, Is It Ethical to Eat Fish?

The timeline of scripture is forward looking. We move from creation through the Fall and redemption to the new creation. So while we do not want to focus our efforts on a re-creation of Eden, we can get hints of what was supposed to be from Genesis and also glimpses of what will be from Revelation. In Genesis 1:20–22 (NIV),

> And God said, "Let the water teem with living creatures, and let birds fly above the earth across the vault of the sky." So God created the great creatures of the sea and every living thing with which the water teems and that moves about in it, according to their kinds, and every winged bird according to its kind. And God saw that it was good. God blessed them and said, "Be fruitful and increase in number and fill the water in the seas, and let the birds increase on the earth."

Concepts from this passage that are particularly helpful as we consider marine populations include abundance, diversity, and distribution.

The waters are meant to "teem with living creatures," or, to put this in more modern terms, there is to be *abundance*. We have seen previously how, for most places on the earth, this no longer describes our marine waters. We also note the marine biodiversity here, with specific reference to the great creatures of the sea (i.e., higher trophic levels). All of this diversity was declared good. It is not enough that there is an abundance of jellyfish or lower trophic-level creatures teeming at this point, because we have not yet fished down the food chain far enough to impact their numbers. Revelation 5:9–13 is a picture of the throne of God and all creation before it worshiping. One of the words in verse 13 which stands out is the word "every."

> Then I heard every creature in heaven and on earth and under the earth and on the sea, and all that is in them, saying: "To him who sits on the throne and to the Lamb be praise and honor and glory and power, for ever and ever!"

The new creation will be a place where the entire range of diversity is meant to worship the Creator. While we cannot say with biblical authority that every marine species that ever existed will be before the throne of God, this passage does give us hints that there will be a wide range of creatures. As we move toward the new creation, that abundant marine biodiversity must be present not only in a few places globally, such as well-protected MPAs, but also as a normal description of the ocean wherever we might go. Distribution is important.

As consumers, we must consider the type of seafood we eat and in what quantities we eat it;[49] it takes additional effort to understand which types of seafood are best to eat to promote the sustainability of fisheries. Increased demand for seafood as a healthy alternative to beef, for example, needs to be tempered such that the increased demand is for sustainably wild-fished species, and that it does not contribute to some of the aquaculture problems noted above. When we know that our tastes for certain species cause local or global extinctions—so that God is not glorified by the full range of biodiversity—then, as wise stewards, we must restrain our consumptive desires. Scientific study can help us make these decisions by providing an understanding of the effects of our actions on marine biodiversity. Our Christian moral framework must then direct our application of this knowledge in subsequent consumer choices.

The links between over-exploitation of marine resources and poverty are clear. Poverty in many people's minds primarily refers to money, as evidenced by the oft-quoted measure of poverty, "living on less than one dollar a day." Yet global analyses of poverty related to natural resources reveal much more nuanced and all-encompassing definitions, including the concept that poverty is actually a web of broken relationships.[50] Thus, as we consider the ethics of eating fish and its relationship to poverty, we must consider more than whether or not our actions or inactions affect a family's ability to place a fish on a table to eat.

Recent attempts to alert consumers to fisheries issues through labeling fish products as sustainably harvested have met with mixed reviews as to their efficacy.[51] While perhaps helpful for raising awareness, and for individually allowing us to choose fish which meet the Genesis 1 and Revelation 5 criteria of abundance, diversity, and distribution, they do not address the more difficult ethical questions raised above. The situations are complex, and understanding the exact poverty issues raised by putting a particular marine animal on your plate is not practical for most consumers. Yet we must begin to ask these questions and help people understand that the problem of fisheries and marine conservation requires answers that not only affect coastal towns but also anyone, anywhere, who is looking for a box of fish fingers in the aisles of their local grocery store. What we buy has a dramatic impact on our neighbor in far-flung places on our blue planet.

As Christians, we are, after all, called to love our neighbor. As the parable of the Good Samaritan teaches us, we must be careful when asking that question of Jesus, "And who is my neighbor?" The link between poverty, conservation, and loving our neighbor was clearly demonstrated and summarized by Boorse et al.[52] In regard to this question of eating fish, the links are clear. We must love our neighbors in what we eat. A significant proportion of Europe's fishing fleet has been deployed to less-fished areas of the world, in particular West Africa, in search of seafood to meet demand.[53] Governments make arrangements to fish inside a country's boundaries, but the foreign countries usually do not contribute

to local infrastructure or economics as fish are taken directly to Europe without landing or processing in West Africa; the fishermen from other countries may compete for resources with local fishermen. This is just one example of how our choices regarding the quantity and species we consume, and our choice of where these organisms are caught, can have a profoundly loving or unloving result.

There are many ethical issues involved in fishing, ranging from the potential pain and suffering inflicted on those animals caught, to what has been called "perverse" government subsidies of fisheries.[54] Some of these ethical issues were addressed in detail in the book *Values at Sea: Ethics for the Marine Environment*.[55] Generalizing, it is interesting that many of the authors in this edited volume suggest that we focus on the sea's value to humans and move away from talk of intrinsic value. As Christians, though, we must value the sea and its inhabitants in and of themselves—because God created them and called them good. Then, alongside this intrinsic value, we, of course, must not forget the value of these resources to humans. This call to intrinsic value may seem idealistic or naïve when considered in light of human suffering. Yet by embracing Genesis 1 and God's declaration of creation as good, even prior to the existence of humans, we see that such a worldview shift could have huge implications for grounding our actions toward creation in love.

If we have as our worldview a metanarrative that places ourselves in the center with creation there to serve us, we face a huge uphill battle to not ground creation care in anthropocentric thinking. But a radically Christocentric metanarrative of scripture that places the focus on God and his work on the cross to redeem all of creation from the results of the Fall, focuses our attention rightly on God's glory and his story which includes his valuing of creation as good, independent of its value in relation to us.

The Conclusion of the Matter?

Each topic above deserves an entire book, and there are many areas we have not had time or space to address. Yet we hope that it is clear from the examples given that marine capture fisheries in many places are at or beyond a point of crisis—we have reached or surpassed limits. It is also clear that the ways in which we have fished have had unintended, or intentionally ignored, consequences and that there are many ethical and theological issues we have only begun to consider as a Christian community. Jesus spent a lot of time with fishermen, loved them, cared for them and, dare we say it, learned from them[56]—we should do likewise.

What are the implications, then, for Christian scientists, relief/development agencies, and churches? Marine capture fisheries have received little attention from the broader Christian community, and it is time for this to change. We are hopeful that the global Christian community can make an important contribution toward the restoration of the oceans and that God may be glorified as we live out a more comprehensive stewardship of the complete breadth of his creation. We do not have to reinvent the wheel—there is much we can learn from what has already been done, regardless of the source. A recent global symposium on marine protected areas summarized its output in six broad points, the last of which focused on, among other things, the spiritual value of the sea.[57] Thus, even in historically secular circles, the opportunity and time has come for local churches to work together with Christian NGOs and scientists to extend the creation care movement to the other 71% of the planet. We certainly hope that this is not the concluding word on this matter, but the beginning of a conversation and set of actions in which we are all more actively engaged in the appreciation, restoration, and conservation of the ocean.

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Meric A. Srokosz

Geoengineering or Planet Hacking?

M. A. Srokosz

With climate change occurring due to increasing levels of carbon dioxide in the atmosphere, one solution that has been proposed is the technological one of geoengineering. This means that we (human beings) would "solve" the problem of increasing carbon dioxide by applying an engineering solution on a planetary scale. Various geoengineering solutions have been proposed, including carbon capture from the atmosphere and storage, ocean iron fertilization, adding reflective aerosols into the lower stratosphere, spraying seawater into the atmosphere to enhance marine clouds, launching giant reflectors into space to reflect sunlight, and so on. All these solutions raise ethical questions such as who decides which of these options is safe to pursue? what will be the impact of the proposed solution on people living in different parts of the planet, particularly on the poor? can a country pursue one of the options unilaterally? This article explores these issues and tries to bring a Christian perspective to them.

The title of this article, "Geoengineering or Planet Hacking?" is deliberately provocative in that the question of whether we (human beings) can engineer a solution to the problem of increasing levels of carbon dioxide in the atmosphere is an emotive one. At one end of the spectrum lie those who think that human technological ingenuity can solve almost any problem. At the other end of the spectrum are those who, aware of the hubris from which humanity so easily suffers, think that any attempt to mess with Earth's natural environment is more like computer hacking, likely to cause more harm than good, and morally questionable.

Polarization of views and inevitable adversarial responses are often the outcome of discussions on this topic, so generating more heat than light. For Christians the question arises: is there a biblical perspective that can be brought to bear on the question? This article seeks to explore this issue. At the very least, Christians are called to be peacemakers (Matt. 5:9) and perhaps called to shed light on the issue rather than simply generate heat.

The Problem

Climate change denial continues to plague the discussion of the impact of fossil fuel use (coal, gas, oil) by human beings on Earth and how humanity should respond. However, scientifically, the observations both of increasing carbon dioxide (CO_2) in the atmosphere, which in 2013 exceeded 400ppm for the first time in the recent geological past,[1] and of global warming are difficult to deny. The recent publication of the Working Group I (WGI) IPCC fifth assessment report (AR5)[2] strengthens the

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evidential basis for human-induced climate change and states

> Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.

It goes on to say that

> Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system.

and

> It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.

Furthermore:

> Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.[3]

In light of the above, there is a clear need to cut the amount of CO_2 in the atmosphere and so reduce the potentially devastating effects that global warming is likely to inflict on the planet. The impacts will be particularly severe for those living in more vulnerable areas of the earth who are, to use biblical terminology, the poor and the needy of the earth.

The best solution is that we (human beings) take the actions necessary to limit climate change, namely by making "substantial and sustained reductions of greenhouse gas emissions." However, to date and on a global scale, there has been little progress on implementing this solution. The lack of political will is evident in the outcomes of the various recent so-called COP (Conference of the Parties) meetings linked to the United Nations Framework Convention on Climate Change (UNFCCC). The lack of progress in substantially reducing greenhouse gas emissions has led some to propose an alternative approach—that of geoengineering—which is aimed at mitigating, by technological means, the effects of continued emission of CO_2 and other greenhouse gases.

Some Geoengineering Solutions

A recent UK Royal Society report has reviewed various geoengineering proposals and the reader is referred to that report for more details.[4] In this article, only a brief description of some of the proposed geoengineering solutions is given. As noted in the report, the solutions can be classified in two categories: (1) CO_2 removal techniques; and (2) solar radiation management. The former mitigates the effects of climate change by seeking to remove CO_2 from the atmosphere; the latter seeks to reflect some of the sun's light and heat back into space. Note that the former approach also has the advantage of reducing the impact of ocean acidification due to increasing CO_2,[5] while the latter does not. In this brief article, there is not space to describe all the possible techniques, so only a few examples of the two types will be discussed—sufficient to illustrate the ethical issues that geoengineering raises.

Carbon Dioxide Removal

Atmospheric carbon capture and storage: Essentially the idea is to capture the CO_2 from the atmosphere and then store it (possibly in liquid form). Various methods have been suggested to capture the CO_2, and it is unclear how effective these would be in practice (some are similar to those being developed for carbon capture from power plants). Perhaps a more challenging issue is how to dispose of the captured CO_2, and proposals include pumping the liquefied gas into oil- or gas-field reservoirs that have been exhausted of their resources. Of course, the problem is that, in the longer term, there may be leakage (akin to the problem with storing radioactive waste). If the leakage were abrupt and severe, it could raise the CO_2 levels in the atmosphere rapidly, seriously exacerbating the global warming problem.

Ocean iron fertilization: CO_2 is absorbed into the ocean and used by photosynthesizers (mainly algae—microscopic plants) in their growth. Some of this carbon makes it into the deeper ocean as part of the food chain in the form of organic matter, faecal pellets, and detritus. As it sinks, some portion is consumed by bacteria, and CO_2 is released back into the water at depth. This so-called "biological pump" influences the concentration of CO_2 in the surface waters and thus its absorption from the atmosphere. Potentially the biological pump could draw down more CO_2 into the ocean if more algal growth could

be stimulated in the ocean surface waters. The limiting factor for such growth is usually nutrients, and in some regions of the ocean (for example, in the large expanse of the Southern Ocean), iron is the limiting nutrient. Hence it has been proposed that ocean iron fertilization could lead to the enhancement of the biological pump and thus to a reduction of atmospheric CO_2.[6] However, by this means, only a small fraction of the carbon will make it into the deep ocean or into the ocean sediments.[7]

Solar Radiation Management

Injection of sulphate aerosols into the lower stratosphere: In some respects, this proposal mimics the effect of volcanic eruptions that increase the aerosol load in the atmosphere and that cool the earth by the reflection of sunlight. Significant dips in global air temperatures have been observed following major volcanic eruptions.[8] If the sulphate aerosol load could be increased sufficiently in the lower stratosphere, where such aerosols already occur naturally, then this would lead to a cooling of the planet.[9] The delivery of the sulphate aerosols or their precursors (e.g., hydrogen sulphide or sulphur dioxide) to the lower stratosphere would need to be ongoing and the delivery method would need to be by aircraft, rocket, or balloon.

Enhancement of marine cloud reflectivity: In rather simplified terms, if the number of cloud condensation nuclei (CCNs) could be increased in those areas of the marine atmosphere that are relatively dust free, then the low-level marine cloud albedo could be increased, thus reflecting more sunlight back to space. One idea is to generate the necessary CCNs from seawater by producing fine particles of sea salt that are sprayed into the atmosphere above (possibly from a ship).[10] Of course, this method requires, as with the previous one, an ongoing generation of CCNs to be effective.

Solar reflectors in space: This would require the launching of solar radiation reflectors into near-Earth orbit so that they could intercept the sunlight falling on the planet. Basically, the idea is that of "mirrors in space." Probably a large number of small reflectors would be deployed. An alternative would be to place a reflector at the so-called Lagrange point 1 (L1) about 1.5 million km from the earth. There the effect of the sun's and the earth's gravitational pulls are such as to ensure that the reflector remains stably in place between the two as the earth orbits the sun.

It should be noted that all of the proposed geoengineering solutions have both technical problems, in terms of implementation, and potential drawbacks, in terms of impact.[11] In addition, there is also the potential for things to go wrong. For example, should an implemented means of solar radiation management fail, there could be a consequent rapid rise in global air temperatures with potentially catastrophic effects. As noted above, a similar problem could arise with CO_2 storage. Should the storage solution fail, then there could be a significant release of CO_2 into the atmosphere, thus accelerating global warming in a potentially catastrophic manner.

The Ethical Questions

While the proposed geoengineering solutions raise many interesting technical and scientific questions, not least the simple one of "Will they work?," they also raise ethical questions regarding their development and use. Preston gives a comprehensive discussion of the ethics of geoengineering but does not consider a Christian perspective.[12] Here some of the key questions are highlighted to set the scene for a possible Christian response.

The first question is whether geoengineering solutions should be considered at all. Would this simply allow people to avoid tackling the problems of human-induced climate change by the obvious expedient of reducing our carbon emissions because they think that there is a technological fix "just around the corner"? Therefore, even considering geoengineering may be problematic from an ethical perspective. It could encourage an irresponsible attitude in people regarding future fossil fuel use.

Given the many uncertainties surrounding geoengineering, the next question is, should research be carried out to examine the potential and the pitfalls of the various geoengineering options? If research is acceptable, what type of research? Theoretical and modelling work has no actual impact on the planet, whereas the addition of sulphate aerosols to the stratosphere or iron to the oceans does.[13] There is also the question of the scale of any experimental work—at what scale do such experiments become

unacceptable because of their possible (perhaps unknown) consequences? Who decides?

Assuming that research suggests that a particular geoengineering approach may be feasible, who has the right (or, more likely, the power) to decide that it should be implemented? What if the solution leads to uneven benefits across the globe, alleviating problems in one area and exacerbating them elsewhere, while overall being good for the planet as a whole? Will the rich and powerful impose their preferred solution on the weak and vulnerable? History would suggest that this is not an unlikely outcome, but is it an acceptable one?

Finally, assuming that a geoengineering solution has been implemented, what is the "exit strategy"? How do you decide whether a geoengineering solution is no longer necessary and should be discontinued? What might be the consequences of such a decision—who benefits and who might suffer?

The standard ethical approaches to such questions fall into three main categories:[14]

1. consequentialist: in which the value of the outcome is the primary consideration;
2. deontological: in which the "right" thing to do is the primary consideration and the outcome is secondary;
3. virtue-based: in which character-related issues, such as arrogance, are the primary consideration.

None of these takes into account the existence of the Christian God per se, nor the possible implications of that existence for ethical decision making with regard to the questions raised by geoengineering.[15] The Royal Society report gives very little space to ethical considerations and concludes, with regard to ethics, that

> many of the ethical issues associated with geoengineering are likely to be specific and technology dependent.

and that

> overall it is clear that ethical considerations are central to decision-making in this field. However when evaluating the role that different approaches to geoengineering could play, it is not possible to make simple yes or no decisions on the basis of ethical reasoning.[16]

Therefore, the question arises: is there a specifically Christian ethical stance than could or should be taken on the issues raised by geoengineering?

A Possible Christian Response

To begin with, it is worth noting that there is probably no single so-called "Christian response" that can be made to the issues raised by geoengineering. Therefore, what follows is a possible response, aimed at stimulating thinking and discussion, and certainly not the "last word" on the topic.[17] Many approaches can be adopted in developing Christian ethics,[18] and it goes beyond the scope of this brief article to interact with them. Instead, a number of key issues will be addressed and possible responses proposed in a more ad hoc fashion.

In an earlier paper, I outlined an approach to environmental ethics based on the biblical metanarrative (the "big story" of the Bible—creation through to new creation—Genesis to Revelation).[19] This drew on the work of Christopher Wright[20] and Tom (N. T.) Wright.[21] It is not my purpose to repeat the arguments of that paper here. Rather, I want to pursue two aspects of that thinking that seem relevant to the issue of geoengineering. First, the need to think and live eschatologically: that is, in the light of the future God intends for his creation.[22] Second, the need to return to Jesus's first and second commandments—to love God and to love our neighbor (Matt. 22:37–40)—when thinking through issues related to the ethics of geoengineering.

Since the concept of thinking and living eschatologically may be less familiar to readers than Jesus's commandments, I will briefly describe what this means here.[23] Focusing on the ultimate end (*eschaton*) should affect our ethical thinking in the here and now, as it holds forth a picture of a future reality which has already begun through Jesus's death, resurrection, ascension, and sending of the Holy Spirit (this is the "now and not yet" aspect of the kingdom of God).[24] Therefore, it would be inconsistent for believers to continue acting as if this future hope had no present relevance.[25] As part of living eschatologically, we are aiming to realize the prayer, "your kingdom come, your will be done on Earth as it is in heaven" (Matt. 6:10). This means that we are working in the present for an earth that reflects the

coming new creation, in part, because of the continuity between this world and the one to come.[26]

Romans chapter 8 suggests that there is both continuity and discontinuity between the present creation and the new creation, just as there is between our present bodies and our resurrection bodies. The latter is exemplified in Jesus, whose resurrection body was clearly both different from, yet similar to, his mortal body (Luke 24:13–49; John 20:19–29). As Tom Wright states,

> Jesus' resurrection is the beginning of a new project … to colonize Earth with the life of heaven. That, after all, is what the Lord's prayer is about …
>
> When the final resurrection occurs, as the centrepiece of God's new creation, we will discover that everything done in the present world in the power of Jesus' own resurrection will be celebrated and included, appropriately transformed.[27]

Therefore, how we live and, in this context, how we treat God's Earth, will, in some way, affect the new creation to come, and this should shape our thinking and our behavior in the present.

Having discussed what it means to think and live eschatologically, it is now time to examine the ethics of geoengineering. Perhaps the most worrisome and important aspect from a Christian perspective is that the geoengineering approach to solving the climate change problem is, at the bottom line, the potential that one of the technologically advanced and richer nations might impose its will on the less technologically advanced and poorer nations. Given the biblical emphasis on God's concern for the poor and needy[28] and Jesus's second commandment to love our neighbor (as noted above), it is clear that from a Christian perspective any potential geoengineering solution must meet God's requirement of love and justice for the poor and needy of this world. Therefore, any geoengineering solution that further disadvantages the poor and needy of the earth must be deemed unacceptable. For example, should a solar radiation management geoengineering solution lead to cooling of the earth overall, but at the cost of changed weather patterns that lead to increased drought in sub-Saharan Africa, where people are already starving and dying due to drought, this would not be acceptable. Of course, to determine the acceptability, or otherwise, of any proposed geoengineering solution requires research, though it is arguable whether research per se would ever provide a sufficiently robust answer on which to base a decision.

If the need for love and justice for the poor and needy has been satisfactorily addressed, what else should Christians take into account when assessing whether geoengineering solutions should be pursued? Let's begin with the simplest issue: should geoengineering be considered at all? From an eschatological point of view, the new creation will not require geoengineering, so perhaps we should learn to live in this creation in a way that does not require it either. However, this is hardly a decisive argument as there are many other things that will not be required in the new creation, but are required in the here and now—medicine being the most obvious example. Turning then to Jesus's commandments, loving God clearly includes caring for his creation.[29] If geoengineering is likely to become an excuse for not caring for God's creation, that is, an excuse for humanity to continue to misuse and harm the earth, then it should not be considered at all. Given the sinful nature of human beings this point needs to be taken seriously. In contrast, the criterion of loving our neighbor might lead to the opposite conclusion if we are convinced that a geoengineering solution might help those in greatest need—the poor of the world. This leads naturally to the question of research.

Should geoengineering research be pursued? An eschatological perspective does not seem to offer much guidance here. However, the commands to love God and to love our neighbor perhaps do. Our creative abilities, including the ability to do science and engineering, are God given and their pursuit is one means of serving and loving him. Likewise, research can be to the benefit of our neighbor, thus, an expression of love—medical research being a good example.[30] In a similar manner, it may be argued that we should pursue geoengineering research as it may provide a "cure" for an "ill" Earth (to use a perhaps questionable medical analogy). The question is whether the "cure" is worse than the "illness." Here, the particulars of any geoengineering solution have to be taken into consideration, but research may help us to delineate the advantages and disadvantages of different geoengineering proposals. Therefore, we might conclude that carrying out research in geoengineering is acceptable.[31]

Should research show that a geoengineering solution might be acceptable, the next question that arises is, should it be implemented? Here an eschatological perspective comes into play. As Christians, we are to live in the light of the future (as noted above), and, in some sense, what we do now affects the new creation. Jesus's wounds were visible after the resurrection (John 20:25–27), so perhaps the "wounds" that we inflict on the earth will be too?[32] This surely requires that any decision regarding geoengineering must be one that is for the good of the earth rather than for doing it harm. For example, injecting sulphate aerosols into the atmosphere could lead to an increase in acid rain. Though this is thought to be a small effect, it could be a significant impact in areas that do not already suffer from the effects of acid rain.[33] Therefore, here each geoengineering proposal needs to be evaluated in this light as a first step.

The next step is to consider Jesus's two commandments. Loving God surely means caring for what he created: after all, "the Earth is the Lord's" (Ps. 24:1). Christopher Wright states,

> Trashing someone else's property is incompatible with any claim to love the other person.
>
> … our treatment of the earth will be … a measure of our own relationship with the creator …[34]

Therefore, any geoengineering proposal must be compatible with caring for God's Earth. Again, the geoengineering solutions will need to be evaluated on a case-by-case basis. This may be a problematic criterion to apply in practice, as our mistreatment of the earth in terms of fossil-fuel use may lead to consequences in which the application of a geoengineering solution may be the lesser of two evils (do nothing vs. do something). Fortunately, we are not yet at that stage and, as noted in the Royal Society geoengineering report,[35] the safest way to ameliorate human-induced climate change is to cut back human emissions of greenhouse gases. Unfortunately, however, this is a solution that western society seems to find hard to accept.[36]

Perhaps the decisive commandment in considering the implementation of a geoengineering solution is Jesus's second one, to love our neighbor as ourselves. As noted earlier, the Bible suggests that God has a special care for the weak and the needy of the earth, and if we are to love our neighbor, we too have to care for the weak and needy, as he does. Since global warming is leading to changing weather patterns that have the most impact on the marginalized of this world, it is likely that some of the geoengineering proposals will do the same. For example, it is almost certain that solar radiation management will have an effect on the earth's weather as incoming solar radiation drives our weather on a global scale. In contrast, carbon capture and storage may have less impact. Perhaps research will clarify the scale and the size of the impact of particular geoengineering solutions, thus enabling a more informed approach in considering the ethical issues. However, given the complexity of the earth's system, research may not provide clear answers.

In addition, all research suffers from some limitations and the actual implementation of a geoengineering solution may have unforeseen consequences that cannot be anticipated in advance (a not uncommon problem in moving from scientific idea to technological implementation). What is clearly unacceptable is the imposition of a geoengineering solution without the consent of the people who will be affected by it. Unfortunately, there are already people travelling down this road, as shown by a relatively recent unauthorized and unethical attempt to carry out ocean iron fertilization on a large scale.[37]

Finally, assuming that a geoengineering solution has been implemented, what needs to be considered in making the decision as to when and how it should be curtailed? This can be dealt with briefly as the issues that this raises are similar to those discussed regarding the implementation of a geoengineering solution. The impact on the earth and on the poor and needy are the key considerations that need to be taken into account again.

To conclude this discussion, I note that, in all this, there is the constant danger of hubris. Too often scientists and engineers have thought that we can solve the world's problems through science and engineering, only to find that the solution creates more problems than it solves. In approaching all the issues—ethical and practical—related to geoengineering, it is good to take note of the fact that humility is a uniquely Christian virtue and an antidote to hubris.[38] Therefore, we should adopt a humble approach, following in Jesus's footsteps.

Conclusions

Geoengineering or planet hacking? Which group should the Christian side with in this debate? Those who have confidence in human technological solutions to the problem of increasing atmospheric CO_2? Or those who, wary of human hubris, see these efforts as planet hacking—more likely to cause harm than good?

The above shows that there is no simple or even single Christian answer to these questions, and taking sides is unlikely to lead to much progress. However, taking a cautious approach and being willing to admit that there is much that we do not know seems a wise way forward (applying humility). It may be that the earth's condition will become so dire due to global warming that geoengineering may be the only solution, but that point seems to be some way off yet. In the meantime, applying the approach outlined above, based on an eschatological perspective and Jesus's first and second commandments, should enable us to begin to address the ethical issues raised by geoengineering from a Christian perspective.

Acknowledgments

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Notes

[1]N. Jones, "Troubling Milestone for CO_2," *Nature Geoscience* 6 (2013): 589.

[2]IPCC, *Climate Change 2013—The Physical Science Basis*, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge: Cambridge University Press, 2013).

[3]All the quotes are taken from the IPCC *Climate Change 2013—The Physical Science Basis*, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Summary for Policymakers (Switzerland: IPCC, 2013), 2, 13, 15, and 17. With regard to the recent "hiatus" in global temperature rise, see K. E. Trenberth and J. T. Fasullo, "An Apparent Hiatus in Global Warming?," *Earth's Future* 1 (2013): 19–32.

[4]Royal Society, *Geoengineering the Climate: Science, Governance and Uncertainty* (London: Royal Society, 2009), http://royalsociety.org/policy/publications/2009/geoengineering-climate/.

[5]On ocean acidification, see Royal Society, *Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide*, Policy Doc. 12/05 (London: Royal Society, 2005), http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2005/9634.pdf.

[6]J. H. Martin, "Glacial-Interglacial CO_2 Change: The Iron Hypothesis," *Paleoceanography* 5 (1990): 1–13; R. S. Lampitt et al., "Ocean Fertilization: A Potential Means of Geoengineering?," *Philosophical Transactions of the Royal Society A* 366 (2008): 3919–45.

[7]Lampitt et al., "Ocean Fertilization."

[8]See, for example, P. Minnis et al., "Radiative Climate Forcing by the Mount Pinatubo Eruption," *Science* 259 (1993): 1411–5.

[9]This proposal has been given more credence due to being advocated by the Nobel prize winner Paul Crutzen. P. J. Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?," *Climatic Change* 77 (2006): 211–20.

[10]S. Salter, G. Sortino, and J. Latham, "Sea-Going Hardware for the Cloud-Albedo Method of Reversing Global Warming," *Philosophical Transactions of the Royal Society A* 366 (2008): 3989–4006. Interestingly, Salter was one of the pioneers of alternative energy in the 1970s, namely of wave power (S. H. Salter, "Wave Power," *Nature* 249 [1974]: 720–4). Had these ideas been pursued more seriously by governments then, this might have led to significant availability of non-CO_2 producing forms of energy by now, thus alleviating the current climate change problems.

[11]Royal Society, *Geoengineering the Climate*.

[12]C. J. Preston, "Ethics and Geoengineering: Reviewing the Moral Issues Raised by Solar Radiation Management and Carbon Dioxide Removal," *WIREs Climate Change* 4 (2013): 23–37. He does not consider a Christian perspective; hence, I am writing this article.

[13]At this point, I should declare a personal interest. I am involved in computer modeling studies of ocean iron fertilization: see J. Robinson, E. E. Popova, A. Yool, M. Srokosz, R. S. Lampitt, and J. R. Blundell, "How Deep Is Deep Enough? Ocean Iron Fertilization and Carbon Sequestration in the Southern Ocean," *Geophysical Research Letters* 41 (2014): 2489–95.

[14]See section 4.3 of Royal Society, *Geoengineering the Climate*.

[15]Note that there are Christian versions of the ethical approaches listed here. For example, Tom Wright, *Virtue Reborn* (London: SPCK, 2010), takes a Christian virtue ethics approach.

[16]Royal Society, *Geoengineering the Climate*.

[17]Since this article was originally submitted (February 2014), a book was published in April in the UK relevant to the topic: M. Northcott, *A Political Theology of Climate Change* (London: SPCK, 2014). Chapter 3, "Engineering in the Air," discusses geoengineering, placing it in the larger context of climate change. However, Northcott's book focuses on developing a political theology rather than addressing the ethics of geoengineering per se.

[18]See, for example, R. Hays, *The Moral Vision of the New Testament: A Contemporary Introduction to New Testament Ethics* (London: Continuum, 1997); B. Witherington, *The Indelible Image: The Theological and Ethical Thought World of the New Testament*, vol. 1, *The Individual Witnesses* (Downers Grove, IL: InterVarsity Press, 2009); B. Witherington, *The Indelible Image: The Theological and Ethical Thought*

World of the New Testament, vol. 2, *The Collective Witness* (Downers Grove, IL: InterVarsity Press, 2010). Surprisingly, B. Brock, *Christian Ethics in a Technological Age* (Grand Rapids, MI: Eerdmans, 2010), discusses neither climate change nor geoengineering, and there is only passing mention of environmentalism and of engineering.

[19]M. A. Srokosz, "God's Story and the Earth's Story: Grounding Our Concern for the Environment in the Biblical Metanarrative," *Science and Christian Belief* 20 (2008): 163–74.

[20]See C. J. H. Wright, *The Mission of God: Unlocking the Bible's Grand Narrative* (Nottingham: IVP, 2006).

[21]See N. T. Wright, *Surprised by Hope* (London: SPCK, 2007).

[22]This would be the equivalent of the new creation "lens" that Hays's *Moral Vision* uses in considering ethical issues (along with the cross and community).

[23]For a more detailed exposition, see N. T. Wright, *Surprised by Hope* and Srokosz, "God's Story and the Earth's Story."

[24]On the "now and not yet" of the kingdom of God, see the reprinted and now classic text, G. E. Ladd, *The Presence of the Future* (Grand Rapids, MI: Eerdmans, 1996).

[25]This also negates Marx's criticism of religion as the opiate of the people and the unreality of the more recent Left Behind series of books, as it avoids escapist fantasy.

[26]On the continuity/discontinuity between the present creation and the new creation, see M. B. Stephens, *Annihilation or Renewal: The Meaning and Function of New Creation in the Book of Revelation* (Tübingen: Mohr Siebeck, 2011).

[27]N. T. Wright, *Surprised by Hope*, 305 and 306.

[28]There are too many references to quote them all but see, for example, Deuteronomy 15:11; Psalm 72:12–13; Proverbs 22:22–23; Isaiah 3:15; and Mark 10:21.

[29]Srokosz, "God's Story and the Earth's Story."

[30]I hasten to add that I do not think that all medical or other research is done out of love for God or for our neighbor. There are too many counterexamples. For the Christian, I think that the saying attributed to St. Bernard of Clairvaux is apt:

> There are many who seek knowledge for the sake of knowledge: that is curiosity. There are others who desire to know in order that they may themselves be known: that is vanity. But there are some who seek knowledge in order to serve and edify others: and that is love.

[31]Given my earlier confession that I am involved in geoengineering research, it might be argued that my view here is not entirely objective. I am willing to concede that point in light of Jeremiah 17:9, but I am happy to leave God to judge, as in 1 Corinthians 4:4.

[32]Subsequent to writing this, I discovered that D. Wilkinson, *Christian Eschatology and the Physical Universe* (London: T&T Clark, 2010) makes a similar point in his chapter 7 on "The Future of Matter." In fact, the whole book is very relevant to the eschatological perspective taken here.

[33]P. J. Rasch et al., "An Overview of Geoengineering of Climate Using Stratospheric Sulphate Aerosols," *Philosophical Transaction of the Royal Society A* 366 (2008): 4007–37.

[34]C. Wright, *The Mission of God*, 414 and 403.

[35]Royal Society, *Geoengineering the Climate,* ix, "Headline Messages."

[36]Although other nonwestern nations now emit significant amounts of greenhouse gases, the western nations have most benefited from such emissions in the past. Therefore, it could be argued that they should make sacrificial cuts in emissions first, recalling Jesus's words, *"From everyone who has been given much, much will be demanded; and from the one who has been entrusted with much, much more will be asked"* (Luke 12:48).

[37]M. Lukacs, theguardian.com, October 15, 2012, http://www.theguardian.com/environment/2012/oct/15/pacific-iron-fertilisation-geoengineering.

[38]M. A. Srokosz, "Humility: A Neglected Scientific Virtue?," *Science and Christian Belief* 25 (2013): 101–12. Of course, this is a Christian virtue ethics approach (see note 15 above).

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Reconciliation Ecology: A New Paradigm for Advancing Creation Care

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Current global environmental challenges—species loss, overconsumption, climate change, and others—have not been countered in the faith community with a response worthy of their significance. While the prevailing faith-based creation-care paradigm, environmental stewardship, has been invaluable in moving us beyond the utilitarian notion of "dominion," the stewardship concept does not sufficiently emphasize our embedded, dependent relationship with the creation. To better represent our creation-care responsibilities, we propose a new paradigm based on a model of servanthood and informed by the concept of reconciliation ecology, which focuses on mending broken relationships between human beings and nonhuman creation. Drawing from the faith-based concept of reconciliation (as it has been applied to the God-human relationship and human-human relationships), we offer five steps that are critical in moving us to a more shalomic relationship with creation: (1) recognizing the wrong we have done; (2) lamenting personal complicity; (3) minimizing further harm and working to fix the wrong that was done; (4) accepting forgiveness; and (5) moving forward in a new relationship marked by mutual flourishing.

We understand and describe reconciliation ecology as the most recent manifestation of how nonindigenous North Americans have historically understood their responsibility toward nonhuman creation. We also discuss how reconciliation ecology is different from Christian environmental stewardship. To highlight the process of reconciliation ecology, we present a case study involving our work in the Plaster Creek Watershed, work that has contributed greatly to our understanding of the concepts we present here. We believe that reconciliation ecology's emphasis on examining and changing our relationship with the creation—the way we think about it and interact with it (i.e., the way we live)—can help people of faith better comprehend and embrace the relevance of creation care to their daily living.

Most of those reading this article have likely chosen to align themselves with Joshua in regard to the challenge he presents in Joshua 24:15:

> *… choose for yourselves this day whom you will serve …*
>
> *But as for me and my household, we will serve the Lord.*

But what does it really mean that we have chosen to "serve the Lord"? To serve (*"abad"* in Hebrew) conveys an intention to relegate our own interests to secondary status in lieu of the interests of whom we serve. Service is a prevalent and critical theme in Christianity. Christ himself is described as having taken on the very nature of a servant, humbling himself in the act of crucifixion (Phil. 2:7–8). As the ultimate servant, Jesus

set aside his own interests and welfare for the sake of those he was serving. And those he was serving includes us human beings, but not only us human beings. Jesus gave his life for all of creation—so that all things could be reconciled (put back into their proper relationships) once again (Col. 1:15–20).[1]

This notion of serving is fundamental to our identity as Christians. We are quite literally "Christ's ones," and since we identify ourselves as followers of the ultimate servant and profess to have been created in his image, an integral part of our faith journey is to keep developing into better and better servants. Choosing to serve the Lord means that we look after the welfare of those we serve. And the model of servanthood Jesus provides is expansive—encompassing all of creation.[2] It should come as no surprise, then, that one of the directives Adam was given in how to interact with the creation Jesus himself helped create (John 1:1–5) was to serve it (Gen. 2:15). Yet most of us would probably confess that much of our daily living does not reflect this kind of compassionate commitment to the creation—one in which our own interests are set aside for the sake of creation's well-being.[3] In fact, quite the opposite has transpired: by serving ourselves and by taking more than we give, we have been increasingly degrading the rest of creation.

For the most part, at least ecologically, we in North America have been able to get away with this one-sided relationship for quite some time. Until perhaps as recently as the industrial revolution, we could pretty much live as we wanted to live without encountering significant, wide-scale ecological consequences. Creation was vast, with enormous buffering capacity, and our impact seemed relatively small and innocuous. These past conditions led to an unfortunate assumption that resources are inexhaustible and creation has limitless resilience. Within the past few decades, this myth has proven undeniably flawed, and today we find ourselves perched at a very interesting point in history, with the fallout from this myth accumulating rapidly. Human population growth, the mounting consequences of our fossil-fuel dependency, and our reckless consumptive behavior provide compelling evidence that our existence occurs within fixed planetary boundaries.[4] We are beginning to understand that, like all other species—from bacteria to blue whales—we too are subject to ecological and evolutionary limits, including the availability of space, food, and water; and to our ability to adapt in the face of an unstable and unpredictable environment.[5]

Within their lifespan, today's college students will see the end of cheap oil, an increasingly unstable climate, precipitous loss of biodiversity, severe shortages of fresh water, rising food costs, and a global population surging past ten billion, resulting in expanding numbers of malnourished, desperate people.[6] It is difficult to imagine another time in all of history when creation was groaning more loudly than it groans today. And God's groaning creation is eagerly and expectantly waiting for the children of God to be revealed—waiting for the children of God to show up (Romans 8). Today we find ourselves in relationship with a wounded creation, embedded within a largely untended, eroding garden. And the groaning Earth of which we are a part is precisely the one God has called us to help him care for—there is no "Planet B" should this Earth become uninhabitable.

The call to step up and reveal our stewardly selves at this point in time is particularly compelling for North American Christians because it has become clear that rich nations are disproportionately degrading creation, and poor nations are disproportionately affected by the degradation.[7] Matters of social and environmental justice intertwine.[8] If one manifestation of loving our neighbors is to make room for them and help them flourish,[9] then we are certainly falling short of this basic biblical directive as we despoil creation and brush off the ecological consequences onto the most marginalized and disenfranchised peoples of the world.[10] By choosing to live in ways that serve ourselves and thereby degrade creation, we are disregarding God's command to love our neighbor.

From this interesting historical perch, we can look back and see how the one-sided relationship has developed and the problems it has elicited. We can also look ahead to an uncertain future, a future that, philosopher Michael Nelson reminds us, we will undoubtedly destroy if we simply continue living as we are living today.[11] But we do not have to continue on this track—we have the capacity to make choices that benefit others: other people, other species, and future generations of both.[12] The great question of today is how do we assist with the necessary and

radical transition from our present environmentally costly, self-serving existence to one that models true servanthood? How do we begin working to heal the significant wounds we have inflicted?

Thesis Statement

Given the growing urgency of Earth's mounting environmental crises, we suggest that a new paradigm is needed—one that moves us beyond the rather detached role of "steward," to one that more emphatically highlights humanity as *being in relationship with* creation.[13] While Christian environmental stewardship has aptly emphasized our responsibility to care for the earth, we believe that it needs to be enhanced and strengthened such that a new governing metaphor can emerge. And we believe that the recently articulated concept of reconciliation ecology can help orient us in such a new and hopeful direction, one that provides fresh and necessary inspiration to help people of faith better understand creation care as a vital component of their daily living and spiritual development.

Historical Context

Reconciliation ecology can be understood as the most recent manifestation in an ongoing developmental progression of how nonindigenous North Americans think about themselves in the context of their natural environment. Our earliest immigrant ancestors understood the landscape primarily as an exploitable pool of resources for improving their existence by meeting basic needs, and later, by turning a financial profit. For example, while many ships from Europe arrived with people, most of them returned to Europe with marketable products, not least of which were trees—towering 250-foot white pines—that were a boon to the British Navy's shipbuilding efforts of the sixteenth and seventeenth centuries.[14]

But already in the 1790s, proposals for establishing preserves of the few remaining old-growth New England forests were offered.[15] However, no serious preservation attempts were undertaken until one hundred years later, in response to pleas by the impassioned naturalist John Muir. Muir's success, as evidenced by the establishment of some of our most cherished National Parks such as Yosemite, Grand Canyon, and Sequoia, reflected a growing awareness that unchecked resource extraction was unhealthy both for the land and its people.[16] In *The Yosemite*, Muir writes: "Everybody needs beauty as well as bread, places to play in and pray in, where nature may heal and give strength to body and soul alike."[17]

Before long, however, land managers came to realize that simply preserving sections of the landscape was an insufficient model for protecting the integrity of both the preserved areas themselves and the whole of earth's biodiversity. It was recognized that even seemingly pristine areas have been directly and indirectly disrupted by human beings through the removal of top predators, suppression of natural wildfire, introduction of nonnative species, and by a variety of interventions in natural processes and cycles.[18] Furthermore, ever since the creation of these protected areas, there have existed political pressures to extract resources from within them.[19] As we began to understand more about the interconnectedness of preserved areas, human-dominated spaces, and the broader landscape, scientists and land managers began studying how best to maintain and manage the landscape to promote biodiversity. This field of study, conservation biology, was also informed by the realization that human beings were causing other species to go extinct. Today, more scientifically informed conservation practices (reintroducing species, conducting controlled burns, removing invasive species, etc.) protect and maintain the biodiversity that had been previously protected via preserves, by setting aside and staying out of the way.

Yet, these notions of preserving some of nature and managing and extracting resources from the rest of it were also seen as insufficient by themselves. In the late 1900s, it became well documented that biodiversity steadily erodes as habitat fragmentation increases.[20] Scientists and others recognized that it was essential to protect larger areas and create connecting habitat corridors between them to maintain biodiversity.[21] In response to this awareness, the field of restoration ecology emerged—the study and practice of assisting the recovery of degraded ecosystems to help them regain some of their former functionality, beauty, and biodiversity. To summarize, here in North America, attitudes toward the natural world have progressed from resource extraction to preservation, conservation, and restoration.

A similar awareness has also been developing in North American Christendom, albeit with numerous impasses and permutations. The church historically perceived creation as a palette of resources given by God to support human life; "dominion" emphasized humanity's special administrative responsibility *over* creation.[22] These ideas supported the notion that we can do with nature as we please. Muir himself, having been raised in the Christian faith, had much to say to the church that questioned this narrow perspective. Over time, some Christians began understanding creation as holding inherent value beyond its usefulness to humankind. The Calvin Center for Christian Scholarship book, *Earthkeeping*, was instrumental in articulating a clear vision for Christian environmental stewardship, emphasizing that God entrusts human beings to care for his beloved creation in ways that ensure its continued fruitfulness and integrity.[23]

The developments described above are steps toward a fuller understanding of potential human relationships with the creation. However, each of these perspectives (including Christian environmental stewardship) is an articulation of how we should think about and act toward nature. Nature is the object; how we perceive it and what we do to it are the questions. What is not acknowledged (or at least emphasized) is that we, too, are part of creation, and its degradation is occurring because of how we have been living within it. Furthermore, climate change is an ongoing illustration of how the effects of degradation caused by certain people in certain places often make life more difficult for other people in other places.[24] The way we interact with creation, while itself worthy of candid consideration, must also be recognized as a vector through which we influence other people in other places.

Reconciliation Ecology: A New Paradigm for Moving Forward

Reconciliation ecology has emerged in response to scientific assessments that approximately 15% of Earth's productive land surface today remains in a condition approximating its natural, prehuman state. The other 85% has been transformed for (or at least bent in the direction of) serving humanity. Estimates for oceanic ecosystems are similar.[25] One species, *Homo sapiens*, now commands 85% of Earth's ecosystems, leaving 15% (and declining each year) for the rest of the 30 million or so species that make up Earth's biodiversity. It is no wonder, then, that our planetary extinction rate is estimated to be in the range of 10,000–40,000 species per year and rising (roughly 25–100 species lost each day).[26] The solution to this devastating loss of diversity is not to more securely protect the 15% that has yet to be seriously altered; Earth's 30 million species will never be able to exist on only 15% of the planet. Instead, we must turn our attention to the 85% and figure out how we can reside in and use these areas in ways that do not eliminate, but rather encourage other elements of creation's web of life to coexist along with us. In more direct language, we need to learn how to reconcile our current human existence with the rest of creation.

Reconciliation ecology has been described as the science of restoring, creating, and maintaining new habitats, and conserving biodiversity in places where people live, work, or play.[27] This approach turns the focus back onto humanity and asks a fundamental question: How can we reconfigure our own existence so that it is more a blessing than a curse to the broader landscape within which we reside? It is a concept that is gaining recognition as increasing attention is being placed on learning how to live more sustainably. Indeed, if reconciliation ecology is done well, sustainable living will result.

Instead of working to take care of a creation that resides "out there" some place, reconciliation ecology emphasizes that we are part of creation—our bodies, our buildings, our cars, our yards, et cetera—and it challenges people everywhere to live in their own places in ecologically affirming ways that enhance biodiversity and restore ecological functionality to their own local places. It strives to reinvent the human presence to better accommodate and affirm the other creatures with whom we live. Reconciliation ecology is a hopeful paradigm—it raises the possibility that the human presence has the capacity to be more a blessing than a strain on the land. It aims to provide answers to important questions about the future of biodiversity and the environmental integrity of our planet: How do we build buildings that generate more energy than they use? How do we change the way we grow food so that our agricultural systems accumulate, rather than erode, healthy topsoil? How do we change the way

we live so that native biodiversity is attracted back to our urban and suburban areas?

A compelling example of reconciliation ecology is given by Douglas Tallamy from the University of Delaware. He studies how native plants used in urban landscaping significantly increase the presence and health of native insects and birds.[28] Another fine illustration of reconciliation ecology in practice is exhibited by the Menominee Nation in central Wisconsin who have maintained high biodiversity and ecological health on their land in spite of the annual, ongoing timber harvesting that has occurred for many decades.[29] New ways of thinking about and interacting with the creation can result in new outcomes. Human beings do not have to live in ways that always degrade. An additional, more detailed example of reconciliation ecology is provided below in the case study of Plaster Creek Stewards.

We believe that reconciliation ecology has the potential to breathe new life into how the faith community understands and engages creation care.[30] Reconciliation of broken relationships is a fundamental tenet of Christian faith; Christ is understood to have come so that we can be reconciled in our relationship with God. The need for reconciliation, for example, "racial reconciliation," is also raised by the church when people have significantly wronged one another.[31] Reconciling people to the creation offers a natural extension of this tenet and a very useful and appropriate means for advancing God's expansive Kingdom of shalom here on Earth.

Faith-Infused Reconciliation Ecology

Reconciliation is a rich term that can be applied in many situations and has been defined in multiple ways, in both secular and faith contexts. Yet all definitions of this term involve the same basic principle: the bringing back together again of things that had been at odds. It involves the restoration of harmony, getting two things to correspond again, and restoring friendly relations. Reconciliation is also the Roman Catholic sacrament of penance, a reminder that apology and regret are critical elements. Reconciling humanity to God is often referenced as the reason why Christ came and died. Our relationship with God had been distorted by sin, but Christ's sacrifice re-established that relationship by bringing us back together again with God. Reconciliation is the beautiful outcome of redemption. Second Corinthians 5:17b–20 is a seminal text:

> *Therefore, if anyone is in Christ, he is a new creation. The old has passed away; behold, the new has come. All this is from God, who through Christ reconciled us to himself and gave us the ministry of reconciliation; that is, in Christ God was reconciling the world to himself, not counting their trespasses against them, and entrusting to us the message of reconciliation. Therefore, we are ambassadors for Christ, God making his appeal through us. We implore you on behalf of Christ, be reconciled to God.*

Paul emphasizes that reconciliation truly changes things. Old things are in the past, new things appear, former offenses are forgiven and new relationships emerge. This passage also describes humanity as being given the ministry or the message of reconciliation. Thus, because of Christ, we have had our relationship with God reconciled, and because of Christ, we have also been designated as reconcilers ourselves.

One way that human beings can actualize this message of reconciliation is in our interactions with each other. By forgiving past wrongs and healing social hurts, we engage in reconciliation with one another.[32] When such restoration of a relationship is determined to be impossible, for example, in a divorce, the reason given for permanent severance is often "irreconcilable differences." Probably the most public venue and most significant example of reconciliation between people has been the South African Truth and Reconciliation Commission (TRC).[33] This group was set up to begin healing the rift between South African blacks and whites in the aftermath of apartheid. Many painful yet powerfully hopeful stories and interactions have been brought to light through the work of the TRC.[34] This work is related to justice, yet it goes beyond justice. Justice can be legislated, forcing offenders to pay for the wrong they have done. Reconciliation attempts to change hearts, and, in so doing, to change the relationships that have been damaged by the wrong that was done (in "justice" terms, Wolterstorff describes reconciliation as essential to "restorative justice"[35]).

From reviewing the work of South Africa's TRC, as well as similar commissions set up in other countries

including Sierra Leone, Canada, Liberia, Australia, Chile, and others (note that no explicit commissions of this type have been undertaken in the US), we have identified five critical steps in the process of reconciliation that occur between people or groups of people, all of which require humility as a prerequisite:

1. Recognizing the wrong that was done (Awareness)
2. Lamenting personal complicity (Repentance)
3. Minimizing further harm and working to fix the wrong that was done (Restoration)
4. Accepting forgiveness extended by the agent that was wronged (Acceptance)
5. Moving forward in a new relationship marked by mutual flourishing (Renewal)

As mentioned above, this process can only work when the perpetrators of injustice come to the process with humility, and display a sincere desire to address the wrongs that were done. Refusing to recognize complicity in the pain that was inflicted will assure the relationship will remain unreconciled.

We believe that much can be gained by applying these principles to the relationship between humanity and the rest of creation. Our relationship with the land, as in our relationship with God and with each other, has been distorted through sin (figures 1–3). We do not think about and interact with the surrounding creation in ways that God intended. God did not create mountains so that we could blow their tops off, the Gulf of Mexico was not meant to be a dumping ground for agricultural effluents, and God's amazing tapestry of diversity was not set in place for our cavalier unraveling. When presented with examples of creation's groaning, we need to come to the humble recognition that these groans are not just happening; they are a direct outcome of our distorted relationship with creation. They emanate from misguided human agency. We have wronged the creation, and our relationship with it needs healing.

The five steps of reconciliation enumerated above can help inform a Christian response to this distorted relationship. Out of regret and lament for our personal complicity in the degradation, we commit ourselves to minimize further harm and become ded-

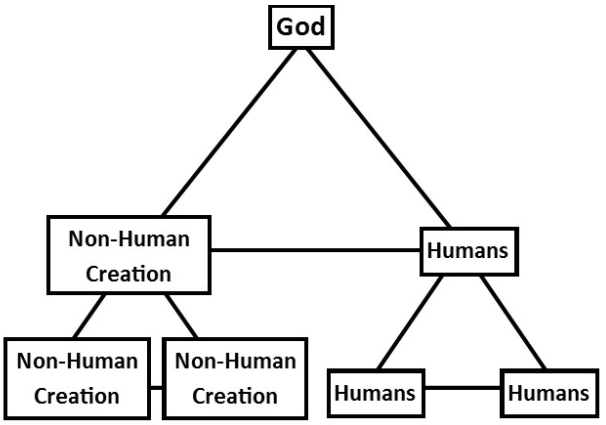

Figure 1. Shalomic Relationships

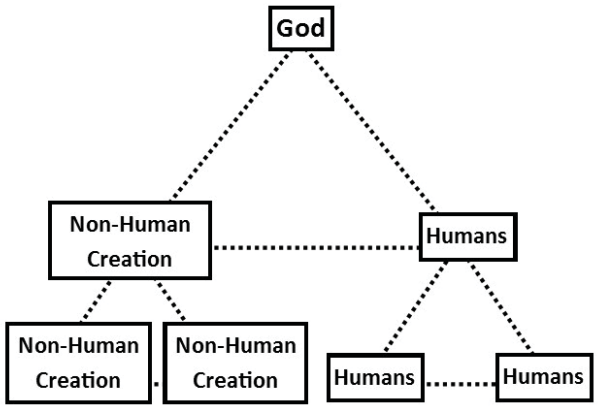

Figure 2. Broken Relationships

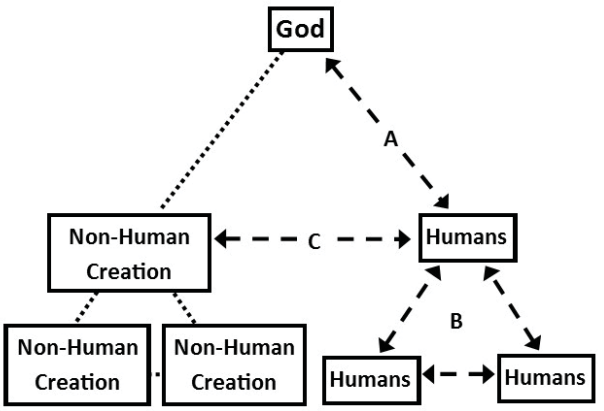

Figure 3. Reconciliation

Figures 1–3. The lines connecting different elements of these diagrams represent relationships between those elements. Shalomic relationships within creation as God intended (fig. 1), are marred by brokenness and sin (fig. 2). Reconciliation (fig. 3) can be thought of as working to restore shalom where brokenness exists in those relationships: reconciliation between God and humans (3A); between people or among groups of people (3B); and between humans and nonhuman creation (3C), which is what we refer to as "Reconciliation Ecology."

icated to correcting harms that have been inflicted. Once this new commitment is made, and efforts are extended toward healing past wrongs, creation will respond. We will not be directly granted forgiveness by creation, but when we work to restore degraded streams, replace lawn areas with native habitat, or advocate for preserving tracts of forest, creation will respond. New life will return to the stream, butterflies and birds will find the native plants, and the preserved forest will be able to supply environmental and aesthetic services that will benefit all kinds of creatures once again, human beings included. In these and so many other ways, nature's resiliency, while not inexhaustible, is lying in wait, eagerly anticipating our conciliatory offerings of hope toward a future marked by humanity and creation existing in a renewed, reconciled relationship.[36]

While not addressing these five steps directly, Michael Nelson illustrates the process rather well:

> We often hear that people only change their ideas, and therefore their behavior, in the face of crisis. But we forget that a crisis can be a moral crisis as well, a sense of revulsion for a life that we are living, a commitment to live differently and to be a different kind of person. We need The Great "yuck!" Yuck, what we are doing is repulsive. Yuck, this is not the way a responsible person lives. The Great "yuck!" can be followed by The Great "no!" No, I will not live this way. No, I will not be this kind of a person, this kind of an agent in the world. Finally, The Great "no!" will give way to The Great "yes!" Yes, I will live a life of respect, of humility, empathy, care, and attentiveness. Yes, I will choose to live with dignity and grace, no matter what.[37]

One of the elements of truly good news in such a reorientation is that there are so many ways we can begin living into this new relationship. Small daily turnings that lessen our environmental footprint can accumulate and build into the kind of significant shift that is necessary for truly sustainable living. As reconciliation becomes a model for creation care, we will come to better understand how our lives never take place in a vacuum but instead result in reverberations throughout God's world. And the good news is that these reverberations need not be negative. The wounds God's groaning creation exhibits today can be salved through the use of more appropriate technology, renewable energy, alternative agricultural practices, heightened biodiversity conservation, sustainable development, urban renewal, ecological restoration, and so forth. The good news is that our relationship with creation, while broken, is not irreconcilable. We are an adaptable species, we can change our ways. And the creation waits eagerly and expectantly for the children of God to be revealed as ministers of reconciliation.

How Reconciliation Ecology Differs from Christian Environmental Stewardship

For Christians working in the area of creation care, the prevailing paradigm over the past few decades has been environmental stewardship. Stewardship calls attention to our peculiar calling as caretakers of creation—watching over something that does not belong to us, but rather belongs to God. The Christian stewardship model has provided a significant and critical advancement over the concept of dominion, which had been used by some to justify rampant use and domination.[38] Stewardship principles expanded the notion of domination to an approach of caregiving, as evidenced in this description by Cornelius Plantinga that bridges the two concepts:

> In the kingdom of God, to have dominion is to care for the well-being of others. To have dominion is to act like the mediator of creation. This means that a human steward of God's good creation will never exploit or pillage; instead, she will give creation room to be itself. She will respect it, care for it, empower it. Her goal is to live in healthy interdependence with it.[39]

The concept of Christian environmental stewardship has promoted human responsibility as guardian over creation, and in so doing has advanced traditional notions of dominion. However, there are limits to this way of thinking as well. While a focused critique of the stewardship concept will not be undertaken in this article, a few shortcomings should be noted.

First, stewardship generally underemphasizes our embedded relationship with the creation, our dependency upon it, and our involvement in its desecration.[40] Stewardship is something we human beings do to the creation. It illustrates an "I - it" relationship, promoting the notion that we are somehow separate from the rest of creation.[41] Conceptually distancing ourselves from creation's degradation (an action similar to geographical distancing) makes

it easier to absolve ourselves of complicity. For example, being a good steward might simply mean cleaning up a polluted stream without addressing the human behaviors that have caused the stream to become polluted (even, possibly, by the steward himself or herself).

Secondly, the biblical concept of stewardship is one in which the steward watches over a resource that belongs to another. Stewards in the Bible never take care of anything that does not have monetary value; this fact may explain why the concept of stewardship has been so easily incorporated into economics and business vernacular and why any attempt at meaningful dialogue between ecologists and entrepreneurs is so easily confounded.

Thirdly, the resource overseen by a steward is cared for while the owner is away. This concept contradicts an understanding of God's immanence in creation, reducing its sanctity, and making it seem less offensive to do with creation as we please. The twentieth-century Dutch theologian Abraham Kuyper would counter, "In everything that in nature lives before our eye, murmurs, throbs and moves itself, we feel the pulse-beat of God's own Life."[42] By contrast, in order for reconciliation to happen, all parties must necessarily be present.

Finally, while it is clear that humanity has a responsibility to care for creation, stewarding the whole of creation is not directly pronounced in scripture. Concepts of ruling, subduing, serving, and preserving are all important directives from which the stewardship concept draws, but no one in the Bible is ever told to "steward" the creation.

In the same way that stewardship advanced Christian thought beyond traditional notions of dominion, we believe that reconciliation ecology can move us beyond stewardship to an even more appropriate understanding of our place and responsibility within God's creation. Reconciliation ecology emphasizes that we are in relationship with the creation, albeit a distorted relationship that needs to be set right. It emphasizes humanity's participation (as part of creation, not apart from creation) both as agent of degradation that wounds creation, and as victim of degradation inflicted by others. We are creation too, and creation care or lack thereof will play out on human beings as well as on other species. By focusing on our embedded relationship with creation, reconciliation ecology is better equipped to address the causes of degradation, not just the symptoms.

We also find the concept of reconciliation to be a more scripturally consistent way of engaging Christians today with modern environmental challenges. For example, the prophets speak frequently about how the land suffers because of the disobedience of the people. Listen to how relevant Hosea sounds with respect to today's biodiversity loss:

> *Hear the word of the Lord, you Israelites,*
> *because the Lord has a charge to bring*
> *against you who live in the land:*
> *"There is no faithfulness, no love,*
> *no acknowledgment of God in the land.*
> *There is only cursing, lying and murder,*
> *stealing and adultery;*
> *they break all bounds,*
> *and bloodshed follows bloodshed.*
> *Because of this the land dries up,*
> *and all who live in it waste away;*
> *the beasts of the field, the birds in the sky*
> *and the fish in the sea are dying."* (Hosea 4:1–3)

And when Ezekiel thunders against the rulers for muddying the waters, this bears strong similarity to how developed-world contributions to climate change play out on poor, developing nations:

> *Is it not enough for you to feed on the good pasture? Must you also trample the rest of your pasture with your feet? Is it not enough for you to drink clear water? Must you also muddy the rest with your feet? Must my flock feed on what you have trampled and drink what you have muddied with your feet?* (Ezek. 34: 18–19)

By calling attention to our relationship with creation, reconciliation ecology more appropriately identifies the significant changes we need to make in our own lives as we work to heal our distorted relationship with creation. Reconciliation is hard work and challenging; it is not comfortable, convenient, nor easy. Yet, reconciliation ecology brings hope—it puts our feet back on a proper path and orients us in the direction of a much healthier, more beautiful, more shalomic future.[43] Finally, although stewardship is a metaphor built from various biblical references, we find it compelling that scripture clearly identifies Jesus as the agent of reconciliation for the world, and his followers as those who have been given the ministry of reconciliation (Col. 1:15–20, 2 Cor. 5:17–19).[44]

Case Study: Plaster Creek Stewards

Working to address problems in the Plaster Creek Watershed over the past decade has informed much of our thinking on reconciliation ecology. We therefore present a description of this work in hopes that it will help to illustrate many of the conceptual arguments we have been making in this article.[45]

Defined simply, a watershed is an area of land that drains to a common point. Frequently, this point is the mouth of a river or a stream that empties into another body of water such as an even larger river, or a pond, lake, sea, or ocean. Whenever we walk on solid ground, be it carpet, asphalt, or forest floor, we walk within a watershed. Rivers and streams represent the veins and arteries of watersheds, and a simple "blood test" (water quality test) reveals a great deal about how people interact with the plants, animals, and soils of their watershed; the quality of water flowing out of a watershed tells us about the relationships that exist within the watershed.

The process of rainwater becoming streamwater occurs via two distinct pathways: (1) direct surface runoff—water running over land and into a stream, or (2) indirect percolation through soil layers—reaching a stream through seepage, subsurface drainages, or springs. The latter route is a much longer process that filters, cools, and cleans the water before it reaches a stream, with a large proportion of the rainwater being absorbed en route by root uptake and soil absorption.

Streams surrounded by natural habitats receive most of their water indirectly, while direct surface runoff accounts for most of the input to streams in developed landscapes. This is one reason why stormwater surges are so common with urban waterways—too much rainwater is draining into the stream too quickly. Furthermore, high volumes of stormwater runoff are accompanied by contaminants that human activity has deposited on the land surface. In this way, stormwater runoff carries direct evidence of how the human-creation relationship is being lived out in a particular watershed.

The Christian Reformed Church of North America (CRC) has a notable presence in the fifty-seven-square-mile Plaster Creek Watershed. This watershed is home to the CRC denominational headquarters, the Christian (Reformed) Recreation Center, a large portion of Calvin College's campus, over one hundred churches (more than twenty of which are of the Reformed persuasion), and literally thousands of Calvin College faculty, staff, students, and alumni. Beginning in agricultural areas south and east of Grand Rapids, Michigan, Plaster Creek flows for fourteen miles through commercial, suburban, and industrial areas before encountering lower income neighborhoods near its confluence with the Grand River, just south of downtown Grand Rapids.

This diversity of land use is reflected in the stream: sediment browns the water; *E. coli* concentrations consistently threaten public health (measured at levels 50x higher than state-sanctioned thresholds); toxic metals contaminate abandoned industrial areas and leach into the stream; and thermal pollution from runoff of extensive impermeable surfaces (e.g., parking lots, roads, roofs) creates temperature fluctuations that make the stream inhospitable to all but the most pollution-tolerant stream creatures. All these problems are exacerbated by the high volumes of water that enter the stream each time it rains. Furthermore, the problems described above are initiated in the rural and suburban upper reaches of the watershed and intensify as the stream proceeds toward neighborhoods of lower income families, causing these most marginalized and vulnerable residents of the watershed to be subjected to the greatest public health threats.

But the stream was not always like this. Before European immigrants began arriving in western Michigan, the region was inhabited by the Odaawaa people. When the first missionaries came to this region in the early 1800s, the Odaawaa leader was Chief Blackbird, who lived on a floodplain island (today called the "Black Hills") that overlooked Plaster Creek, at that time known as "Kee-no-shay" Creek (meaning "water of the walleye"). Apparently, Chief Blackbird was resistant to evangelical attempts, insisting that God was not confined to a book or a church building. One day he took one of the missionaries to a place where Kee-no-shay Creek poured over a large rocky outcrop of orange-hued stone. Blackbird described to the missionary the importance of the waterfall to his people, as a place of spiritual significance where his people would go to be with

their God. The missionary took a sample of the rock and sent it to Detroit to have it analyzed. The sample was identified as gypsum, which could be ground up and sold as an agricultural fertilizer and as the base for plaster. Before long a plaster mill was established at this site, which became the first of many such operations in the Grand Rapids area.[46] Over the course of the next century, Kee-no-shay Creek became increasingly polluted from gypsum mining and urban expansion, and eventually the walleye and many other life forms that had once thrived in these waters were eliminated. The less attractive but more descriptive name, "Plaster Creek," gained acceptance.

The story of this encounter not only identifies people of faith as being complicit in the degradation of Plaster Creek from early on, it also shows that Plaster Creek's degradation was preceded by a fundamental shift in the way inhabitants thought about and interacted with the stream. Plaster Creek Stewards is a group of Calvin College faculty, staff, and students working with local churches, schools, and community partners to restore health and beauty to the stream. We understand this to be reconciliation work—primarily reconciliation between people and the creation. But because of creation's interconnectivity, our work also involves reconciliation among different communities of people that reside within this watershed because the polluted stream is a vector through which upstream residents adversely affect the welfare of their downstream neighbors.[47]

Much of the community-based work done by Plaster Creek Stewards follows the five steps of reconciliation described above. The stewards conduct education and outreach programs for schools, churches, and community organizations, detailing the historical degradation of the creek and hoping to increase awareness regarding the plight of the stream (step one: recognizing the wrong that was done). Many of our presentations include the story of Chief Blackbird and the early missionary, and when presenting to church audiences, this story often results in a compelling realization of the faith community's involvement in the degradation.

We also collect oral histories from residents who are willing to share their personal experiences with the stream. Many of these stories involve childhood memories of playing, fishing, or exploring in and around the stream—stories that serve as powerful articulations of a changed landscape and a lost sanctuary. Current practices that contribute to stormwater runoff and other problems are highlighted, underscoring broad participation in the ongoing contamination of Plaster Creek (step two: lamenting personal complicity).

Plaster Creek Stewards is also intentional about providing opportunities for residents to become directly involved in doing restoration work.[48] We have seen that these activities can foster a deeper appreciation for the creek, resulting in the beginnings of changed behaviors and transformed relationships.[49] These communal experiences include greenhouse work of propagating native species, planting the native species in rain gardens or bioswales, distributing rain barrels, stenciling storm drains, removing invasive species, and so forth (step three: minimizing further harm and working to fix the wrong that was done).

The fourth step in the reconciliation process, forgiveness, is harder to visualize when the party harmed is nonhuman creation. However, as our work progresses, we are finding that creation is capable of extending, at least symbolically, what we translate as an offering of forgiveness. As an example, when we work on a restoration project such as the installation of native habitat to capture stormwater runoff, there are a variety of preparatory elements required of us

Figure 4. Plaster Creek Stewards volunteers help plant a rain garden at a school in the watershed after attending an educational presentation about stormwater pollution in Plaster Creek.

to ensure the success of the work—existing weedy vegetation must be eliminated, the site and the soils must be properly readied, and the plants that suit the site must be chosen appropriately and properly planted and cared for. When this work is done well, over time the native vegetation matures, extending roots downward and shoots upward; our efforts of reconciliation are greeted by a response from creation. Soil is held in place by the deep roots that also filter excess nutrients, and caterpillars, bees, grasshoppers, butterflies, and birds show up to accept the offering of biomass, nectar, and seeds. In a way, this response indicates to us that creation is extending forgiveness, and we accept its response of buzzing, humming, chirping, and chomping with great joy (step four: accepting forgiveness extended by the agent that was wronged).

In many of our public presentations, as well as in meetings with community partners, we often talk about what a new (or renewed) relationship between people and creation might look like within the Plaster Creek Watershed. This fifth step in the reconciliation process will not take place completely until the broader community learns to think about, appreciate, and interact with the stream in new and affirming ways. This new relationship would involve a political, cultural, social, and systematic shift toward slowing down stormwater runoff, capturing it where it lands, and spreading it out over an area where it can be treated (like a rain garden or a retention area). In this way, the water would be treated by soils, plants, and natural filtration processes that would result in clean, cool, and clear groundwater feeding into healthier waterways. Reconciliation in the watershed would also mean that communities of lower economic status would not face increased risk of being exposed to toxic contaminants introduced in upstream areas. They would have equal access to the same high-quality green spaces and parks presently more common in affluent communities. Reconciliation in the watershed would mean that children, no matter where they live, would be able to enjoy the stream for what it once was, a playground for swimming, fishing, and exploring.[50] It would result in a stream and a landscape that provides safe spaces for the thriving of a broad variety of biodiversity, humanity included (step five: moving forward in a new relationship marked by mutual flourishing).

Figure 5. Calvin College students conduct winter macroinvertebrate (e.g., caddisfly larva, crayfish) sampling in Plaster Creek. The sampling is an effort to measure the biological health of the stream by looking at the biodiversity found within it.

We present this case study as an example of reconciliation ecology in process. Plaster Creek Stewards is not simply applying for grants to support environmental remediation companies to come in and restore the creek. Instead, we are intentional about working with watershed residents, focusing on changing the way people think about the stream and the way they live within the watershed. We are working to change the relationship between people and creation within the context of this watershed. In a very real sense, the overall goal of this project is to bring the good news of reconciliation to all the inhabitants of the Plaster Creek Watershed (Mark 16:15), and in so doing, help restore shalom to this beloved portion of God's creation.[51]

Conclusion

Coming to terms with how we have wronged the creation and resolving to live more creation-affirming lifestyles is both biblically mandated and an essential testimony to our contemporary world.[52] The call to reconciled living is summarized in Wendell Berry's pithy directive to the faithful to "practice resurrection."[53] The path toward reconciliation is also embedded in Paul's admonition to *"work out your salvation in fear and trembling"* (Phil. 2:12).

Lutheran theologian Joseph Sittler articulates it this way:

> If in piety the church says, "The Earth is the Lord's and the fullness thereof" (Psalm 24:1), and in fact is no different in thought and action from the general community, who will be drawn to her worship to "come and see" that her work or salvation has any meaning? Witness in saying is irony and bitterness if there be no witness in doing.[54]

The paradigm of reconciliation ecology, although developed and used until now largely by secular scientists, is ripe for introduction to the faith community. Rather than utilitarian arguments for preserving nature, Christian faith provides motivation for lifestyle changes by recognizing the creation, including humans, as the object of God's loving care. Furthermore, being the only creatures to have been created in God's image, humans are called into a special responsibility of nurturing and encouraging creation's flourishing. Recognizing this, we confess that we have largely failed in that relationship and we repent, seeking to be reconciled to all that we have injured. Reconciliation ecology's emphasis on changing our relationship with the creation—the way we think about it and interact with it, or, put simply, the way we live—can inspire tangible, daily turnings on behalf of creation's well-being. This new paradigm can also help people of faith to better comprehend and embrace the relevance of creation care to their daily lives, especially as they witness signs of God's grace and forgiveness in creation's response to their changing behaviors.

Reconciliation ecology is the business of both the individual and the church. Each member of every household is in a position to better understand how their actions influence life around them. But Christ's body, the church (and its manifestation in Christian colleges and universities), represents a potentially powerful place to practice and teach reconciliation ecology corporately. For example, reconciliation ecology can be a powerful framework within which Christian college or church campuses can be inspired to fresh insights and action. Green spaces and campus gardens can provide habitat for humans and native creatures alike and can provide excellent venues for study of the interactions between these parties.[55] In such efforts, these places can become potent demonstration sites for sustainable landscaping, sustainable food generation, purchasing, consumption, waste processing, and carbon neutrality initiatives. In support of the last of these examples, the presidents of many colleges and universities have already signed or are considering signing the American College and University Presidents' Climate Commitment (ACUPCC), an effort to stem the accelerating rate of climate change; more presidents should be encouraged to do so.

For creation to heal and flourish, the old order needs to pass away (Isa. 43:19, 65:17; Rev. 21:1). The toxic contamination and species extinctions, the removal of mountain tops and steadily climbing carbon dioxide levels, all need to pass away. The good news is that the God we worship is making all things new again (Rev. 21:5). The Kingdom is coming, and it does not look like bacteria-laden, effluent-choked urban streams framed by a dangerously altered climate. God's renewed Kingdom looks like a river of life, clear as crystal running through the heart of a beautiful city, with well-watered trees, the leaves from which provide healing for the nations (Revelation 22). As Christ's ones ("Christ-ians") here on Earth, he is calling us to "show up;" to join him in the exciting and deeply meaningful work of reconciling all of creation.

> The end is reconciliation,
> the end is redemption,
> the end is the creation of the beloved community.
> —Dr. Martin Luther King, Jr.[56]

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David Warners *grew up in Grand Rapids, Michigan, and graduated from Calvin College with a major in biology and chemistry in 1985. He earned a Master's degree in environmental studies from the University of Wisconsin-Madison and a PhD in plant ecology and evolution from the University of Michigan.*

Between graduate degrees, Dave and his wife Teri lived and worked for the Christian Reformed World Relief Committee in Tanzania, from 1990 to 1992. He has been teaching botany and ecology courses at Calvin College since 1997. Dave's research/scholarship interests include restoration ecology, plant systematics and evolution, academically based service learning, and the intersection of faith and science. In 2009, Dave and Gail Heffner (Calvin's Director of Community Engagement) started the Plaster Creek Stewards, a collaboration of Calvin faculty, staff, and students; a variety of community partner organizations; and a growing number of local churches and schools who work together to restore health and beauty to the Plaster Creek Watershed. Finally, Dave is an advocate for using native plants in urban landscaping and has helped design and establish over thirty native landscape plans at schools, parks, and other locations in the West Michigan area.

Michael P. Ryskamp *graduated from Calvin College with a BA in international development. He then spent a year with the Michigan Department of Natural Resources working to restore native habitats in state parks. Before returning to Calvin College to earn a BS in biology, Michael spent a year in Beijing teaching English with his wife Rachelle. He is currently working at Calvin College as the program coordinator for Plaster Creek Stewards. His job affords him ample opportunities to think about and practice reconciliation ecology on a daily basis. In his off time, Mike enjoys fishing, camping, gardening, and landscaping his yard with native plants.*

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Donald Morton

Article

Climate Science and the Dilemma for Christians

Donald C. Morton

We hear from many sources that the most important environmental problem is global warming caused by carbon dioxide (CO_2) from the burning of fossil fuels. However, after a gradual rise of about 0.6°C from 1978 to 1998, the global temperature, contrary to the predictions of climate models, has remained essentially constant for the past sixteen years while the atmospheric concentration of CO_2 has steadily increased. We do not know whether natural effects or anthropogenic CO_2 and similar gases are the primary cause of the recent increase in temperature. It could begin to rise again as we generate more CO_2, or it could fall as suggested by the present reduction in solar activity. This uncertain situation raises many questions about the usefulness of policies of mitigation and their unintended effects.

The Present State of Climate Science

Much current discussion of the environment centers on the predictions for our changing climate. Experts tell us that the warming of the earth by anthropogenic carbon dioxide (CO_2) is the most serious problem facing humanity so we must take action immediately. The difficulty with this view is that global temperatures stopped increasing after 1998 while the concentration of atmospheric CO_2 has continued its steady rise.

Figure 1 from the US National Oceanic and Atmospheric Administration shows how temperatures have not followed the rise in CO_2 as expected from all the model calculations. The recent paper by John Fyfe et al. provides further evidence of the deviation of climate models from the temperature observations.[1] Already in 2009, climatologists were concerned by the discrepancy and posed the rhetorical question, "Do global temperature trends over the last decade falsify climate predictions?" Their response was the following:

> Near-zero and even negative trends are common for intervals of a decade or less in the simulations, due to the model's internal climate variability. The simulations rule out (at the 95 % level) zero trends for intervals of 15 yr or more, suggesting that an observed absence of warming of this duration is needed to create a discrepancy with the expected present-day warming rate.[2]

Now we are beyond the fifteen-year test with no warming.

Government officials developing climate policies depend on the reports of the Intergovernmental Panel on Climate Change (IPCC). The 2013 Fifth Assessment Report (AR5)[3] includes figure 2, which shows the predicted temperatures rising steadily while the measurements follow the lower boundary of the models, even for these with only a modest increase in atmospheric CO_2. Clearly the global temperature is not following the expected increase from the rising CO_2 concentration. The models

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are failing the essential test of a scientific theory. It must make valid predictions. This criterion is especially important for climate models because the calculations depend on many adjustable parameters to represent physical effects too complicated to code explicitly. These are chosen to fit the observations so reproducing existing data is not an effective test.

As a consequence of the observed plateau, the AR5 Report broadened the range of the predicted temperature increase to 1.5 °C to 4.5 °C from the previous 2 °C to 4.5 °C for a doubling of the CO_2 concentration, thus allowing for a little less warming while retaining the alarming upper limit in spite of admitting that there may be a heating bias in some models. The report quickly passed over the change in slope of the temperature curve and a possible clue to some overlooked physics of climate change such as stable intervals between the chaotic shifts described below. Instead the report highlighted the conclusion,

> Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions in greenhouse gas emissions.[4]

Note that the growing of plants in glass houses actually depends on the plants and ground absorbing sunlight and heating the surrounding air, which is prevented from mixing with colder air outside. Atmospheric heating occurs through the tropospheric absorption of infrared radiation from the earth's surface in the molecular bands of the incorrectly named greenhouse gases. Besides CO_2 these

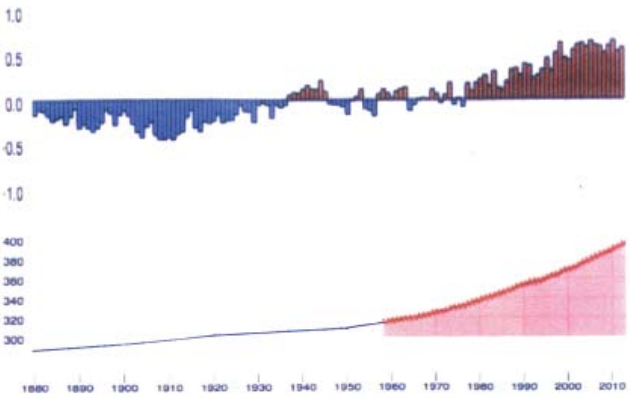

Figure 1. Global Average Temperature Anomaly (°C) upper, and CO_2 concentration (ppm) lower from http://www.climate.gov /maps-data by the US National Oceanic and Atmospheric Administration with ice-core data from the Antarctic Law Dome showing a gradual increase in the CO_2 concentration from 284 ppm in 1832 to 334 ppm in 1978. See ftp://ftp.ncdc.noaa.gov /pub/data/paleo/icecore/antarctica/law/law_co2.txt.

are methane (CH_4), nitrous oxide (N_2O), ozone (O_3) and several chlorofluorocarbons (CFC's). In the IPCC reports, their effects are roughly cancelled by cooling attributed to albedo changes due to land use and aerosols including clouds, so the heating often is described in terms of just the CO_2 concentration, now about 400 parts per million. However, absorption by the highly variable concentration of water vapor dominates the effects of the other gases. Temperatures at night drop much more quickly in arid desert locations than where the humidity is high.

Concerns about Climate Models

There are many reasons to question the basic assumptions used in the models and the procedures for computing them, as described by Christopher Essex and Ross McKitrick in their very readable book.[5] Climate, like the weather, depends in part on the chaotic processes of convection and turbulence. Thus, very small changes in the initial conditions can result in very large differences in later states. Models of weather systems begin to diverge after a week or two, even though the models have been refined many times by comparing predictions with observations. The IPCC Report recognizes the problem with the statement, "There are fundamental limits to just how precisely annual temperatures can be projected because of the chaotic nature of the climate system."[6] However, it gives no time estimate and, without justification, plots graphs to 2100.

Furthermore, the model makers assumed that the recent temperature rise of about 0.6 °C was caused primarily by anthropogenic generation of the absorbing gases, neglecting possible natural causes. Absorption of infrared radiation by these gases does

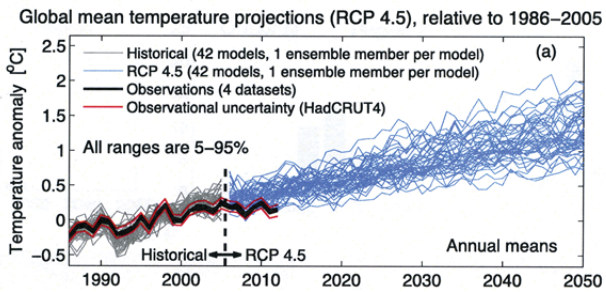

Figure 2. Model Predictions and Temperature Observations from IPCC Report 2013, p. 11–102. RCP 4.5 (Representative Concentration Pathway 4.5) labels a set of models for a modest rise in anthropogenic greenhouse gases corresponding to an increase of 4.5 Wm^{-2} (1.3%) in total solar irradiance.

increase the air temperature and, hence, global sea and land surface temperatures, but the calculated backwarming is only about one-third to one-half the observed effect.[7] Consequently, the models needed to assume amplification by a positive feedback caused by hotter air holding more water vapor, which absorbs more radiation. The computer simulations approximated this feedback and many other effects by choosing parameters to match the observed temperature rise and produce a range of future scenarios. Essentially the feedback was calibrated by the past rise in temperature. If it is no longer rising, the estimated feedback is wrong and even could be negative due to the extra water vapor forming more clouds that reflect more sunlight. Without the assumed feedback, the increase in absorbing gases will warm the earth but not enough for serious alarm.

We also need to recognize the uncertainties in the temperature statistic that attempts to calculate a single quantity to represent worldwide climate change with time. The usual plots, such as figures 1 and 2, show the temperature anomaly, the difference in centigrade degrees from a mean over many years (for example, 1961 to 1990) for each time and date at the site. Then climatologists average the anomalies over days, nights, seasons, continents, and oceans with extrapolations from other regions for missing data. Further corrections are necessary for changes in measuring practices, abandoned stations, extra heating in cities and the altitude of the station. Moreover, as emphasized by Essex and McKitrick, temperature is an intensive thermodynamic variable that has no physical meaning when averaged over different locations and times in a nonequilibrium system.[8] Nevertheless, this is the statistic adopted by the IPCC to represent global climate so it is reasonable to expect the predictions of the models used by the IPCC to be consistent with it.

For the purpose of this discussion, the divergence between the models and temperatures in figure 2 is sufficient reason to conclude that we do not yet understand climate. Susan Solomon, as reported by Jeff Tollefson, now is saying that fifty to one hundred years is needed to recognize a change in climate.[9] If so, the rise from 1978 to 1998 could be a short-term fluctuation not necessarily caused by CO_2. Kevin Cowtan and Robert Way have suggested a bias in the temperature record because of incomplete data on the recent Arctic warming.[10] However, Ed Hawkins has shown that this correction is insignificant.[11]

Many climatologists recognize the temperature plateau as a serious challenge to their predictions, so they are busy investigating many phenomena omitted from the present models. The hypotheses include

1. an overestimate of the effect of the absorbing gases in some models,[12]
2. inadequate inclusion of clouds that reflect sunlight,[13]
3. uncertainty in the contributions of other liquid and solid aerosols, some of which reflect and others absorb radiation,[14]
4. cooling by SO_2 aerosols from recent volcanoes,[15]
5. a decreasing concentration of stratospheric water vapor that slowed the rise in surface temperatures,[16]
6. a major South Pacific El Niño warming in 1998 so the plateau did not begin until 2001,[17]
7. a deep reservoir for the missing heat mainly in the Pacific Ocean[18] or the Atlantic Ocean,[19]
8. the Atlantic multidecadal oscillation,[20]
9. a multidecadal climate signal with many inputs propagating across the Northern Hemisphere like a stadium wave,[21]
10. reduced absorption by chlorofluorocarbons because their concentration has stopped rising following the Montreal Protocol,[22]
11. unpredictable climate due to chaos,[23] and
12. lower ultraviolet solar irradiance around 200 nm that reduces the formation of ozone and hence the absorption of solar energy between 240 and 320 nm in the stratosphere.[24]

Thus, there are many processes partially or completely omitted from the models that we were told were dependable for climate predictions. Several of these effects also could be natural contributions to the warming from 1978 to 1998. Consequently, we must wait for the development of new theories and new models to assess the importance of each item and how the predictions turn out as global temperatures evolve over the next decades—or longer, if we think fifty to one hundred years are needed to assess climate change. The testing of climate predictions takes time.

The simplest explanation for any variation in the global temperature would be a change in the total solar irradiance. However, we know from satellite

observations beginning in 1978 that the luminosity of the sun integrated over all wavelengths varies by only 0.1 % over the 11-year sunspot cycle and has remained within that range during the present cycle.[25] The direct effect on temperature is only 0.1 °C, but reduced solar activity also lowers the strength of the heliosphere magnetic shield permitting more cosmic rays to reach the earth and seed more clouds that then reflect more sunlight.[26] The solar wind also varies with solar activity, affecting cloud formation through interaction with global electric circuit.[27]

These are interesting possibilities because beginning about 2003, there was a major change in solar activity. The sunspot count in figure 3 shows an active sun from 1978 to 2003 followed by a broad minimum and a weak maximum just passed. Figure 4 shows that the previous occasions of weak activity were the Dalton Minimum from about 1800 to 1820 and the Maunder Minimum from 1645 to 1715. These events occurred during the Little Ice Age, a cold period that lasted from about 1430 to 1850 when glaciers in both the Northern and Southern Hemispheres advanced. We know from the cosmogenic nuclides ^{14}C in tree rings and ^{10}Be in ice cores that cosmic rays were stronger during these minima, confirming that the sun was less active. Gerard Bond et al. determined the history of North Atlantic sea temperatures for the past 12,000 years from the latitudes of sea-floor debris dropped by melting icebergs originating in Canada and Greenland.[28] They found a strong anti-correlation of temperature with the ^{14}C and ^{10}Be proxies for solar activity. Whether the lower temperatures resulted from a weaker total irradiance or some other solar influence we do not yet know, but solar activity does appear to affect climate. Similarly with a stalagmite taken from a cave in Oman, anti-correlation of $^{18}O/^{16}O$ with ^{14}C demonstrated the influence of solar activity on rainfall.[29]

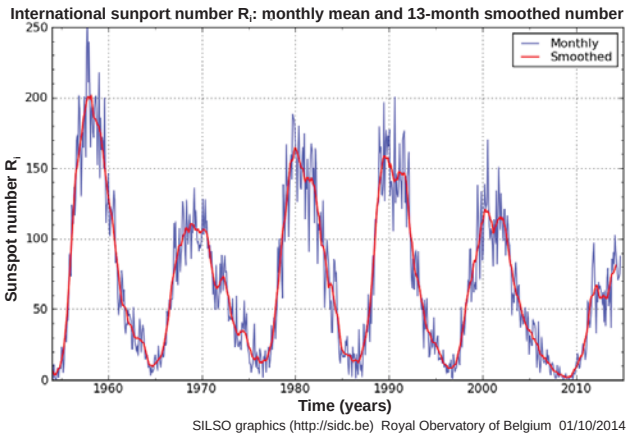

Figure 3. Monthly sunspot numbers for the past 60 years by the Royal Observatory of Belgium at http://sidc.oma.be/sunspot-index-graphics/sidc_graphics.php. The recent minimum was unusually broad with 820 spotless days compared with 230, 274, 275, and 310 days during the previous four.

Thus, temperatures could begin to rise again as we add more CO_2 to the atmosphere, or they could fall if the weak solar activity leads to a cooler earth. At present, some cooling process is providing a remarkable balance with the known global heating due to increasing concentrations of CO_2 and the other absorbing gases. While the present plateau lasts, we easily will match the proposed goal of limiting the temperature rise to 2 °C since the industrial revolution. If temperatures rise again, we cannot say how much, if at all, we will need to constrain our CO_2 emissions because we do not know the fraction of the heating due to natural causes. In fact, a modest increase in temperature and CO_2 could have net benefits for crop yields. Operators of greenhouses often add CO_2 to stimulate plant growth.

The Dilemma for Christians

So this is the quandary for Christians and anyone else who cares for our planet. With these uncertainties about future temperatures and other aspects of our climate, should we still adopt the aggressive policies necessary for a significant reduction in the global CO_2 output or wait until we have a better understanding of the natural causes of a changing climate?

Specifically, here are some issues that deserve serious discussion.

1. As insurance against possible future warming, should we in the developed countries still make

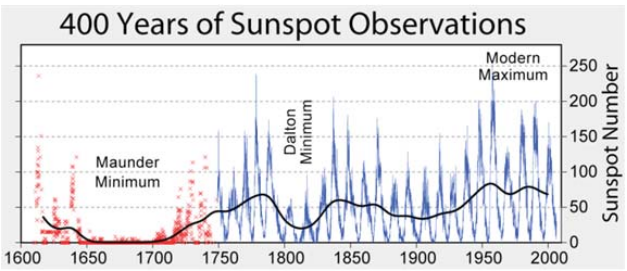

Figure 4. This plot from the US National Oceanic and Atmospheric Administration shows sunspot numbers since their first observation with telescopes in 1610. Systematic counting began soon after the discovery of the 11-year cycle in 1843. Later searching of old records provided the earlier numbers.

major reductions in our generation of the absorbing gases and accept the consequent economic pain? Small reductions with minimal economic impact are unlikely to be effective. The CO_2 curve in figure 1 shows the annual photosynthesis cycle but not the recession of 2008.

2. What will be the consequences of proposed policies for the poorest people in the developed countries and for all but the wealthiest in poor countries?

3. Are there other environmental issues equally or more important than the possible effects of CO_2? We do not have the resources to address all the problems.

4. Are all of the current efforts to reduce CO_2 emissions effective? Is subsidizing biofuels helpful? Why oppose pipelines for transporting petroleum products when shipping by railcar requires more energy and is more dangerous? Is it useful to construct large installations of windmills, solar cells, or mirrors if there is no way to store the energy? The excessive feed-in tariffs required to repay the investors add to everyone's electricity costs, and in the United States, windmills need special White House dispensation because they kill endangered birds such as bald eagles. A recent report in *The Economist* describes how unfavorable the real costs of wind and solar power are compared with hydro, nuclear, and gas sources.[30]

5. As developing countries such as China and India use more and more energy, they are becoming the major emitters of CO_2. Do we expect them to constrain their growth short of our standard of living? If not, how do we deal with all the extra CO_2?

6. Should we advocate and practice zero population growth to help limit global warming?

7. At the United Nations conference in Warsaw in November 2013, developing nations, with the support of China, demanded reparations from the developed countries for all the CO_2 they have added to the atmosphere since the industrial revolution and compensation for damage caused by hurricanes, typhoons, and spells of drought. How should we respond to such demands?

8. How serious are higher sea levels for island communities? According to the IPCC Report, the mean sea level is rising by 1.5 to 1.9 mm/yr, but the evidence for the expected acceleration is weak with a range of -0.002 to 0.019 mm/yr^2.[31] Data from the tide-gauge records show that rising sea level will not be a problem this century.[32] Except for a few places such as Manila in the Philippines, where the land is subsiding, the real threats may be human developments that hinder the natural reef-building processes that follow a rising sea level.[33]

9. The 2013 IPCC Report states that the pH over the open oceans ranges from 8.4 to 7.8, has decreased on the average by about 0.1 logarithmic units since the industrial revolution, and now is trending lower at 0.15 to 0.24 units per century.[34] Even if anthropogenic CO_2 is not causing serious global warming, is the decreasing alkalinity of the ocean sufficient reason to curtail the emission?

10. How much should we constrain travel? Should we use a train or bus in place of a one-hour aeroplane flight for a business meeting even if the longer duration surface travel requires being away an extra night or two? Should we take our vacations close to home? Should we travel to conferences in interesting places on other continents? Should we be using video conferencing instead?

What Should We Do?

It is my view that we should use this time of uncertainty in the predictions to pause in our actions and review the usefulness of the current and proposed projects. With whatever policies we choose, we must ask some basic questions. Will any of the mitigation schemes have a noticeable effect on the increasing atmospheric CO_2? Where is adaptation to be preferred? Could the available funds be spent better some other way? What are the unintended consequences? Also we should adopt a little humility and stop claiming that climate science is settled or that we understand climate well enough to be sure that we know how to control it.

Most importantly, we must eschew the notion of science by consensus and the denigration of skeptics. Even 90+ % of climatologists believing that anthropogenic CO_2 is warming the earth dangerously does

not validate the hypothesis. There was consensus that anxiety or spicy food caused gastric ulcers until 1982 when two Australian researchers identified the bacterium *Helicobacter pylori*. Similarly, by consensus, the treatment of malaria once was to move the patient away from the "bad air."

Science progresses by the relentless questioning of every hypothesis, every theory, and every model and by comparing them with experiments and observations.

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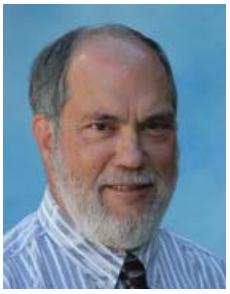

Thomas P. Ackerman

Article

Christian Action in the Face of Climate Change

Thomas P. Ackerman

Basic physics and chemistry tell us that adding carbon dioxide (CO_2) to the Earth's atmosphere will certainly result in warmer surface temperatures, rising sea levels, and ocean acidification. While the directions of change are certain, the exact magnitude and precise timing remain somewhat uncertain due to our lack of understanding of the complex climate system of Earth. Climate models represent our most complete understanding of the climate system and our only means to project the future climate of Earth. These models are not expected to precisely predict the trajectory of Earth's climate because climate variability is due to a combination of two types of change: deterministic change due to external forcings and stochastic or random change due to internal variations in the climate system. On timescales of years to decades, the stochastic variability dominates, making it extremely difficult to predict annual and decadal changes in climate. The uncertainty in our understanding of climate change caused by increasing CO_2 concentrations should drive society to make every effort to reduce these emissions and reduce the risk of disastrous change. Christians should be leading these efforts because we are charged to love God, including his creation, and to love our neighbors, including future generations. We know what we should do; unfortunately, we lack the will to do it.

Humankind is engaged in a large-scale modification of Earth's climate through the emission of carbon dioxide (CO_2) to the atmosphere and partial solution into the ocean. The inevitable result will be a warmer planet with rising sea levels and increasing acidification of the ocean. These outcomes are the result of straightforward applications of the laws of chemistry and physics. The exact magnitude and timing of these effects remain somewhat uncertain due to the complexity of the climate system and limitations of increasingly complex climate models.

Christians are called to be stewards of creation and seekers of justice for the poor and powerless. In the face of uncertainty about the magnitude of the effects, principles of risk management argue for caution regarding heedless production of more CO_2. Rather than using the uncertainty in predictions of amount and timing of effects to argue for nonaction, Christians should be calling for immediate action to reduce the effects of climate change by reducing, and ultimately stopping, emissions of human-made CO_2.

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Global Warming Certainties

Do not be confused. Increasing the concentration of CO_2 in the atmosphere must warm Earth's surface. Planet Earth has a strong greenhouse effect that is critical to maintaining our present climate. That greenhouse effect is caused by the absorption and emission of thermal (heat) radiation, primarily by three naturally occurring gases: CO_2, water vapor, and ozone. Water vapor is the most important of the three, but its atmospheric

concentration is limited by the temperature of the atmosphere; higher atmospheric temperatures result in more water vapor in the atmosphere. CO_2 is the second-most-important greenhouse gas; its atmospheric concentration is not limited by short-term climate processes and has increased by 40% over the past 150 years due to human activity, namely the burning of fossil carbon. This additional CO_2 increases the greenhouse effect of the atmosphere that, in turn, must increase the temperature of Earth's surface. The laws of physics do not permit any other outcome. Because removal of CO_2 from the atmosphere occurs very slowly, the CO_2 that we are now emitting into the atmosphere will, for the most part, remain in the atmosphere for hundreds of years.

We have multiple paths of evidence for a warmer climate, including increasing atmospheric temperatures, increasing heat storage (warming) in the ocean, rapidly declining amount of summer sea ice in the Arctic, lengthening of the growing season in the Northern Hemisphere mid-latitudes, and earlier arrivals of migratory birds and blooming of spring plants. A warmer ocean means expansion of ocean water and an increase in sea-level height. In addition, the Greenland ice sheet is melting at an ever more rapid rate, and there are disturbing indications of the collapse of ice shelves in the Antarctic, which may lead to a more rapid slippage of Antarctic ice sheets into the ocean. Both effects will also increase sea level. Roughly half of the CO_2 emitted since the start of the industrial revolution is in the atmosphere. Much of the rest has dissolved in the mixed layer of the ocean (roughly the top few hundred feet), forming carbonic acid and acidifying the ocean. Both ocean acidification and sea level rise are inevitable consequences of increasing CO_2 concentrations in the atmosphere.[1]

We, the human race, are currently engaged in a huge, uncontrolled climate experiment on planet Earth. We are burning fossil fuels at an ever-increasing rate. The concentration of CO_2 in the atmosphere is not only increasing, but increasing at an ever-greater rate; the increase each year exceeds the increase in the previous year. At current rates of increase, the CO_2 concentration in the atmosphere will be more than double the pre-industrial revolution value before the end of this century. Global temperatures will warm, sea level will rise, and the ocean will continue to become more acidic.

Global Warming Uncertainties and Climate Models

Donald Morton presents a number of well-worn criticisms of climate models. These criticisms have all been addressed before by many different individuals and organizations. The end of this article contains a brief list of reports on climate science written in the last few years by teams of scientists in the United States and worldwide. The interested reader is referred to these reports for discussion and refutation of the criticisms raised by Morton.

The one issue that I wish to address here is the purpose and validity of climate models. Climate models were originally developed to help guide our understanding of how the physical climate system works. Early models were quite primitive due to a lack of computer power, but even these very early models suggested that doubling the concentration of CO_2 in the atmosphere would produce a surface temperature rise of 2–4 °C.[2] The interesting feature of this warming is that it arises from a combination of direct warming from an increasing CO_2 concentration and warming due to feedback processes, primarily an increasing water vapor concentration associated with a warmer atmosphere.

As our scientific understanding of climate processes grew through the 1970s and early 1980s, climate scientists became increasingly concerned about the distinct possibility of warming Earth through human activity. Scientific investigation moved from whether increasing CO_2 concentrations would increase temperature to questions of how much warming would occur (determined to a large degree by climate feedbacks) and how fast it would occur (determined largely by heat storage in the ocean). The only way to answer these questions, short of waiting many decades, is to build a climate model capable of simulating climate and changes in the climate system. This task has engaged climate scientists for the past three to four decades.

Climate models that started out as simple one-dimensional atmospheric columns now include a three-dimensional (3D) representation of atmosphere and ocean, cloud processes, sea and land, ice and snow, atmospheric chemistry, land surface vegetation, and carbon cycles. Early 3D climate models (which share the same basic mathematical structure

with forecasting models) were extensions of atmospheric forecasting models that were designed to predict atmospheric behavior on timescales of a week or two, but were streamlined computationally in order to allow simulation times of years in order to understand the behavior of climate. The current generation of forecasting models is much more complex than previous versions, and these models are used to forecast both immediate weather (one to two weeks) and the statistical probability of seasonal (three to nine months) weather. Climate models, originally simpler than atmospheric forecasting models, now exceed forecasting models in terms of size and complexity and are arguably the largest and most complex scientific computer codes that have been built. Our use of them has expanded as well. The original purpose was to understand the complex interactions of the climate system, a use that we continue to exploit, but we now also use them to understand how climate will change in the future and to examine climate change in the past.

How accurate are these models and how should we view their output compared to the actual trajectory of Earth climate? Or, in other words, with what fidelity should we expect climate models to simulate Earth climate and on what timescales? This is, as one might expect, a very knotty issue. We have learned that the earth climate system, in all its beauty and complexity, is both deterministic and stochastic. This latter term simply means that there is an element of randomness or unpredictability in the climate system, which may arise because the system is truly random or because the processes causing the apparent random behavior are too small or too complex for us to understand completely. An example may help here. Imagine you are somewhere in the central United States on a warm summer day. In the morning, the sky is relatively clear but scattered clouds develop as the day wears on. We can predict that these clouds are very likely to occur (deterministic), but we cannot predict exactly where or precisely when they will form (stochastic). By midafternoon, some of these clouds grow into thunder clouds and produce rain. Again, we can predict the likelihood that this will occur, but we cannot predict exactly when and where the rain will fall.

Climate simulation has a very similar problem. Climate has both deterministic processes, such as the response of atmospheric thermal radiation to increasing greenhouse gas concentrations, and stochastic processes, such as the occurrence of an El Niño event in the equatorial Pacific. We cannot predict the timing of El Niño events, perhaps because our knowledge is incomplete or perhaps because these events are truly unpredictable and depend on random interactions between the atmosphere and ocean. One way we seek to understand the relationship between deterministic and stochastic processes is to run our models many times for the same set of prescribed external climate forcings such as solar variability and changing greenhouse gas concentrations. We can then look at the multiple runs to identify which aspects are similar (or deterministic) and which are dissimilar (due to stochastic processes). What we find is that deterministic processes generally have long timescales on the order of a decade or more, while stochastic variability occurs on shorter timescales. We all recognize this latter variability as the difference in climate from one year to the next, including successive years of above average precipitation or drought.

So how does all this relate to climate change? The climate we have on Earth is only one possible climate history out of many, many possible histories. If I start my climate model in 2000 and run it out to 2015 one hundred times, I might be fortunate enough to reproduce the exact observed history of Earth one time. The more likely outcome, however, is that I have no exact simulation but several that are somewhat close. Given the stochastic nature of climate, it is unreasonable to expect that any climate model will exactly duplicate the climate history of Earth from year to year for a decade or perhaps even two decades. Climate scientists have known this for many years. We recognize that "decadal" prediction is the most difficult problem that we face in forecasting.

Does this mean then, as Morton states, that "the divergence between the models and temperatures … is sufficient reason to conclude that we do not yet understand climate"?[3] Not so. The fact that the actual trajectory of Earth climate over the past decade[4] has diverged from most model simulations indicates that the short-term stochastic processes are not occurring in our models in the same way that they are currently occurring in the one actual climate realization that we have, namely the climate of Earth for the last decade. Climate scientists, such as I, see this not as an indication that we do not understand

climate, but as a challenge to improve our understanding of the complex interactions that determine the intricate details of climate. Why is this current pause in warming occurring? Well, our best answer at this point is that the extra heat being produced by the greater greenhouse warming is warming the ocean rather than the atmosphere. We have evidence that the ocean is, in fact, warming,[5] but we do not have a complete explanation of why this warming has occurred at a greater rate over the last decade than in the previous couple of decades, resulting in a decadal hiatus of atmospheric warming. We also have evidence of increased volcanic aerosol concentrations in the stratosphere over the last decade that may have helped cool the planet. Give us a few years and we may be able to give you a better answer.

So where does this leave us? Increasing greenhouse gas concentrations must increase the temperature of Earth. We can provide reasonable estimates of the magnitude of that increase on timescales of several decades or more. Model estimates of global surface temperature change for a doubling of CO_2 have remained remarkably constant at around 2–5 °C (multiply by 2 if you prefer an estimate in degrees F). The exact timing of that warming is open to discussion, but there is very little doubt that it will happen before the end of this century. Increasing heat storage in the ocean leads to a warmer ocean that is expanding in volume and producing a rising sea level. Increasing ice melt from Greenland and Antarctic ice sheets will increase that rise. Best estimates are for sea level rise of at least a meter by the end of the century. Ocean acidification is perhaps the most certain outcome because it depends only on simple solubility relationships that have been known for more than a hundred years. The outcome of ocean acidification is not well understood, but it will certainly impact negatively the plankton at the bottom of the ocean food web, and that damage to the bottom of the food web will then propagate up through the ocean ecosystem.

What Then Should We Do as Christians?

Morton argues:

> It is my view that we [Christians] should use this time of uncertainty in the predictions to pause in our actions and review the usefulness of the current and proposed projects. With whatever policies we choose, we must ask some basic questions. Will any of the mitigation schemes have a noticeable effect on the increasing atmospheric CO_2? Where is adaptation to be preferred? Could the available funds be spent better some other way? What are the unintended consequences? Also we should adopt a little humility and stop claiming that climate science is settled or that we understand climate well enough to be sure that we know how to control it.[6]

Not surprisingly, I have a different view. Morton does not specify what "actions" he thinks should be paused, but I doubt that it is the most obvious and important action that we are taking. We are dumping CO_2 into our atmosphere at an unprecedented rate. Between the last glacial maximum (about 20,000 years ago) and 10,000 years before present, atmospheric CO_2 increased from around 180 to 260 ppm.[7] Between 10,000 years before present and about 1850, CO_2 increased a mere 20 ppm to a value of about 280 ppm. In the last 160 years, CO_2 has increased from 280 to 400 ppm which is more than in the preceding 18,000 years! In 1957, when David Keeling began his measurements of background CO_2 concentrations at the atmospheric observatory on Mauna Loa in Hawaii, the measured value was about 315 ppm. Twenty-five years later the value was about 342 ppm; another twenty-five years later, the value was 385 or so. Thus, it took about one hundred years to add 35 ppm (315–280) or 9 ppm per quarter century. We then added about 27 ppm in the next quarter century and 43 ppm in the last quarter century (1985 to 2010).

These rates of CO_2 change show that we are now conducting an unprecedented climate experiment. If someone told us that "they" were going to begin dumping some gas into the atmosphere today and its concentration would increase by 35% in the next one hundred years but that we should not worry because everything would be fine, we would all be upset and rightly so. Just because we have been doing this for one hundred years is no reason to continue to do it, especially in the face of rising scientific knowledge and consensus about probable outcomes that are deleterious to most ecosystems. I and other climate scientists are *not* claiming that we know enough to control climate; we are considerably more humble than that. I am stating exactly the opposite: please

stop putting CO_2 into the atmosphere because we collectively do not understand completely the consequences of our actions.

Morton is apparently willing to discuss the unintended consequences (which by definition are unknown) of mitigation strategies, but he is not willing to consider that there are known consequences, and may be unintended consequences, of continuing to pour ever-increasing amounts of CO_2 into the atmosphere. As a climate scientist, I am continually baffled by the willingness of our society to ignore the known consequences of our ongoing actions while being fearful of the unintended consequences of stopping, or even reducing, the magnitude of those actions.

I want to take a moment here to discuss the idea of consensus in science. Scientific research is, in large part, an attempt to reach consensus among scientists about specific questions. We have a consensus about gravitational attraction, and those who defy that consensus do so at their own peril. We also have a scientific consensus about thermodynamics, electromagnetic wave propagation, and fluid dynamics (the principal scientific elements of climate science). The lone scientist who defies consensus and establishes a new paradigm is largely a mythical figure, particularly in Earth sciences, because those sciences are almost entirely based on well-established classical physics and chemistry. Yes, that scientist does exist in the history of science, but a lot less frequently than one may be led to believe. To suggest that the vast mainstream of climate science is incorrect after decades of research and is going to be overturned by one heroic "skeptic" is, simply put, ridiculous. (And, if indeed that were the case, I would love to be that scientist because it would ensure my enshrinement in the pantheon of science!)

Science does indeed progress "by the relentless questioning of every hypothesis," but *only* if that questioning is done in the context of proper scientific investigation. Sniping from the sidelines and posting unreviewed comments on a blog is not science. Challenging established climate science requires developing new theories of climate behavior grounded in well-established laws of physics and chemistry, construction of new and/or improved climate models, testing and validation of these models, and publication of results in the peer-reviewed literature, showing how the results of these new models differ from existing model results. No such articles exist because no such models exist. The direct or implied statements of the "skeptics" that climate scientists are ignoring certain mechanisms or suppressing inconvenient evidence is nonsense and insulting to climate scientists. It is especially insulting to climate scientists who are Christians when this canard is parroted by members of the Christian community.

We scientists do not think that climate science is "settled," depending on your definition of that term. We do have more to learn, but we also have learned a great deal. One might say that the scientific conclusion that lung cancer is caused by smoking is not "settled" because we still cannot predict who will get lung cancer from smoking and at what age. But that is not the same as saying "keep smoking" because we have not settled all the science yet. We understand very well the fundamental basis of climate science and climate change. We are still working on short-term (decadal) prediction and exact magnitudes and timing.

What we should be doing as Christians is to ask, what are the likely consequences of our current actions? What is the probability that the climate science community is correct in its projections, and what does that mean for the future of ecosystems and human life on this planet? We need to approach these questions from the point of view of creation stewardship, social justice, and risk management. We are charged to love God, including the creation that he gave us. We are charged to love our neighbors, which includes not doing harm to the least among us or to our children and our children's children. We are called to use the intelligence that we have been given to assess the probability of risk and to take actions to mitigate that risk for current and future generations. We know how to do this. What we lack is the will to assume our responsibility for reducing carbon emissions. Even if the consequences of climate change are less than currently predicted, reducing emissions will benefit air and water quality, reduce our dependence on the production and producers of fossil fuel (enhancing our national security along the way), stimulate the economy through investment in new technology, and preserve our limited store of fossil fuels for important uses other than burning.

If climate scientists are correct, or perhaps underestimating projections of climate change (which is certainly as probable as overestimating them), then actions to reduce CO_2 emissions now may be critically important for maintaining our climate near its current values.

Christians should be at the forefront of care for creation and love for humankind. We should be leading the calls for action in our countries. Our Christian witness should be that God's love for us and our love for God compels us to act. Instead, we use slivers of doubt and modest uncertainties in scientific projections to argue for a continuation of our problematic behavior and a maintenance of our wasteful lifestyle. My prayer is that Christians will emulate the persistent widow (Luke 18:1–8) so that our government officials will say, "Even though I don't fear God or care what people think, yet because [these Christians] keep bothering me, I will see that [they] get justice" for those affected by changing climate.

Notes

[1]Evidence is summarized in a variety of places. Graphs of some physical changes are provided, for example, by NASA at http://climate.nasa.gov/evidence. Links to a wide variety of published scientific studies on physical and biological changes can be found at http://www.skepticalscience.com/evidence-for-global-warming-intermediate.htm.

[2]See, for example, S. Manabe and R. T. Wetherald, "Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity," *Journal of the Atmospheric Sciences* 24, (1967): 241–59.

[3]D. C. Morton, "Climate Science and the Dilemma for Christians," *Perspectives on Science and Christian Faith* 66, no. 4 (2014): 238.

[4]Morton uses the figure of sixteen years, which is incorrect. (See Morton, "Climate Science and the Dilemma for Christians," 236.) Climate warming (or cooling) should not be based on one year but rather on an average of no less than ten years. A running average (that is an average for each year based on averaging the five years before and after that year) shows that it is approximately the last decade in which Earth surface air temperature has been relatively constant.

[5]G. C. Johnson et al., "State of the Climate 2012: [Global Oceans] Ocean Heat Content," *Bulletin of the American Meteorological Society* 94, no. 8 (2013): S50–S53. Graphs of ocean heat storage and sea level are provided by the NOAA National Oceanographic Data Center (NODC), http://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/.

[6]D. Morton, "Climate Science and the Dilemma for Christians," 240–1.

[7]Parts per million; i.e., in every one million molecules of dry air, 260 molecules are CO_2.

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John P. Bowen

Communication

The Gospel Is Always Bigger[1]

John P. Bowen

> *He has rescued us from the power of darkness and transferred us into the kingdom of his beloved Son, in whom we have redemption, the forgiveness of sins. He is the image of the invisible God, the firstborn of all creation; for in him all things in heaven and on earth were created, things visible and invisible, whether thrones or dominions or rulers or powers—all things have been created through him and for him. He himself is before all things, and in him all things hold together. He is the head of the body, the church; he is the beginning, the firstborn from the dead, so that he might come to have first place in everything. For in him all the fullness of God was pleased to dwell, and through him God was pleased to reconcile to himself all things, whether on earth or in heaven, by making peace through the blood of his cross.*
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> —Colossians 1:13–20, NRSV

Sixty years ago, J. B. Phillips, the Bible translator, wrote a book entitled *Your God Is Too Small*.[2] It was about our tendency to shrink God to manageable proportions. But I think Paul might say that not only is our God too small but also that our Jesus is too small. Paul is writing Colossians to Christians who think that they need to supplement their worship of Jesus with other things—with religion and ritual and philosophy—a kind of "Jesus-plus" spirituality.

And Paul says, "No, no, if you think that, you haven't really understood Jesus yet." So he is trying to set the record straight, and the heart of his argument is here in Colossians 1. Part of that argument is the theme of your conference, which is also the historic motto of McMaster University: "In Christ all things hold together."

It's an amazing vision, isn't it? Paul somehow sees that the carpenter of Nazareth is also the one who made absolutely everything and who holds absolutely everything together. It is this Jesus who gives coherence and meaning to everything that exists. This Jesus holds together the atoms in our bodies, keeps the laws of physics constant, and keeps the distant stars in their courses. When we do our work, it is this Jesus who keeps our brain functioning, this Jesus whose world we are exploring, this Jesus whose truths we are discovering. It is even Jesus who enables our brains to doubt whether he even exists.

It would be interesting to know whether John and Paul ever had a conversation and, if they did, to know what they said to each other. They would have had a lot to talk about, not least because both have a huge understanding of who Jesus is. I imagine Paul saying, "I like to think of him as holding all things together." John says, "I've been thinking about that too. In fact, I'm thinking of writing a biography of Jesus, and I think I might call him the *logos*—I'm sure you know the idea (it crops up in so many religions and philosophies these days), that there's a rational principle behind the universe. And, of

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course, you and I know the name of that rational principle." And Paul says, "Shoot, I wish I'd thought of that."

But if we put these two things together—the Jesus whom Paul says holds all things together, and the Jesus John calls the *logos*, the creative mind of God become flesh—then every discipline that ends in "logy" is a whimsical reminder of the centrality, the bigness, of Jesus Christ. He is the *logos* in cosmology, geology, biology, entomology, biotechnology, climatology, zoology, kinesiology, even paleoanthropology (which was a new one to me). And because Jesus is at the heart of all our work, whatever our discipline (whether or not it ends in "logy"!), that gives us hope and purpose and meaning that frankly is very difficult to find anywhere else.

This is why "All things together—all things cohering—in Christ" makes such a great motto for a university. It says that, whatever our discipline, whether humanities or social sciences or sciences, we are all engaged in the same project, and there is an overarching coherence to all we do. All of us are seeking to think God's thoughts after him, in all their diversity and beauty and complexity. Whatever our discipline, we know that "all truth is God's truth" because Jesus Christ is holding the universe together. Hence, of course, the word "uni-versity." Without that, we are just a "poly-versity" or a "multi-versity." No wonder it is hard for universities these days to replace Christian mottos with secular ones. How do you express the rationale of the institution in a single phrase when there is no unifying principle, no sense that all knowledge is part of some greater whole? A motto such as "Try harder" really doesn't cut it.

But Paul didn't write Colossians to justify the use of the word "university." He has bigger fish to fry. So in verse 18, as Tom Wright points out, Paul moves from talking about creation to talking about a new creation.[3] We can't stop at saying that Christ created all things and that Christ holds all things together. There's more.

So, in the verses that follow, Paul talks about Christ's incarnation (*"in him all the fullness of God was pleased to dwell"*), about his atoning death (*"making peace through the blood of his cross"*), and about his resurrection (*"the firstborn from the dead"*). And what is the purpose of these things? It is *"so that he might come to have first place in everything."*

But this is a little puzzling: if Christ created all things and Christ upholds all things, doesn't he already have first place in everything? The answer, of course, is that Paul is thinking of sin and the fact that this is a fallen world, a world in which we do not see Christ supreme much of the time. And the purpose of his incarnation and death and resurrection is precisely so that *that* supremacy, which is his rightfully, might be restored. Or, to put it Paul's way, *"through him God was pleased to reconcile to himself all things, whether on earth or in heaven."* Ultimately, God is about the renewal of the cosmos—he is not content with forgiving our sins, cleaning up our lives, and renewing us by his Spirit. He is concerned to redeem, restore, and renew *all* things (the word "all" is used eight times in just six verses)—our relationships, our neighborhoods, our cities, our cultures, our work, and all the ways that the natural world has been hurt by the evil of human beings. It is as though the redeeming work of God through Jesus is a series of ripples spreading out and out from the cross until they embrace the whole of creation.

I love the way that Eugene Peterson translates Colossians 1:18–20:

> He was supreme in the beginning, and—leading the resurrection parade—he is supreme in the end. From beginning to end he's there, towering far above everything, everyone. So spacious is he, so roomy, that everything of God finds its proper place in him without crowding. Not only that, but all the broken pieces of the universe—people and things, animals and atoms—get properly fixed and fit together in vibrant harmonies, all because of his death, his blood that poured down from the cross.[4]

But there is a word in the middle of this Colossians 1 passage that jars on me, and maybe on you too. It's the word "church." *"He is the head of the body, the church"* (v. 18, NRSV). Maybe it jars because it has such negative connotations in our world today. But, of course, when Paul says church, he doesn't have in mind what we often associate with church; he means something which fits perfectly into this vision of Christ. What then does he mean?

One of the most helpful ways of thinking about church comes from New Testament scholar Tom Wright. He has suggested that the Bible is like a five-act play[5]—although (as Richard Middleton and Brian Walsh have pointed out[6]) it works better if we think of it as a six-act play.

- Act 1 is the story of creation: God creates a beautiful and fruitful world, and entrusts it to our care.
- Act 2 is the story of what has gone wrong in our world: we decide that we know how to run it better than the Creator.
- Act 3 is the story of the Old Testament: God in love begins over, starting with Abraham and Sarah and the promise that, through their descendants, blessing will be restored to the whole world. Everywhere sin has done its dirty work, the redeeming work of God is sure to follow.
- And then, in Act 4, the Creator writes himself into the script—as if Shakespeare should write himself into the plot of *Hamlet* so that Hamlet could get to know his creator. When the Creator appears on the stage, he shows us what a fully human life is like: he dies for our sins, he rises from death, and he returns to heaven. And we call him "Jesus."
- Finally, in Act 6, the Creator brings down the curtain on this drama at the end of time, God's work of dealing with sin, evil, and brokenness is complete, and the new heaven and the new earth are ushered in.

So what is Act 5? This is where we are now, the time between Christ's first coming (in Act 4) and his second coming (in Act 6), the age of the church. There is no script for Act 5. We need to exercise "faithful improvisation," living as the people of God in contexts the biblical writers never envisioned, and yet being faithful to the spirit and the direction of the story as we have received it.

How does the church fit, right there, in the middle of Paul's glorious vision? Because at its heart, the church is the community of those called by God to work with him in the redemption of the world. I used to say that the church is a community of Jesus's disciples, which it is, but "disciple" is kind of an old-fashioned religious word. So, for a time, I used to say that a disciple was a student, but then I realized that student in our culture means someone (generally young) sitting at a desk, taking notes from a lecture—which is hardly what Jesus meant. (You probably know the old definition of a lecture: the means by which the lecturer's notes become the student's notes, without passing through the minds of either.)

I have come to think these days that a better word than disciple is probably apprentice. The church is the community of apprentices of Jesus. Like any apprentices, we are learning from the master craftsman how to do the things the master does so well. In the case of Christian apprenticeship, we are learning from Jesus our Teacher—in whatever field we are called—how to do the work of God to restore, renew, and redeem all things. That is why the church—with you and me as part of it—is right there in the middle of Paul's vision. We are part of this amazing work of God.

I don't know who you are, but I do know this: that whatever your role is in this world—whether professor, researcher, or student; whether physicist, neurobiologist, or medical ethicist; whether it's in an office, a classroom, or a lab; whether beginning your career or ending your career or somewhere in the middle—if you are a disciple, an apprentice of Jesus Christ, he will work in you and through you—he is already working in you and through you—to do this work of redeeming, renewing, and restoring all things.

Friends, this is what we were made for, this is worth getting up in the morning for, this is worth giving our all for. Yes, it is the way of suffering and self-sacrifice certainly—Jesus never promised it would be easy—but it is also the way of joy. Isn't this the heart of the Gospel? That through Jesus Christ—his life, death, and resurrection—God is restoring joy to a fallen world—joy in us, and joy through us and through the church, to the world.

Notes

[1]A sermon given by John Bowen at the Sunday worship service of the ASA/CSCA/CiS Annual Meeting at McMaster University, Hamilton, ON, on July 27, 2014.
[2]J. B. Phillips, *Your God Is Too Small* (New York: Macmillan, 1954).
[3]N. T. Wright, *Tyndale New Testament Commentaries: Colossians and Philemon* (Grand Rapids, MI: Eerdmans 1986), 73.
[4]Eugene H. Peterson, trans., *The Message: The Bible in Contemporary Language* (Colorado Springs, CO: NavPress, 2005), 1612.
[5]N. T. Wright, *The New Testament and the People of God* (Minneapolis, MN: Fortress Press, 1992), 140–1.
[6]Richard Middleton and Brian Walsh, *Truth Is Stranger Than It Used to Be* (Downers Grove, IL: InterVarsity Press 1995), 182, 240.

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Environment

LET CREATION REJOICE: Biblical Hope and Ecological Crisis by Jonathan A. Moo and Robert S. White. Downers Grove, IL: IVP Academic, 2014. 187 pages. Paperback; $20.00. ISBN: 9780830840526.

At a time when Earth's environmental problems can seem insurmountable, Jonathan Moo and Robert White present a case for Christians to look forward with both hope and diligence in their efforts to care for God's creation. Their vision of biblical hope does not gloss over the grim realities of the damage that has been done to our world by human destruction, pollution, and overexploitation of resources. *Let Creation Rejoice: Biblical Hope and Ecological Crisis* is structured upon the idea that Christians are called to both joy and lament—to a hope based on the promises of God's kingdom and to groaning alongside all creation.

The reasons for lament come first in the book. Moo and White provide a whirlwind tour of the ecological crisis, carefully working through major issues that threaten the future of life on Earth, and, in the process, addressing the implications for the health and wellbeing of both people and the nonhuman creation. The authors find that, at its root, the brokenness of creation results from humanity's broken relationship with God. The first chapter in this section covers a range of topics including population growth, ecological footprint, nitrogen cycling, water use, and food production. The next chapter is dedicated entirely to the subject of climate change, walking the reader through the repercussions of a rapidly warming Earth, the evidence for human-caused climate change, and future prospects. They do not shy away from pointing out the ways that media coverage has highlighted flashy stories (such as investigations into fraud among climate scientists) rather than what can appear to be small increases in global average temperature (yet which still have major effects), or how corporations that make their profits from fossil fuels have sought to propagate uncertainty and confusion over the issue of climate change.

After lamenting the present state of the planet, the subsequent call to hope and joy is truly needed and appreciated. Moo and White stress that Christians do not work alone in addressing the ecological crisis: God continues to work in his creation. Christians also have hope in the future redemption of creation. This future hope can be misconstrued or misused to condone an attitude of indifference toward the groaning of creation, but the authors counter this misunderstanding with very convincing arguments for working toward the new creation. In this picture of future hope, they use recurring imagery of the *already* and *not yet* of God's kingdom. God's kingdom is here, yet much suffering is found on Earth. Christians are waiting for the full revelation and renewal of the earth, yet even now we have foretastes—which can be seen when we help the earth to flourish, such as through ecological restoration. During this time of waiting, we must be ready and active, preparing for the Lord's return.

This book highlights many reasons to care about creation, focusing on those particularly relevant to a Christian worldview. God is the Creator, and he shows his care for all creation; those who follow God should show this care as well. To care for human brothers and sisters (those of the future and those of today around the world), we must care for the environment. With their focus on the future, the authors provide considerable discussion of the end times and what will become of the earth. They argue that God will purify and renew the earth rather than simply destroy it: "*this creation*, this very earth, will not be left behind" (p. 111). Thus, as Christians work alongside Christ, they, too, should work toward the renewal of all creation.

The reader is challenged to consider whether his or her culture is like the kingdom of Babylon described in Revelation. Rather than rejoicing at the fall of Babylon at the end times, would Christians lament? Many stumbling blocks have led people to fall in step with the ways of Babylon and have prevented them from taking action to be better stewards of the earth. These impediments range from self-interests to economic incentives to consumer culture. In addition, our human perspective makes it difficult for us to deal with the long-term effects of our actions rather than just those of the short term. While some might hope for a specific plan of action from the authors, they did not go this route. Rather than provide specific prescriptions, they sound a call to serve Christ and others through positive interactions with creation.

Those considering this book might also consider (or might already have read) Steven Bouma-Prediger's *For the Beauty of the Earth: A Christian Vision for Creation Care* (2010). Both of these books provide an assessment of the state of our planet, give powerful arguments for Christian earthkeeping, and thoughtfully consider large scripture passages (as opposed to proof texting). Bouma-Prediger focuses on addressing specific accusations against Christians with regard to poor environmental stewardship, and

he covers a repertoire of reasons various people find to care for creation. For those looking for a book that excels in describing the Creator's handiwork in crafting different ecosystems and his covenanting with all of creation, Bouma-Prediger's book is stronger. On the other hand, while Bouma-Prediger also looks forward to the renewal of the earth, Moo and White go into much greater depth on what scripture says about the future and how that affects our current hope and understanding. Both books are excellent contributions to the discussion of Christian environmental stewardship, each with its own strengths.

The Christian story is one that looks forward to the time when Christ will come again. Rather than an excuse to neglect our responsibilities, his return is a call to be found ready and to participate in the renewal of creation in this time of the *already* and the *not yet*.

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Ethics

A POLITICAL THEOLOGY OF CLIMATE CHANGE by Michael S. Northcott. Grand Rapids, MI: Eerdmans, 2013. 345 pages. Paperback; $30.00. ISBN: 9780802870988.

The core presupposition of this sprawling book is that the most alarming scientific claims currently being made about climate change are trustworthy. Northcott, a Christian ethicist at the University of Edinburgh who specializes in the environment, cites study after study, from all over the world, indicating that anthropogenic climate change is not only changing current weather patterns but also threatens to harm and finally destroy the very human civilizations that are producing it. We are facing "a slow catastrophe" (p. 4), a "climate emergency" (p. 160). Even though "slow change leading to catastrophic outcomes is … counterintuitive" (p. 6), a "climate apocalypse" is indeed coming. In the short term, climate change will affect different regions and populations unevenly, but in the long run, we may be looking at "the end of the human species within two hundred years" (p. 14).

Some readers will check out immediately in the face of this particularly alarming take on current climate science, either because they cannot bear to be told such things or because they simply do not believe them. But as this magisterial, interdisciplinary, and intellectually sophisticated work unfolds, it becomes clear that Northcott has a much bigger story to tell—and prescription to offer. One could ratchet back his scientific claims by a few degrees (pun intended) and still be swept up by his majestic political-theological-philosophical analysis of what has gone wrong with human civilization to get us to this point of climate crisis—and what still might be done about it.

Northcott is explicitly offering "climate apocalyptic" (p. 16). Like New Testament apocalyptic, he says, climate apocalyptic indicates the imminence of a moment of judgment on the present form of human civilization. Like all apocalypticists, climatologists and those analysts who extrapolate the implications offer an "unveiling" of the sins of our civilization, and "heral[d] judgment," but also put forward a last-minute call to moral and political transformation (p. 26).

Impressively fluent in biblical studies and theology, science, ecology, and western intellectual history, Northcott's grand narrative begins with the claim that the very brief history of human civilization took a fundamental turn when humans moved from hunter-gatherer civilizations to agrarian economies (the "agrarian fall," reflected perhaps in Genesis 1–3), that were then able to support ever-larger cities. The Bible is written against the backdrop of this agrarian-urban transformation, beginning about 8,000 years ago, which marked the first and much more modest stage of deforestation, raising of domestic animals (with their emissions), large-scale rice-growing, and other changes which began the slow anthropogenic rise of carbon dioxide and methane in the atmosphere.

But the change from the "Holocene" era to the "Anthropocene" (e.g., our unintentional transformation of Earth into a place where humans became a greater influence on climate than the tilt of the earth in relation to the sun) accelerated around 1750 with the industrial revolution and the dramatic rise in the use of coal, a story Northcott describes in chapter 2. From 1750–1950, not only because of coal but also oil (chap. 3), carbon dioxide levels went from 270 to 310 ppm; but from 1950 to the present, the numbers have spiked upwards exponentially from 310 to 400 ppm. This latter "great acceleration" has brought humanity into "new climatic territory" (p. 2) with already-visible effects, guaranteed global temperature rises, and potential catastrophe in the future.

Alongside this eco-history, Northcott also offers a fascinating parallel intellectual history. A core theme is that ancient biblical political theology offers resources for reconnecting humanity to creation, which were displaced for centuries by desiccated

forms of modern philosophy and political economy. Northcott suggests that ancient Jewish and historic Christian communities (as well as others, in their own ways) believed in a fundamental connection between God, humans, and the natural-meteorological-seasonal-agricultural rhythms on which human life depended. This looked different for biblical Israel than it did for early Christians or medieval Christendom, but all had in common a belief in active divine sovereignty over both nature and culture as well as a belief that human behavior affects and interacts with creation and its well-being.

However, in the period we often call "modernity," this integral understanding of a relationship between God, humanity, creation, and culture splits apart. Ranging widely across the landscape of modern science, philosophy, and political theory, Northcott shows how, in various ways, the modernists split nature and culture, drove God out of any involvement with creation, and reconceived humans as the scientific explorers, masters, exploiters, and manipulators of a spiritually empty natural world—all of which proved highly convenient in underwriting the birth of modern industrial capitalism as well as the vast western colonial and imperial projects.

This was the path we took to building the high-tech, fossil-fueled, private-property-fixated, autonomy-driven, "growth"-oriented, free-market capitalist, prosperous (for a few) world that we now live in, governed by nation-states viewing themselves as responsible only for their own territory and prosperity. We did this with everyone apparently assuming the inexhaustibility of the "natural resources" and unchangeability of the "natural world" on which this way of life depends. This intellectual, material, and political culture continually proves itself impotent to respond to obvious environmental distress.

But now our climatologist-apocalypticists are telling us that our ideological-economic-political assumptions were wrong, and that our way of life cannot be sustained—and soon enough (unless we change) our cities will be drowned and food supply ruined as nature roars back and takes control once again over wayward, recalcitrant humanity. The ancients, it turns out, were wiser than we are in seeing a connection between nature and culture, between humans and creation. Now, far more quickly than is comfortable, individuals, communities, nations, and humanity as a whole must respond immediately to the "ecological limits" the planet is revealing to us. Part of the needed response is a new political theology—and related ecclesial and communal praxis—with much greater interconnection between God, creation, and the nations, with greater humility before ecosystem boundaries and ecological limits, and an awareness that if humanity is to have a future, we must choose it right now.

Such a choice must mean an end to consumerism, fossil-fuel-based economies, economic "growth" as the measure of prosperity, much of what we understand to be private property, and most personal autonomy related to environmental and economic choices. It also means an end to the ideologies that have undergirded this way of life, ideologies with partisans that push back fiercely, even today, as such dramatic changes are proposed.

I hope that Northcott's reading of the science is wrong to the extent that human civilization has more time to make the changes that, I agree, we need to make. I fear that the lifestyle changes he says are mandatory ask too much of us, absent a spiritual and moral revolution that sweeps the planet.

But if Northcott is right, and we do not, in fact, change our thinking and our practices, and God does not swoop in *deus ex machina* and rescue us, this terrifying, brilliant book is one of a handful I would nominate for placement in the proverbial time capsule to be read by whatever life form visits Planet Earth a thousand years from now and tries to find out what happened to the profligate species that used to live here.

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THE PERIL AND PROMISE OF MEDICAL TECHNOLOGY by D. Gareth Jones. Oxford, UK: Peter Lang, 2013. 280 pages. Paperback; $71.95. ISBN: 9783034307758.

Medical technology, present and projected, is amazing: assisted reproductive technologies, organ transplants, artificial organs, brain stimulators, imaging devices, designer drugs, individual genomic sequencing, gene therapies, and genetic engineering, just to illustrate a few. These technologies have revolutionized medicine. Ideally, they are profound blessings promoting health and human flourishing by improving the quality of life and extending life expectancy. But they also invoke significant costs, not just economically, but also socially, ethically, and theologically. And now there is the distinct possibility that technological interventions might so alter us as to call into question whether the very essence of being human will be changed.

Gareth Jones, an ASA Fellow, is familiar to persons interested in Christian perspectives on bioethical issues. Now an emeritus professor at the University of Otago, New Zealand, his career as a thoughtful Christian neuroscientist and bioethicist has spanned the rise of bioethics and led to his publication of *Genetic Engineering* (1978), *Brave New People: Ethical Issues at the Commencement of Life* (1985), *Manufacturing Humans: Challenge of the New Reproductive Technologies* (1987), *Designers of the Future: Who Should Make the Decisions?* (2005), and *Speaking for the Dead: The Human Body in Biology and Medicine* (2009). This, his latest work, *The Peril and Promise of Medical Technology*, is published as volume 8 of the New International Studies in Applied Ethics. It continues his quest for theological guidance on difficult issues while being attentive to scientific analysis and insights.

For the framework for his theological insights, Jones draws heavily from the late Allen Verhey, theological ethicist from the Reformed Christian tradition, suggesting that Verhey's "interpretive rules" are better understood as "directives." The first directive is a call to humility. No individual or faith tradition, regardless of the richness of their heritage, strength of their commitment, or declarations of their church hierarchies, has the most assured answer on any bioethical issue. The second directive is to avoid interpretive arrogance. We must keep in mind what the biblical writers had in mind and be cautious about asserting positions as scriptural that are drawn upon nonscriptural viewpoints. As examples, he specifically cites the inclination to assert that (1) since God saw and knew the psalmist before birth, the human "soul" must be present from conception, and (2) that since all human beings are created in the image of God, this must be true from conception, and we should derive that all embryos image God and possess a right to life. The third directive is to avoid privatization of ethical deliberation. Ethical deliberation cannot be done by individuals or only by biblical scholars, theologians, and ethicists. Rather, the broader Christian community must be involved, including, the author insists, scientists and clinicians as well as others, including theological scholars.

In weighing the appropriate role for the Bible and other sources of concepts and thinking, Jones identifies four possible scenarios: (1) the Bible alone provides a complete guide to ways in which Christian decision making should be framed, making scientific input irrelevant; (2) the Bible is one of a number of sources of concepts and information, but is the major determinant whenever there is conflict or confusion; (3) the Bible is one of a number of sources of concepts and information, and helps to inform decision making, but may not be the major source; and (4) the Bible is irrelevant and hence can provide nothing of any interest to scientists or ethicists.

The author illustrates how the first three approaches might differ with respect to the reproductive decision making of a Christian couple who are contemplating more children and whose first child has cystic fibrosis.

In chapter 2, Jones compares and contrasts issues in the reproductive realm (which are fairly extensively addressed by Christian ethicists) with those arising in the realm of neuroscience (which are less extensively addressed by Christian ethicists). He notes that many of the tensions and complexities are similar while acknowledging that reproductive choices may involve choosing one life over another and neuroscience choices may involve changing human functioning of individuals for their entire lives.

In the ensuing chapters, Jones examines specific medical technologies from the foundational issues addressed in the first two chapters. In chapter 3, he looks at assisted artificial reproductive technologies, noting the profound blessings of children for couples who previously were infertile, alongside the vexing issue of left-over frozen embryos. He observes how key issues have evolved since the inception of IVF-ET in the late 1960s with the rise of embryo freezing, oocyte freezing, preimplantation genetic diagnosis, and embryonic stem cells. In chapter 4, he examines genes and self-identity, noting the urge to search for genes for all our traits including, for example, alcoholism, homosexuality, obesity, and religiosity. Here he focuses on the rise of personalized medicine that portends new and better treatments for many patients, but also has led to the direct-to-consumer market of DNA sequencing with variable and insufficient attention to issues of privacy, accuracy, and education about genetic risks. Subsections address the relative roles of genes and environmental factors, genetic determinism, genetic lottery, and genes and the person.

In chapter 5, Jones moves toward neuroscience and the potential to modify our brains. Whereas traditional Christian anthropology has emphasized a dualism of body and soul, developments in neuroscience focus on the brain and the person. Critiquing the neural determinism of Francis Crick, Jones notes the contributions of Donald MacKay, Malcolm Jeeves, Joel Green, and Nancey Murphy to incorporate the ongoing discoveries of neuroscience into a Christian framework. Jones proceeds to work from a

physicalist position, noting how brain damage may have a profound effect upon an individual's personality and value systems. From this vantage point, he presents a framework that incorporates observations on the effects of injury and disease on the brain with the capacities of learning and adaptation, which can be subject to both human and divine influences. In chapter 6, Jones moves to address the potential for biomedical enhancements of morality. While current efforts such as deep brain stimulation and transcranial direct current stimulation are relatively crude means of altering brain function, they create an anticipation that someday we may be able to create much more specific changes, not just by repairing damage, but also by working toward specific goals such as morality. Jones presents a framework for endorsing therapeutic interventions, while strongly criticizing moral enhancements as an abrogation of our responsibility as image bearers of God.

In chapter 7, Jones looks at ageing and human bodies, distinguishing four categories of our efforts to alter ageing: (1) overcoming the appearance of ageing; (2) overcoming the accompaniments of ageing; (3) decelerating the process of ageing—increasing lifespan; and (4) overcoming the process of ageing—achieving immortality. The chapter proceeds to look at theological insights into ageing and immortality, but then focuses on the challenges presented by the preservation and presentation of the dead through plastination (i.e., the *Body Worlds* traveling exhibition of plastinated human bodies). In chapter 8, he turns to our increasing dependence upon technology, moving from regenerative medicine to cyborgs to post-persons, acknowledging the transition from realistic and therapeutic to the speculative.

In a concluding chapter, Jones articulates a means to move forward with medical technology from a Christian perspective. Here he develops an appropriate relationship between God's care and human care, the discerning features of what it is to be human, and how to live with an unknown and uncertain future. As he does throughout his book, Jones articulately advocates taking both science and theology seriously toward a hopeful future consistent with God's intent.

The Peril and Promise of Medical Technology is a thoughtful and formidable work that deserves a wide reading and consideration from undergraduate students to professionals, scientists, and theologians alike. It is a significant contribution to Christian perspectives on these topics in biomedical technology. The publisher has chosen to publish this book (and series) as a fairly expensive paperback, affordable by many libraries, but not individuals; it would be most helpful if the publisher would make this book available as a significantly discounted e-book to reach a much larger audience.

Reviewed by Hessel Bouma III, Professor of Biology, Calvin College, Grand Rapids, MI 49546.

History of Science

INVENTING CHEMISTRY: Herman Boerhaave and the Reform of the Chemical Arts by John C. Powers. Chicago, IL: University of Chicago Press, 2012. viii + 260 pages, notes, bibliography, index. Hardcover; $40.00. ISBN: 9780226677606.

Ideas may travel, but so do techniques, procedures, pedagogical approaches, and strategies. These may be carefully crafted, publically demonstrated, and minutely described in lectures and textbooks. That, in brief, is the moral of the book *Inventing Chemistry* written by John C. Powers, assistant professor in the Department of History and co-director of the Science, Technology, and Society program at Virginia Commonwealth University. The focus is on Herman Boerhaave (1668–1738), a Calvinist medical and chemistry professor at the University of Leiden, who was famous in the eighteenth century as the man who taught Europe chemistry, and whose influence even reached to the American colonies.

Boerhaave institutionalized chemistry by bringing it out of the academic shadows as an ancillary subject in medical instruction to claim its rightful place in the university curriculum. One could say, employing a term first introduced by William Newman and Lawerence Principe, "chymistry" became chemistry by way of medical instruction and pedagogy. Powers wants the reader to take the title of the book quite literally: *Inventing Chemistry* details Boerhaave's educational philosophy and its role in making chemistry a discipline not only relevant to medicine, but also one respected in the broader university curriculum. Powers expertly traces this development beginning with Boerhaave's student days in Leiden through his publication of *Elementa Chemiae*, first printed in 1732, with forty separate printings through 1791. In short, Boerhaave created a new philosophical chemistry in which he "sought to generate knowledge as well as things, by establishing and organizing the precepts and principles of the art" (p. 201). As an important teacher in Europe, Boerhaave's work inspired at least two generations of chemists. One can think of influential chemical textbooks: Antoine Lavoisier's *Traité Élémentaire de Chemie* (1789), Wilhelm Ostwald's *Lehrbuch der Allgemeinen Chemie* (1891), Linus

Pauling's *The Nature of the Chemical Bond* (1939), come readily to mind, but none with the widespread appeal of Boerhaave's volume.

But how did Boerhaave set out on this reform of chemistry? The narrative of *Inventing Chemistry* spells this out in chapters two through seven detailing Boerhaave's chemical teaching, both the philosophical rhetoric used to systematize his investigations and the important role instruments played in ways of demonstrating and understanding chemical events. We gain good insight into the development of eighteenth-century chemistry, from the didactic chemistry initially taught at Leiden, the incorporation and critical examination of some alchemical practices and procedures, to the philosophical chemistry expounded by Boerhaave in his *Elementa Chemiae*. Note that all of these chemical developments happened prior to the later work of Lavoisier (1743–1794) with which most readers are more familiar.

What may interest readers of *PSCF* are Boerhaave's motives in pursuing science, and the religious viewpoints which shaped his chemical philosophy. This is presented in the second chapter entitled "Medicine as a Calling." Powers discusses Boerhaave's religious and philosophical background. He wishes to straddle (or perhaps amalgamate) two strands of thought: the philosophical and the theological, giving roughly equal weight to each. He gives a bow to Harold Cook for his analysis of the philosophical contextual debates of the day and to the general Calvinist (Protestant) "mind-set" of working out one's sense of being part of God's elect with an appeal to Max Weber's "Protestant ethos." Powers does mention Rina Knoeff's work recently presented in *Herman Boerhaave (1668–1738): Calvinist Chemist and Physician* (Amsterdam: Royal Netherlands Academy of Arts and Sciences, 2002), but he does not explore her theological interpretation in any depth. Nor does Powers interact with Peter Harrison's *The Fall of Man and the Foundations of Science* (New York: Cambridge University Press, 2007). Knoeff maintains that we need to go beyond a "general religious sensibility" to a more specific Calvinist interpretation of Boerhaave's position. Two motives, she argues, dominate Boerhaave's thinking: (1) the idea that nature provides insight into God's design of creation (an appeal to Article II of the Belgic Confession), and (2) the idea that the human intellect is affected by sin, and by itself cannot arrive at true knowledge. The noetic effects of the Fall caused Boerhaave to assume an anti-Cartesian and anti-Spinozist position, in contrast to trumpeting the power of human reason and intellect. Rather, much like Francis Bacon, Boerhaave advanced an empirical/inductive role for pedagogy, experiment, and demonstration in the chemical arts. For a Calvinist like Boerhaave, to live a life of obedience as a thankful response to God's grace and as a calling for a studied examination of God's creation is not, in the first instance, a charge to develop a "natural theology" or the construction of an apologetics providing reasoned evidences for God's existence.

Inventing Chemistry is a well-written book filling a lacuna in the study and understanding of eighteenth-century chemistry. It does, however, in my opinion, underestimate Boerhaave's theological background. All in all, it is good to hear a Dutch voice profiled since so much of the history of science has been subject to an Anglo-Saxon hegemony in which many non-English contributions have been both undervalued and frequently misunderstood.

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Medicine

MEDICINE AND RELIGION: A Historical Introduction by Gary B. Ferngren. Baltimore, MD: Johns Hopkins University Press, 2014. 256 pages. Paperback; $24.95. ISBN: 9781421412160.

The interchange between science and faith is a much discussed topic in the lay setting and among medical professionals. In this regard, *Medicine and Religion: A Historical Introduction* by Gary B. Ferngren, certainly provides a context for religion's influence in medicine throughout world history. Ferngren is a professor of history at Oregon State University and has previously written books evaluating the interaction between religion, including Christianity, and the sciences and medicine.

The aspect of this book that most impressed me was the author's ability to provide an in-depth analysis of the development of medicine as a science with clarity and succinctness. The author makes it very clear he wishes to avoid "Whiggism," which consists of viewing past practices through our present abilities. This fallacy can lead to an artificial diminution of medical ability in the ancient world by ignoring the very real fact that modern medical technology is a relatively recent development.

The book starts off quickly by exploring medical care in Mesopotamia and Egypt, which tended to place an emphasis on magic and cosmic forces while at the same time providing some of the first written records of both medical and surgical care (for example, use

of peppermint to help with birth). Some of the first trappings of Hebrew medicine are discussed as well: for example, the idea that disease is not necessarily due to someone's actions (i.e., sin), the importance of hygiene, and sustaining human life in order to preserve the image of Yahweh.

Similar care is spent on exploring the relationship between medicine and religion in ancient Greek and Roman culture. As in many ancient cultures, both Greeks and Romans emphasized illness as a form of retribution from the gods, and medical care, especially chronic care, was influenced as a result. Hippocrates and the resultant tradition of his influence lead to the "Hippocratic Oath" in all of its variations as well as to the beginning of empirical care of patients in a format similar to what we would see today as a case report or case series. Although the use of standardizing rational thought in medical care was a significant advance, progression to clinical research outcomes was very different from today and did not go past the equivalent of "level of evidence 4" defined by the Oxford Centre for Evidence-Based Medicine (http://www.cebm.net).

In a similar manner, the Romans personified illness, which led to worship of specific deities such as the goddess Febris (as in "fever"). Galen (c.129–c.217) comes to the forefront during the Western predominance of Roman culture, and Ferngren does a good job of describing his contributions to the field of medicine. An imposing figure historically, Galen not only combined philosophy and medicine to a degree that codified a scholastic aspect of medicine, but his medical ideas continued to persist for over a thousand years. I was fairly familiar with Galen before I read this book, but it did strike me that he likely is overlooked as one of the world's great thinkers in the same category as Newton or Einstein, even if some of his medical theories were incorrect.

The book then covers both Christian and Islamic influences in medicine. I found it fascinating to consider that early Christian beliefs, including caring for the poor and proper burial of the dead, were important factors that led to the Roman Empire adopting Christianity. Early hospitals also were started by Christians, although such buildings would have no resemblance to modern-day hospitals since they were mainly used for charity care. Ferngren does point out that inpatient facilities and even the first semblance of early professional care developed in these first hospitals. As Christianity grew across Europe in the Middle Ages, monasteries began to be the main "data centers" for medical texts (especially among the Benedictines). Some of the first schools which we would recognize as "medical schools," as well as licensure, also began to form during this time. Shortly afterwards, as medicine became more professionalized in the High Middle Ages, physicians were criticized for wanting money—eerily similar to our modern conception of some physicians. In a similar manner, Islamic medicine advanced during the European Middle Ages. I was struck by the faster advancement in the understanding of pathophysiology and professionalization of medicine in Islamic countries compared to their Christian counterparts. In fact, I found Chapter 6 ("Islam in the Middle Ages") to be one of the better chapters of the book simply because it covered information with which I was very unfamiliar.

The latter parts of the book entail the early modern time period and focus on differences between Protestant and Catholic influences in the field of medicine. Laypersons in Protestant countries, in particular, developed an interest in doing their own medical care, and ideas such as home remedies grew very quickly. I was struck by the similarities of this type of care to the modern complementary alternative medicine (CAM) movement. At the same time, however, practicing medicine became very similar to today's care model with physician specialization and secularization of care, namely, the use of the scientific method as opposed to religious ideas, such as prayer, to cure disease. I found it interesting that the Protestant Reformation led to an emphasis on "experimentation and the search for natural causes," which seems to run counter to the current distrust of science and modern medicine often seen in evangelical Christian circles.

The book ends by looking at medicine in the nineteenth and twentieth centuries, wherein the author points out areas of debate quite current in our understanding of medicine and medical ethics, such as professionalization of nurses, use of evolutionary naturalism as a way to study disease, use of the Flexner Report to improve teaching standards in United States medical schools, and hospice care, just to name a small number of issues covered. Of note, the epilogue which examines the positive and negative issues that occur in the interaction between medicine and faith is very well written and worth reading.

Overall, this book is quite wonderful. I have recommended it to many of my friends in the medical field. It covers a large amount of history in the setting of a relatively short book, but the information that is contained in the eight chapters and epilogue is incredibly well presented in an easy-to-read manner.

My only quibble with the book is that some important individuals in the pantheon of medicine, such as Andreas Vesalius and Ambroise Paré, are only briefly mentioned. For more detail on individual physicians and their influence on scientific discovery in the history of medicine, I would recommend books in the line of Nuland's *Doctors: The Biography of Medicine* (New York: Alfred A. Knopf Publishing, 1988). However, there is such a wonderful quantity of information covered in this book that Ferngren likely has much fertile ground for future books if he wants to concentrate on other aspects of the history of medicine. I recommend this book for anyone who wants an outstanding review of the ever-entwining, ever-fascinating relationship between faith and medicine.

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Religion & Science

THE SECRETS OF ALCHEMY by Lawrence M. Principe. Chicago, IL: University of Chicago Press, 2012. 281 pages, 12 color plates. Hardcover; $25.00. ISBN: 9780226682952.

Alchemy is enjoying a renaissance spurred on by the popular interest in the mass media (think of Harry Potter) and, for our purposes, by an exponential growth in the number of scholars and publications devoted to the history of alchemy. One could say that the best alchemical secret is how radically our knowledge of alchemy has changed over the past few decades. Marcos Martinon-Torres's recent review of developments in the historiography of alchemy (*Ambix* 58 [2011]: 215–37), which employed a word cloud search for "alchemy" in JSTOR, identified some of the leading scholars responsible for this development: William Newman, Lawrence Principe, Bruce Moran, Pamela Smith, and Tara Nummedal. The most seminal and widely cited paper in the literature that Martinon-Torres mentions is one written by William R. Newman and Lawrence M. Principe, entitled "Alchemy vs. Chemistry: The Etymological Origins of a Historiographic Mistake" (*Early Science and Medicine* 3, no. 1 [1998]: 32–65).

What mistake? To the popular mind, alchemy is synonymous with the activity of charlatans making outlandish claims about transmuting baser metals into noble metals such as gold, of endless secretive and futile searches for the "Philosophers' Stone," or of activities involving the invocation of supernatural vitalistic and theological principles in the preparation of alchemical elixirs. This is not to hold that such activities or claims never occurred. But stated this baldly, it is far too easy to dismiss alchemy as "pseudoscience," at odds with more sophisticated modern scientific methods. For recent scholars, that claim would be a mistake. To view the history of "esoteric" alchemy as being at odds with "scientific" chemistry would run counter to the fact that, prior to the eighteenth century, the two were indistinguishable. In the above-mentioned article, Newman and Principe suggest that instead we use the term chymistry to denote this state of affairs. If we critically consider this early modern interest in "experimenting" with nature (creational givens), it then has an important role to play in the development of what we take to be modern science. Even Robert Boyle, often described as the father of modern chemistry, spent countless hours practicing alchemy. Earlier interpreters who solely understood him through mechanical philosophical eyes have misread him (see, for example, Lawrence M. Principe's book, *The Aspiring Adept: Robert Boyle and His Alchemical Quest* [Princeton, NJ: Princeton University Press, 1998]).

Now to the book at hand. Lawrence Principe, professor of organic chemistry and history of science at Johns Hopkins University, is one of the foremost chroniclers and interpreters of alchemy. In *The Secrets of Alchemy*, he situates alchemy in its important role in human history and culture. The book is written at two levels: for nonspecialists and for those inclined to follow up on the extensive endnotes. Besides historically detailing the practices of alchemists as craftsmen or experimentalists with their often cryptic and arcane recipes, Principe displays how, in fact, alchemy has impinged on art, literature, theater, and religion. The first few chapters of the book describe the historical development of alchemy in (almost) chronological order: the first three chapters describe ancient Greco-Egyptian origins of *chemeia*, the Arabic development of *al-kīmiyā'*, and the medieval Latin science of *alchemia*. Chapter four skips ahead in time to describe the developments in alchemy from the eighteeenth century to the present. Chapter five is devoted to the golden age of alchemy: practicing chymistry in the early modern period (1500–1700). The following sixth chapter focuses on two of the major areas of concentration in chymistry: chrysopoeia (metallic transmutation) and chemiatria (pharmaceutical medicine or medical chymistry).

One thing that makes this book so interesting to read is that Principe not only gives an account of the development of alchemy, but also experimentally demonstrates procedures described in the vast alchemical literature. Much of medieval and early modern alchemy is, in fact, repeatable. No, Principe

does not make gold, but by interpreting alchemical texts, complete with allegorical language depicting certain operations (such as solution, sublimation, putrefaction), as well as providing some photographs of the outcomes (such as the golden glass of antimony and the Philosopher's Tree), he convinces one that there is method and forethought in the work of these often enigmatic practitioners of the art of separation and combination.

The last chapter, seven, seeks to "put" alchemy in its cultural place. Entitled "the wider worlds of chymistry," this chapter shows that despite its "shaky cultural and intellectual position," being "both condemned as fraudulent or useless and praised as powerful, even sacred, in almost every context" (p. 178), chymistry found its way into literature and art, poetry, and religious literature. Allegorical and alchemical imagery abounds, both in literature and in the reading and interpretation of the Scriptures. For practitioners, alchemy is seen as a "gift of God," enabling one to divine God's way with Nature.

If you want to understand the development and appeal of alchemy, the intellectual and religious contexts that nurtured it, by all means read this well-written book. The book may challenge views of the "Scientific Revolution," which usually fixate on astronomy and the mechanics of motion complete with mathematical description but usually undervalue the experimental and craftsmanlike know-how of alchemists. In addition, the subsequent blossoming of the discipline of chemistry will remain an enigma without a good knowledge of its alchemical roots.

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TOUCHING A NERVE: The Self as Brain by Patricia S. Churchland. New York: W. W. Norton & Company, 2013. 304 pages. Hardcover; $26.95. ISBN: 9780393058321.

Patricia Churchland has written an excellent, accessible overview of the most recent findings in the areas of neuroscience. Though she is referred to, on the dust jacket, as a "trailblazing neurophilosopher," there is relatively little philosophy in this book. It is more a book on the science of the brain and the search for "platforms" (parts of the brain) that serve as the material basis for human conscious and unconscious activities. Philosophically, Churchland tends toward reductionism and naïve realism. She holds both that reality consists of what (neuro)science tells us is really "out there," for example, the brain and its neural circuitry, and that any layer of reality or causality beyond the brain and its electro-chemical workings are epiphenomenal, that is, illusory as cause.

Churchland has a winsome, down-to-earth style indicative of her upbringing on a farm where, confronted with urgent, practical problems on a daily basis, there was no time for contemplative lollygagging. One must assess, solve, and act. Her no-nonsense character comes through in the general tenor of her handling of the scientific and philosophical issues of the book. This is both an asset and a liability, since there are some problems in science that require this sort of work-a-day attitude, but she also appears to be tone deaf to some of the depths to which philosophy should and must go.

She speaks of science as "an extension of common sense," as "common sense gone systematic" (p. 264). I cannot agree with her here. Common sense is "the sun rises and sets." Science is "the earth rotates on its axis in relation to the sun." The history of science shows us that individuals and cultures struggled to overcome commonsense thinking in order to arrive at scientific conclusions. Churchland overestimates the reach of common sense and common sense solutions. She does not appreciate that some things are not, properly, the purview of the reasoning appropriate to plumbing or carpentry.

In chapter one, Churchland makes it clear that she favors the view that she, as a person, is co-extensive with her brain. I suppose this is no surprise since the subtitle of the book is, "the self as brain." But it is a little disturbing that Churchland rarely refers to herself or to others as "persons," preferring to speak of the brain as the subject of this or that activity. There is an underlying tone of impatience with stick-in-the-mud humanists and philosophers who refuse to come clean about the plain facts revealed by neuroscience and cling to outmoded worldviews. She tells a story of an "anti-Enlightenment" individual at a bioethics conference who wagged his finger at her, chastising her naïve trust in scientific solutions to social problems (p. 23). Churchland will have none of it. She claims that such anti-Enlightenment ambivalence stems from insulation from the harsher realities of life, such as life on a farm.

Chapter two takes aim at dualists, who persist in believing in some nonmaterial component of the self, independent of the body and continuing after death. Churchland does a good job of showing the difficulties with the dualist position and how neuroscience points in the direction of psychosomatic unity. It is interesting to note here that, while Churchland is condescending or dismissive of religious thought,

the Hebrew understanding of the person also favored psychosomatic unity, opposing the Platonic and Cartesian dualism she opposes. It would have been helpful had Churchland discussed her position in relation to other physicalist, but nonreductionist positions on the soul-body issue, for example, the dual-aspect monism of Warren S. Brown, Stuart J. Judge, Nancey Murphy, or John Polkinghorne.

Chapter three consists of a general debunking of near-death experiences. Her assumption seems to be that the existence of heaven stands or falls with the validity of these experiences. Churchland argues that individuals reporting such experiences were probably not brain dead but in a coma, and their experiences can be explained in terms of lower oxygen levels (inducing strange feelings and perceptions) along with the release of "endogenous opioids" (p. 70) causing feelings of euphoria and peace. Other forms of religious experience are really just so much "neural funny business," completely explainable within the physical order. Pascal's overwhelming conversion experience of 1654, for example, comes down to a migraine headache (p. 76). Anticipating dismay and resistance, Churchland counsels us with almost evangelical fervor to resist the self-deception of giving credence to what we know ain't so, and to "Stand in the truth" (pp. 80, 166, 262). This is good advice, but one wonders what could possibly be the scientific basis of Churchland's unwavering commitment to Truth, and, more pressingly, where would the neural basis of her stance be located?

In chapters four and five, she gives neuroscience's take on morality, sex, and aggression. Again, on so many issues, Churchland furnishes much valuable and interesting information on the neurochemistry of the brain and its functioning. What appears to be lacking is any sense that giving the necessary, physical basis for some function, supplying the mechanism as it were, can sufficiently account for the whole ball of wax. So, for example, when giving an account of why mammalian mothers "go to great lengths to feed and care for their babies," Churchland tells us that oxytocin and vasopressin are "central characters in the explanation of mammalian other-care." One could have wished for a fuller analysis, even of nonhuman, motherly love.

Chapter six, on war, offers a more nuanced view on the role of culture in relation to human biology than previous chapters. Here, Churchland stresses the multivalent quality of causal relations between genes, the brain, and culture in her discussion of aggression and self-control.

Chapter seven discusses whether human beings have free will and can be held responsible for their actions, then considers the question of punishment for criminal offense. Churchland rejects a dualism which holds that we can be free only if there is some break in physical causality in which the nonphysical soul may operate. She opts, instead, for a definition of free will as "freedom from external constraint, not from internal causality" (Stuart J. Judge, "Nothing But a Pack of Neurons?" p. 3). This position is consistent with her earlier argument about the unity of body and soul. She discusses, at length, the issue of criminal responsibility and the many shades of gray that exist here, given her belief that chemical and neurophysiological causes can influence the status of intention as well as action.

Chapter eight discusses some very interesting research on the relation between the conscious and nonconscious brain and its role in decision making and acts of self-control. Churchland claims that the "real you" comprises both your conscious and nonconscious elements.

Chapter nine considers the question of sleep and why all mammals engage in it, as well as an attempt to furnish a neuroscientific framework for explaining consciousness itself. The basic platform, according to Churchland, is a combination of very well-connected neurons called "rich club" neurons that are capable of integrating enormous amounts of information, "global ignition" in which external stimuli reach areas at the front of the brain, and the central thalamus neurons firing at about 40 hertz and enabling us to achieve a kind of focus and awareness of things in particular.

In the epilogue, Churchland addresses some of the charges commonly levelled against her brand of materialism: reductionism, scientism, atheism, meaninglessness. She exhorts us, again, to face facts and embrace the real world, not the world of our fantasies:

> I have told you a little about how I see things, but that is only how I see things. Longing for heaven and preparing to enter heaven seem much less pressing to me than making a difference here and now. I am more grateful to George Washington and Thomas Jefferson than I am to the monks who spend their time praying for their own souls in hopes of going to heaven. I am more grateful to those who invented safe and effective contraception than I am to those who merely warned that my soul was doomed if I used it. (p. 265)

The world of Patricia Churchland is clean, simple, and flat.

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TECHNOLOGY

ALONE TOGETHER: Why We Expect More from Technology and Less from Each Other by Sherry Turkle. New York: Basic Books, 2011. 384 pages. Paperback; $16.99. ISBN: 9780465031467.

Sherry Turkle makes the profound statement, "Technology is seductive when what it offers meets our human vulnerabilities" (p. 1). This strikes at the very heart of the matter: we humans crave intimacy but fear the risk and vulnerability that come along with it. Turkle's focus is the constant yet shallow technological connectivity of today's youth culture (particularly high school and college students), and its significant impact on interpersonal relationships as well as on the whole of our society.

The author touches a nerve with both the young and the not-so-young in this work that is both incisive and insightful. Turkle herself admits to loving technology (in a 2012 TED talk she refers to getting an encouraging text from her daughter as being "like getting a hug"), but insists that too much can be problematic. Texts are convenient, and can be useful and even uplifting, but they do not work very well for truly getting to know someone.

In the internet's early days, Turkle recounts that users would occasionally unplug, step back, and learn from the virtual world how they could be better human beings in the real world. With the more recent proliferation of mobile devices, she says that we are now allowing these technologies to take us to places we never wanted to go.

Real-life human relationships are rich, as well as messy. In our high-tech age of constant connection through the web, we assume the make-believe persona of avatars interacting in a virtual world. Online we can edit and re-touch the thoughts and images of the versions of ourselves that we present to others. We hide behind our profiles, showing each other only the attributes we want others to see, rather than the real, whole person that each of us is. This absence of vulnerability results in a world lacking in true intimacy: a world in which one neither knows nor is known by anyone else.

We are fearful of being alone, but also fearful of the risks associated with intimacy. Turkle implicates the sense of control offered by technology in masquerading as the antidote to our fears and vulnerabilities. Even as we complain about the distractions of multitasking and never having anyone's full attention, our mobile devices offer us a façade of control. They allow us to control exactly where we put our attention; to make sure we always have an audience (via our texts, posts, shares, etc.); and to always be connected, however superficially. Additionally, technology offers us distraction from a sometimes painful present reality, allowing us to postpone or even completely avoid contemplation or self-reflection. Turkle revises René Descartes's famous line, "I think, therefore I am," into the more contemporary descriptive, "I share, therefore I am."

The author points out that this controlled virtual connectedness gives us the illusion of companionship without the demands of real-world friendship. A step beyond online communities and social media, robot pets and companions appear to fill the need for someone who listens and shows compassion, but it is merely the clever pretense of programmed artificial intelligence.

Ironically, our technological ability to satisfy the need to be heard has turned us into very poor listeners and friends to anyone or anything other than what we selfishly find attractive and interesting. Turkle observes that it is in listening to the boring and imperfect parts of real human conversations that we really get to know each other.

Turkle worries that this pervasive craving for constant connection exacerbates our inability to be alone, asserting that if we are not able to be alone, we are only going to end up more lonely. Prescriptively, the author asserts that we need to create the time and space for greater awareness, reflection, and conversation about how technology is changing us individually and as a society. Furthermore, we must insist that technology lead us back to the real world and our real lives.

As Christians, we have an even higher calling to make sure that our use of technology demonstrates love for our fellow humans, rather than exploiting our fellow humans through our love of technology.

Alone Together is a very well-written, thought-provoking, and enjoyable read. It is written in an engaging yet scholarly style, easily accessible to a broad audience.

Reviewed by Leslie Wickman, Center for Research in Science, Azusa Pacific University, Azusa, CA 91702.

Theology

THE ENTANGLED TRINITY: Quantum Physics and Theology by Ernest L. Simmons. Theology and the Sciences series. Minneapolis, MN: Fortress Press, 2014. ix + 205 pages. Paperback; $39.00. ISBN: 9780800697860.

THE MYSTERY AND AGENCY OF GOD: Divine Being and Action in the World by Frank G. Kirkpatrick. Minneapolis, MN: Fortress Press, 2014. xvii + 163 pages. Paperback; $39.00. ISBN: 9781451465730.

These two books from Fortress Press can be read as complementary: what is argued by Simmons from the "bottom up" level of quantum mechanics can be understood also in light of Kirkpatrick's more "top down" philosophical-theological approach. Both are trained philosophers of religion who seek to clarify divine presence and especially activity vis-à-vis the world. The difference might be that the former's panentheistic model of the God-world relationship is extended by the latter's personalistic commitments.

Those who have followed developments at the theology and science interface will recognize Simmons's contribution to the discussion in various journal articles and book chapters over the last two decades. This volume deepens ideas he has written about, but, more importantly, sets them within a broader framework that includes (in part I) clarification of underlying epistemological, methodological, and foundational issues on the one hand, as well as (in part II) substantive explication of the history of trinitarian theological reflection on the other hand. The result is a useful book that can be used in advanced undergraduate courses in theology and in seminary curricula.

The basic thesis builds off the application to theology of the phenomenon of quantum entanglement proposed in the last decade or so (by John Polkinghorne and Kirk Wegter-McNelly, among others) and seeks to extend such to understanding the doctrine of the Trinity. Simmons's argument is that the entanglement and superposition of nonlocal quantum phenomena (at a distance) provides a physical metaphor and model for understanding how the immanent trinitarian perichoresis (indwelling) of divine persons is intertwined also with the economic Trinity as creating, redeeming (in the incarnation), and sanctifying the world. In this framework, the world participates in, panentheistically, the triune reality of God. Consistent with the process and Whiteheadian philosophical assumptions prevalent among some at the vanguard of the theology and science conversation, the concomitant proposal is that given this immanent-and-economic trinitarian interrelationality, God can be understood to evolve as interwoven with the world. The important point, however, is arguably practical: that the entangled Trinity invites creatures like human beings to cooperate vocationally with God, which is the appropriate response of those who follow Simmons in seeing theology and science as mutually informative and creatively interactive.

If Simmons's springboard is developments in quantum physics, Kirkpatrick's motivation throughout his long career as a philosopher of religion and a philosophical ethicist (the volume under review is his eighth book publication) is the quest for a religiously satisfying God as personal agent in a scientific age. If scientific integrity seems to demand a noninterventionistic deity, an overly transcendent deism fails to meet human need and does not square with human experience. In conversation with philosophers of action (especially John Macmurray, Raymond Tallis, and Edward Pols) who have explored the metaphysics of at least human agency, the solution proposed is of God as primordial and personal agent whose direct actions create, supervene upon, and utilize cosmological laws, events, causes, and creatures to bring about divine intentions. Just as only human intentionality and agency can intervene amidst or comprehend a whole sequence of interactions, so also divine activity similarly operates transcendently (to the cosmos) but no less personally (vis-à-vis personal creatures) upon and pervasively within the infrastructure of the whole socio-temporal-material world.

What is being sought is an appropriately anthropomorphic conception of God, one that makes sense of what monotheistic scriptural traditions assert about a self-revealing deity, but yet also is plausible for late modern minds. By and large, the author seems to agree that discernment of divine acts in history, while inferentially possible (albeit not because the causal joint between the divine agent and any cosmic event is identifiable), occurs most dependably in the light of scriptural attestations to such activity. Attempting to chart a *via media* between deconstructionists and Barthians who decry metaphysics (albeit for different reasons) on the one side and pietists and dualists who affirm supernaturalistic divine agency (again, for different reasons) on the other side, Kirkpatrick suggests a metaphysically robust account of God as personal agent, but yet not exactly in the same sense as human agents.

Whence then the mystery of God noted in the title of Kirkpatrick's book? While not deploying eschatological notions, the argument tends precisely in that direction: that, in a Pannenbergian sense, any attempt to grasp divine being and action in the world proceeds not least from a posture of faith, one that is open to confirmation (or not) in the end. From this perspective, one might say that Kirkpatrick provides a primordial theory of divine action that is simultaneously also eschatologically and teleologically oriented according to patterns discerned by scriptural traditions of inquiry. The divine character illuminated in such cases is not uncontested, of course, but such contestation is surely what should be expected when attempting to define personality from agency. The point is that any primordial divine activity is nevertheless fully intelligible only against an eschatological horizon, or according to the overarching telos or design, to use philosophical terminology.

The Mystery and Agency of God is a sustained argument in philosophical theology while *The Entangled Trinity* is fundamentally a theological reflection approached from various angles (methodologically, historically, and scientifically). If the author of the former might urge the latter to consider more personalistic conceptions of divine agency, the latter might suggest to the former that quantum metaphors and analogies might fill out the mysterious character of such divine being and action. Fortress Press is to be commended for facilitating such potential conversations even if it might be pressured by market demands to publish otherwise.

Reviewed by Amos Yong, Fuller Theological Seminary, Pasadena, CA 91182.

Letter

Concordism vs. Context

In a recent paper (Harry Lee Poe, "The English Bible and the Days of Creation: When Tradition Conflicts with Text," *PSCF* 66, no. 3 [2014]: 130–9), the thesis is advanced that since the days of creation in Genesis 1 do not have a definite article in the original Hebrew, they should be translated not as "the second day," "the third day," and so forth but "a second day," "a third day," et cetera. Poe says that the "absence of the definite article with the days of creation almost certainly means that the days are meant to be understood as not occurring in immediate succession to one another without any intervening time" (p. 137). In fact, Poe argues that, although the days were probably 24-hour days, the text allows for "an indeterminate time span between days" (p. 130) which could cover the fourteen billion years which modern science assigns to the age of the universe.

Poe's interpretation is thus concordist: there is concord between the Bible and the findings of modern science. I question some of Poe's grammatical points. For instance, almost all of his examples to show that the word "day," when modified by an ordinal, usually takes the Hebrew article, do not seem comparable to Genesis 1, because unlike Genesis 1 they employ a prepositional phrase (usually "on the ordinal day") while, except for the seventh day, Genesis 1 does not employ a prepositional phrase. But my interest is not in refuting Poe per se but rather in using his work as an illustration of how concordism takes verses of Scripture out of context in order to interpret them as agreeing with modern science.

The first relevant contextual datum for the interpretation of the days of Genesis 1 is Genesis 2:3: *"Then God blessed the seventh day and sanctified it, because in it He rested from all His work which God had created and made."* This verse, along with the sequence of six days in Genesis 1, ties Genesis 1 to Exodus 20:9, 10: *"Six days you shall labor and do all your work, but the seventh day is a sabbath of the LORD your God; in it you shall not do any work …"* This is a commandment that the Israelites had to obey. How long a period of time did they think the six days of labor covered? Is there any real question that they thought those days covered six immediately consecutive 24-hour days? How long and when did the Israelites think God wanted them to do no work? Was it not for the twenty-four hours of the seventh day which immediately followed the six days of labor?

Having set forth this scenario of seven immediately consecutive 24-hour days, Exodus 20:11 continues with an explanation of why the Israelites were commanded to work six days and rest the seventh: *"For (meaning because) in six days (which the context has just defined as immediately consecutive days) Jehovah made heaven and earth, the sea, and all that is in them, and rested the seventh day …"* The ancient Israelites, to whom all this was addressed, had no problem accepting as fact the creation of the universe in six immediately consecutive 24-hour days, but a modern concordist cannot accept this because it is so clearly contrary to the scientific evidence. So, the modern concordist (apparently unconsciously) ignores the biblical context, sets the offensive biblical passage into the context of modern science, and then figures out a way to make the passage agree with (or at least not disagree with) modern science.

Letter

Poe's interpretation of the days of Genesis 1 relies on the fact that the Hebrew grammar per se in Genesis 1 does not exclude the possibility that the days of creation were each separated by an indefinite period of time. Employing these gaps, he brings the Bible and modern science into concord, and the grammar does not forbid his solution. But, the context does. Not only does the context define the days as immediately consecutive, but also, if there were indefinite periods of time between the days, the Israelites, wanting to rest on the seventh day, would have no way of knowing when that day had arrived.

Paul H. Seely
ASA Fellow

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